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Foreword

The information age presents us with tremendous possibilities as well as unique challenges. This is a very exciting time to be working in the communications industry as technology is evolving quickly and new applications are being devised constantly. For a nation considered to be having the fastest-growing telecom industry, the issue of clarity in understanding the Radio Frequency (RF) spectrum and its optimum utilisation merits attention.

RF spectrum is a scarce, limited natural resource wherein spectrum management and regulatory mechanisms are key elements for ensuring efficient and interference-free spectrum usage. RF spectrum transcends geographical and political boundaries; hence, coordination at the international level, regarding the efficient, rationale and need-based use of spectrum is the hallmark of spectrum management. While the ITU holds court as the international forum for regulating spectrum, the Wireless Planning Committee (WPC) under the Ministry of Communications & Information Technology (MoC&IT) in India plays the role of Spectrum Manager while the TRAI plays the role of Regulatory Authority, creating a fine balance in meeting the strategic requirements of Defence/Government agencies as well as commercial requirements, both of which are in

the nation's interest. It is thus imperative to have an understanding of the organisations and processes for regulating spectrum at the global, regional and national levels, for optimal projection of the spectrum requirements of the Armed Forces.

Previously, if one wanted to develop a village, people used to ask the government to build a road, because the moment a road was built, it opened the door for the villagers to access other parts of the country, where they could sell their produce, besides providing avenues for growth of business, employment, education and healthcare. The village thus used to develop and grow just because of the connectivity provided by the road. In the digital era, RF spectrum provides 2G, 3G, 4G connectivity (with 5G round the corner), which are all types of a digital highways required for development of business and for growth of education, healthcare and other infrastructure. Digital connectivity is not just about communications alone; it is in fact about improvement and growth in the fields of industry, automation, education, healthcare and other infrastructure—the list is endless. It is an end-to-end road for functioning and growth in various fields, as was evident during the recent COVID-19 crisis. With the world locked down to contain the spread of this pandemic, the governance of nations, routine administration, provisioning of essential goods and services, education and commerce is possible only due to the established communication and IT networks, which had been facilitated in no small measure by the grid of wireless networks. This is thus the importance of spectrum.

The movement of our society and much of the world from the industrial age to the information age has been hastened largely by the liberalised availability of frequency spectrum which has, in turn, led to the proliferation of social media. The same has had an impact on the Armed Forces, providing both opportunities and challenges to both friend and foe alike.

Countries that control the Geo-Technology domain will control all the other three domains of Geo-Strategy, Geo-Politics and Geo-

Economics; nations which control these three domains, will control the world. In the emerging world order, India has a major role to play; though it is a global player, in order to become a global leader, India needs to optimally utilise the RF spectrum and harness the latest technologies like 5G and IoT.

The Defence spectrum requirements need to be judiciously managed and aligned at the national, regional and global levels, for ensuring efficient and interference-free spectrum utilisation. In view of the ongoing contest for spectrum allocation for commercial applications, it is necessary that Defence be aware of and have an understanding of the organisations and processes for regulating spectrum at the global, regional and national levels, to ensure optimal projection of the spectrum requirements of the Armed Forces. It is extremely important to understand the spectrum requirements, in order to be able to apply it or exploit it optimally for reaping military benefits.

This important aspect and many other relevant factors have been lucidly covered in the study report on the "Appraisal of the Spectrum Requirements of the Armed Forces for Optimal Utilisation of the Defence Band". This report is a seminal work in this field which will help the reader to understand this complex subject and its interplay in various aspects of defence preparedness and at the national and international levels.Lt Gen (Dr) Rajesh Pant, PVSM, AVSM,VSM (Retd), National Cyber Security Coordinator (NSCC), NSCS

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National Cyber Security Coordinator (NSCC), NSCS

Rationale for undertaking the research study

Frequency Spectrum is no longer merely about communication systems alone. The requirement of spectrum is all-pervasive and is likely to affect and shape all platforms of war fighting in the days to come. Spectrum can be treated akin to a digital national highway, whose presence and availability is essential to drive various means of transport. Until 2006, the defence forces were major users and held a majority stake in the spectrum. However, a need was felt to offset Spectrum currently held with the defence forces for commercial use and to cater for the communication requirements of the Armed Forces, a dedicated defence band was identified and promulgated in 2015. The defence band in the EM spectrum is a prime resource and it needs to be judiciously managed for ensuring efficient and interference-free spectrum utilization for the Armed Forces.

There is likely to be increased pressure from commercial players on the part of EM spectrum promulgated as a defence band. Spectrum is a strategic need of the country and there is an urgent requirement to both optimise the usage of the defence band by means of projecting for spectrum requirements and to support both the present and future capacity build up of the Armed Forces. A holistic study in this field was required so that the defence forces

are able to overcome the challenges of spectrum access constraints while continuing to deliver on their mandated task.

In this Research Study Paper, the author, Brig (Dr.) Navjot Singh Bedi has carried out an in-depth study to explain various issues faced prior to promulgation of defence band and the rationale on which the defence band was based and earmarked to bring out the interests of the Armed Forces in each of the sub bands. In order to holistically understand the subject, an in-depth study of the various spectrum regulating organisations and processes has also been carried out and the evolution of the RF spectrum allocation process in India over the last two-and-a-half decades has been explained. The present and futuristic frequency requirements of the Armed Forces in various sub bands, compiled through the medium of responses to questionnaires and by data survey and seeking views of subject matter experts (SMEs), have subsequently been analysed and practical implementable suggestions have been offered, including the need to have in place an organisation which can effectively monitor the Defence Band, to prevent such situations.

With 5G services planned to be rolled out in the country, there might be a requirement for spectrum, presently earmarked for defence, to be considered to be released for commercial purposes, in the overall national interests. Defence preparedness is also equally important for safeguarding the sovereignty of the nation, which permits all such commercial activities to take place. Thus, there is a need to reconcile both these requirements and Defence must be prepared to optimally plan for utilization of the frequency spectrum allocated to them and that the present holding is being managed well in a judicious manner.

At the same time, the need for continued retention of the Defence Band needs to be viewed in the light of the strategic implications of defence operations and key reform initiatives being undertaken at the highest level. Knowledge regarding the various spectrum

regulating organisations at the global, regional and national levels and the processes that are followed, is essential to understand the criticality of spectrum and this study report has provided clarity on the same. There is thus a need to put in place systems and procedures, that despite the peculiar constraints of the Armed Forces, they are able to overcome the challenges of spectrum access constraints, while continuing to deliver on the mandated task. This Research Study Paper provides a deep insight into this niche subject and is recommended to be read and understood in all Service HQs and Category A establishments within the Armed Forces and HQ IDS and with select government organisations.

Place: New Delhi

Vinod Bhatia
Lt Gen (Retd)
Director CENJOWS

Date: June 2019

Executive Summary

Radio frequency spectrum is a scarce limited natural resource extending from 3 KHz to 3000 GHz wherein spectrum management and regulatory mechanisms are key elements for ensuring efficient and interference free spectrum usage. Propagation of radio waves has different characteristics in different frequency bands and these waves are influenced by the phenomenon of cosmic/man-made noises, terrain and varying climatic conditions. Though the Radio Frequency (RF) spectrum appears to be extensive, it is considerably limited as its usage is contingent to availability of appropriate technologies for communication purposes commercially. An efficient, rationale and need-based use of spectrum is the hallmark of spectrum management.

The defence forces were earlier holding the majority of the frequency spectrum until 2006. However, with the growing demand for spectrum, primarily for mobile telephony (especially 2G and 3G services) and digital TV broadcasting, a need was felt to offset Spectrum currently held with the defence forces for commercial use. This led to a review of the National Frequency Action Plan (NFAP). At the same time, to cater for the communication requirements of the Armed Forces, the Defence Band (DB) was identified and

promulgated in 2015 wherein 09 sub-bands were earmarked exclusively for defence use, while in the remaining 42 sub bands the defence forces were asked to coexist with other commercial users. The Defence Band in the EM spectrum is a prime resource and it needs to be judiciously managed for ensuring efficient and interference-free utilisation.

The DB is however open to review and portions of it, not utilized/earmarked for utilization by Defence, might be made available for auction for commercial/other purposes. The DB is scheduled to come up for review after five years, i.e., in 2020. However, the impending rollout of 5G and other national interests may possibly warrant an earlier review of the same and the Armed Forces must be prepared for the same. It is also possible that a few portions of the frequency spectrum, presently earmarked for Defence, might be reviewed in consultation with the MoD, if found to be lying un-utilised.

In view of the likely contest for spectrum allocation for commercial applications, it is necessary that the Armed Forces must be able to optimally plan for utilization of the frequency spectrum allocated to them and that the present holding is being judiciously managed. At the same time, the Defence Band (DB) needs to be viewed in the light of the strategic implications of defence operations, the long gestation period in fructification of defence procurements and key reform initiatives being undertaken at the highest level. This study is a step in that direction that despite the peculiar constraints of the Armed Forces, they are able to overcome the challenges of timely spectrum access, while continuing to deliver on the mandated task. It brings out that the frequency spectrum for defence cannot be taken in isolation as spectrum being a national resource, there are linkages of frequency spectrum for defence with the future changes in technology, market structure and government policy. It also explains both the

necessity to understand and address this issue and also covers an unintended but very relevant offshoot of the liberalised availability of frequency spectrum, i.e., the impact of liberalised availability of spectrum on proliferation of social media and its effect on the Armed Forces.

1
Introduction

Telecommunications today is considered one of the key factors in the development of a nation-state, be it in the field of economic, social, commercial or cultural issues. The telephone, which just used to be a communication device some time ago, has now the potential of being an instrument of empowerment. Most modern communication technologies are dependent on the use of radio spectrum usage to facilitate proliferation of voice, video and data, converged as triple play services, over the network in digital form.

The Radio Frequency spectrum comprises Electromagnetic (EM) waves propagating over a scarce limited natural resource, extending from 3 KHz to 3000 GHz, wherein spectrum management and regulatory mechanisms are key elements for ensuring efficient and interference-free spectrum usage. Though the radio frequency spectrum appears to be extensive, it is considerably limited as its usage is contingent to availability of appropriate technologies for military/communication purposes commercially. Different frequency bands have different characteristics for propagation of radio waves, which dictate its utilization for military/commercial purposes. The propagation characteristics are even influenced by the phenomenon of cosmic/man-made noises, terrain and varying climatic conditions.

An efficient, rationale and need-based use of spectrum is the hallmark of spectrum management, and the same can facilitate harmonious coexistence of defence and commercial interests.

The Wireless Planning Committee (WPC) under the Ministry of Communications (MoC) in the country plays the role of Spectrum Manager, while the Telecom Regulatory Authority of India (TRAI) plays the role of the national Regulatory Authority. Both these create a fine balance in meeting the strategic requirements of Defence/ Government agencies as well as the commercial requirements, both of which are in the nation's interests.

Background

The defence forces were holding majority of the spectrum until 2006. However, with the growing demand primarily for mobile telephony (especially 2G and 3G services) and digital TV broadcasting, a need was felt to offset Spectrum currently held with the defence forces for commercial use, which led to a review of the National Frequency Action Plan (NFAP). At the same time, to cater for the communication requirements of the Armed Forces, a dedicated Defence Band was identified and promulgated in 2015 wherein nine sub-bands were earmarked exclusively for defence use, while for the remaining 42 sub-bands, the defence forces were asked to coexist with other commercial users. The Defence Band in the EM spectrum is a prime resource and it needs to be judiciously managed for ensuring efficient and interference-free spectrum utilization for the Armed Forces.

5G services are further planned to be rolled out in the country and there might be a requirement for spectrum, presently earmarked for defence, to be considered to be released for commercial purposes, in the overall national interests. Defence preparedness is also equally important for safeguarding the sovereignty of the nation, which permits all such commercial activities to take place. Thus, there is a

need to reconcile both these requirements. The peculiar constraints of the Armed Forces, especially in so far as the long gestation period in fructification of defence procurements, needs to be factored into the deliberations. In view of the ongoing contest for spectrum allocation for commercial applications, it is necessary that defence must be prepared to optimally plan for utilization of the frequency spectrum allocated to them and that the present holding is being managed well in a judicious manner.

At the same time, the need for continued retention of the Defence Band needs to be viewed in the light of the strategic implications of defence operations and key reform initiatives being undertaken at the highest level. A holistic study is required to so that the defence forces are able to overcome the challenges of spectrum access constraints while continuing to deliver on the mandated task. There is also a requirement to be aware of the various spectrum regulating organisations at the global, regional and national levels and the processes that are followed, in order to better understand them. Knowledge regarding the RF spectrum allocation process in India is also essential to understand the criticality of spectrum. There is thus a need to put in place systems and procedures that, despite the peculiar constraints of the Armed Forces, are able to overcome the challenges of spectrum access constraints, while continuing to deliver on their mandated task.

Scope of the Study

Towards this end, the scope of the study is as follows:

(a) Analyse the EM spectrum and frequency spectrum requirements in different sub-bands of the EM spectrum and its utilization by the Armed Forces.

(b) Study the various Spectrum Regulating Organisations and Processes and get an overview of the RF spectrum allocation process in India.

(c) Analyse the Defence Band promulgated in 2015, the Spectrum Management for Armed Forces and examine the present and futuristic spectrum requirements of the three Services based on existing/future build-up of communication/surveillance infrastructure and weapon platforms.

(d) Recommend measures to ensure optimal utilisation of the Defence Band thus safeguarding defence frequency spectrum interests.

(e) Analyse the impact of the liberalised availability of spectrum on proliferation of social media and its effect on the Armed Forces.

Methodology Adopted

An in-depth study was carried out to understand the rationale on which a Defence Band was earmarked to bring out the interests of the Armed Forces in each of the sub-bands. This involved the study of literature pertaining to promulgation of the Defence Band and issues faced prior to it's its to gain an insight into the matter. An-in depth study of the various spectrum regulating organisations and processes was carried out. The evolution of the RF spectrum allocation process in India over the last two-and-a-half decades was studied. Thereafter, analysis of Defence Band was carried out and the Spectrum Mgt techniques and procedures being followed for Armed Forces were studied. The present and futuristic frequency requirements of the Armed Forces in various sub-bands was then compiled through the medium of responses to questionnaires and by data survey and seeking the views of Subject Matter Experts (SMEs). This also entailed analysis of the existing and projected frequency requirements based on various communication/ surveillance projects, which are used by/ being considered by the armed orces of certain nations.

In order to gain information for the study, interaction with the three Services HQs and with WPC and industry was carried out on a need-to-know basis, to understand the emerging commercial requirements that could infringe in Defence Spectrum interests. Certain recommendations to improve the usage of spectrum earmarked for the Defence Band and safeguard it were also deliberated upon in the end.

Conclusion

The spectrum has an associated economic value necessary for any nation-state to be able to leverage it and use the monetary gains for societal and development causes. There is going to be increased pressure from commercial players on the part of EM spectrum promulgated as the Defence Band. Thus, in order to be able to appreciate the defence spectrum requirement, which is a strategic need of the country, there is a requirement to understand the various spectrum-regulating organisations and processes and analyse the Spectrum Management (Mgt) techniques and procedures being followed. There is an urgent need to optimise the usage of the Defence Band by means of projecting for spectrum requirements to support both the present and future capacity build up of the Armed Forces.

2

EM Spectrum & Spectrum Requirements

Electromagnetic (EM) Spectrum

Electromagnetic spectrum is the entire distribution of electromagnetic radiation according to frequency or wavelength. Although all electromagnetic waves travel at the speed of light in a vacuum, they do so at a wide range of frequencies, wavelengths, and photon energies. The electromagnetic spectrum comprises the span of all electromagnetic radiation and consists of many sub-ranges, commonly referred to as portions, such as visible light or ultraviolet radiation. The various portions bear different names based on differences in behaviour in the emission, transmission, and absorption of the corresponding waves and based on their different practical applications. There are no precisely accepted boundaries between any of these contiguous portions, so the ranges tend to overlap.

Types of Electromagnetic Radiation

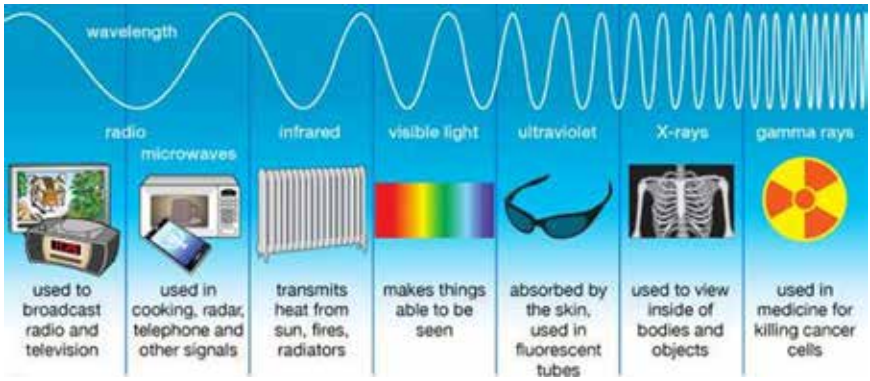


Figure 2.1: Types of Electromagnetic Radiation

The entire electromagnetic spectrum, from the lowest to the highest frequency (longest to shortest wavelength), includes all radio waves (e.g., commercial radio and television, microwaves, radar), infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays. Nearly all frequencies and wavelengths of electromagnetic radiation can be used for spectroscopy.

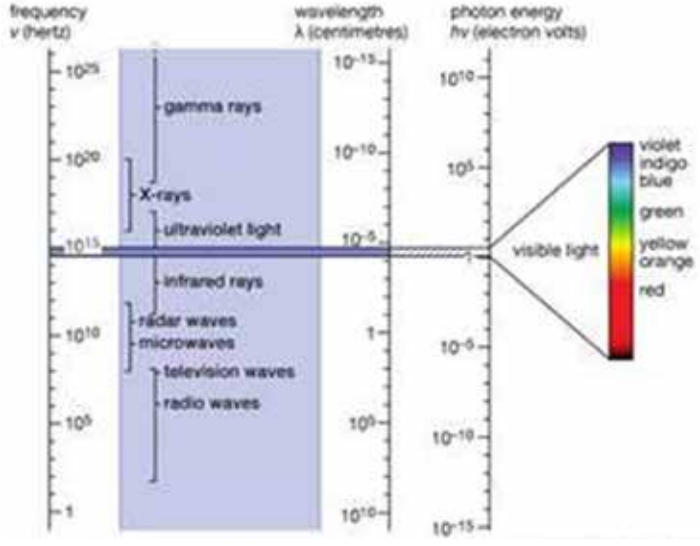


Figure 2.2: Frequency & Wavelength Distribution of EM Spectrum

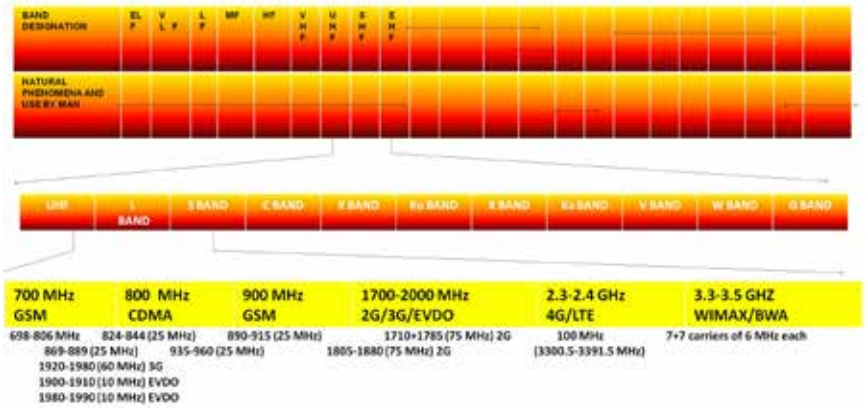


Figure 2.3: Utilisation Based Frequency Distribution

Spectrum Requirements in the Armed Forces

Communications in the Services can largely be categorised into Strategic and Tactical domains based on the level of formation supported. However, with increased digitisation and seamless information flow, traditional boundaries are being blurred and higher commanders continuously seek inputs pertaining to operations in the forward areas for better situational awareness and planning of future operations. In view of the changing scenario and with availability of better communication technologies, spectrum requirements of the Armed Forces in various sub-bands of the EM spectrum are evolving at a fast pace. As more and more systems are inducted, a seamless reliable grid needs to be established to network a wide variety of platforms like communication systems, surveillance devices and weapon systems. The spectrum requirements for the Armed Forces are discussed below:

(a) **Very Low Frequency (VLF) Band.** This band is utilised by the Navy for communication from shore-to-submarines submerged up to a certain depth, as water penetration of electromagnetic waves in this band is more. Because of high wavelength, only one-way communication is possible

in this band as submarines cannot carry large antenna systems required at larger wavelengths.

(b) **Medium Frequency (MF) Band. Defence use is limited to** homing devices like air navigation beacons. The requirement is likely to increase in the future as the same might be used for UAVs also and for other aerial platforms, the numbers of which would proliferate with 5G and Internet of Things (IoT).

(c) **High Frequency (HF) Band.** This band is highly important as it is utilised for both strategic and tactical communications by all the three Services. In peacetime, HF communication is restricted; however, it is likely to be extensively used during operations. The band is suitable for both voice and limited data communications at both short and long ranges and can be deployed as a backup at all levels.

(d) **Very High Frequency (VHF) Band.** The fixed as well as mobile communication systems of all the three Services are based in this band. Communication ranges in this band are constrained by the availability of Radio Line of Sight between the transmitter and the receiver and thus prone to screening due to terrain. Due to range limitations, communication in this band is limited to tactical domain and defence spectrum requirements are not likely to diminish in future. It is also used for navigation and air traffic control systems.

(e) **Ultra High Frequency (UHF) Band.** It is considered the most important band for the defence forces as the spectrum requirements of both existing and futuristic communication, surveillance and weapon systems exist in it. The band extends from 300 MHz to 3 Ghz and has a stringent line-of-sight requirement for communication.

UHF-based radio systems are deployed to establish communication in both strategic as well as tactical domains. The band is suitable for both fixed and mobile communications. Fixed stations are established generally as a backup or to cover voids in optical fibre-based communication links. Satellite communications in L Band (1 GHz – 2 GHz) and partially in S Band (2 GHz – 4 GHz) also exist which are critical for defence use. Links using UHF radios are less prone to weather and therefore more stable. Commercially, all 2/3/4 G communications are concentrated in this band; hence, the pressure on Defence to vacate it for commercial use is the maximum. Also, data links to airborne platforms like UAVs, drones and AWACS which are part of the country's future acquisition plan, are established in this band. Hence, there exists a need for deliberate and effective spectrum management to optimise usage by the Armed Forces in this band.

(f) **Super High Frequency (SHF) Band.** This band gained relevance owing to high bandwidth digital communication possible in it. Terrestrial communications links using Microwave communication technology over long ranges can be established in this band. Defence is already in a process of coordinating assignments for Project Network for Spectrum (NFS) in this band. Satellite communications in S, C X, Ku bands (sub-bands in SHF band) also exist. The defence requirements in this band are likely to further increase with the adoption of a network-centric approach to operations. Most modern radars designed in this band are likely to be deployed in the future as part of early warning systems.

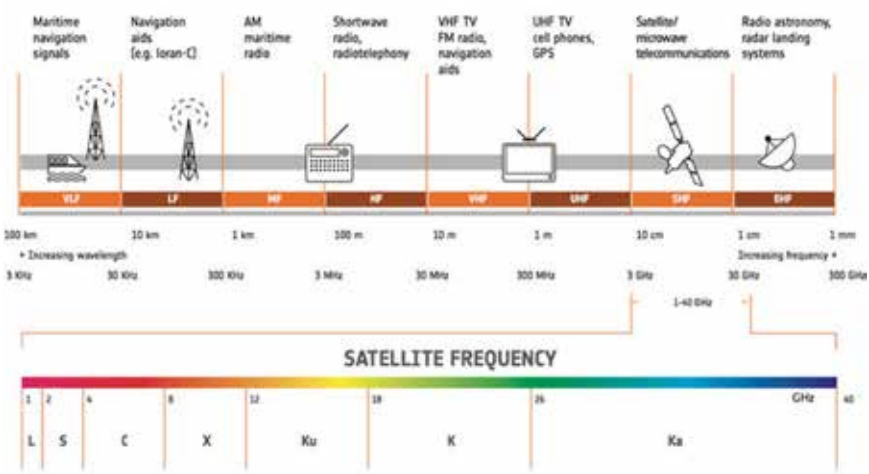


Figure 2.4: Utilisation of EM Spectrum

Drivers of Defence Spectrum Requirement

The Armed Forces have been mandated to defend the country from external forces and, in special cases, to carry out IS duties like in J&K and the Northeast. The frequency spectrum requirements are to support the operational capabilities of the forces, wherein communication technologies can be leveraged to even enhance the efficiency. Thus, envisaged drivers which aid identification of spectrum needs in respect of the Armed Forces are listed as under:

(a) **Mandate of the Armed Forces.** The present mandate and any perceived additional responsibilities in the future will dictate the operational capabilities and hence the spectrum needs. It however needs to be appreciated and understood that building defence capability is an on-going process and is not a toggle switch which can be switched on or off. There is thus a requirement to be always prepared for war and it is in this context that there is a need to earmark certain frequencies for use by defence. In addition, as equipment procurement is a time-bound process, it necessitates that from the time some equipment/weapon platforms be

identified or considered for being identified for use by the Armed Forces. An application for issue of a decision letter for allotment of the associated frequency spectrum required to gainfully operate this equipment must be forwarded through the concerned SHQ to JCES, HQ IDS.

(b) **Existing/Futuristic Communication Technologies.** Technology innovation can be leveraged to meet the enhanced bandwidth/range requirements hence optimising spectrum requirements. The flip side is that new technology innovations can lead to increased spectrum needs as in the case of proposed mobile ad-hoc networks.

(c) **Electronic Warfare.** The build-up of enemy EW infrastructure/capabilities will lead to an increase in spectrum needs in terms of the diverse equipment we use to avoid/work through jamming. For example, to communicate through jamming of own communications by the enemy during operations, one measure is to use Frequency Hopping sets, which increases the band of operation of a radio net and hence increases spectrum requirements.

(d) **Future Warfare Concept/Methodologies.** The proposed net-centric warfare/operations will necessitate seamless connectivity for sensors, shooters and commanders (decision makers). Inherently "Network-Centric" war is focused on achieving information superiority. It is the concept of activity management of groups of troops (forces), which increases their combat power by creating a unified information-switching network connecting the sensors (data sources), the decision-makers and implementers. It provides communication to the participants of action and necessary information about the situation and acceleration of the process of management of forces and resources.

Consequently, it increases the pace of operations and the effectiveness of an opponent. This has a direct connotation to the spectrum requirements in multiple bands.

(e) **Early Warning/Surveillance.** To gather as much information as early as possible, the Armed Forces need to rely on both air- as well as ground-based surveillance systems. Such systems impose not only heavy bandwidth requirements but the number of such systems likely to be deployed by the three Services in future shall dictate spectrum needs in a big way.

Safeguarding Defence Spectrum Requirements.

Defence spectrum requirements are evolving as per the ongoing modernisation of the Armed Forces. Since the economic value of the spectrum cannot be ignored, it is required that the requirement of the Armed Forces be articulated holistically. This is required to be carried out in the Defence Band also as today the spectrum for the Armed Forces is no longer a 'given' thing. The spectrum identified as the Defence Band is also subject to review for development and societal reasons. In order to identify spectrum needs, the following is recommended:

(a) Spectrum needs based on Long Term Acquisition Plan in respect of surveillance, communication and weapon platforms be formulated.

(b) Utilisation of Defence Band be maximised and at the same time additional spectrum requirements for futuristic modernization be projected to MoC through MoD at the earliest.

(c) Build-up of roadmap for achieving Net centricity.

(d) Development of software tools to ensure effective spectrum management at all levels.

(e) Identify communication technologies that optimise spectrum usage in terms of bandwidth and fall within the Defence Band.

(f) Re-use of spectrum at national and theatre levels.

(g) Analysis of National Telecom Policy and policy roadmap for digital India which can impact spectrum usage at the national level.

(h) Study of en EW capabilities to identify impact on own communication methodologies and overall spectrum requirement down to theatre level.

(j) Spectrum requirements are subject to change. Hence, we can identify spectrum dependent systems and then identify the spectrum based on the life cycle of the platform for which it is required.

Conclusion

The spectrum has an associated economic value necessary for any nation-state to be able to leverage it and use the monetary gains for societal and development causes. There is going to be increased pressure from commercial players on the EM spectrum promulgated as the Defence Band and hence needs to be safeguarded. Though the defence spectrum requirement is a strategic need of the country, it should not be taken for granted due to pressures from other sectors. There is an urgent need to optimise the usage of the Defence Band by means of projecting the requirement of spectrum needed to support both the present and future capacity build up of the Armed Forces.

NOTE: There are some numbers in square brackets in the text. If they are footnote numbers, they have to be in chronological order. Author to check and decide.

3

Spectrum Regulating Organisations and Processes

Introduction

Radio Frequency **(RF)** spectrum is a scarce limited natural resource wherein spectrum management and regulatory mechanisms are key elements for ensuring efficient and interference-free spectrum usage. RF spectrum transcends geographical and political boundaries; hence, coordination at the international level regarding the efficient, rationale and need-based use of spectrum is the hallmark of spectrum management. To achieve the same, there are certain organisations and processes for regulating spectrum at the global and regional levels. The Wireless Planning Committee **(WPC)** under the Ministry of Communications **(MoC)** in the country plays the role of Spectrum Manager while the TRAI plays the role of the Regulatory Authority, creating a fine balance in meeting the strategic requirements of Defence/Government agencies as well as commercial requirements, both of which are in nation's interest. It is thus imperative to have an understanding of the organisations and processes for regulating spectrum at global, regional and national levels, for optimal projection of spectrum requirements of the Armed Forces.

Historical Background.

By the middle of the 19th century, the telegraph was transforming communications across Europe and North America and extending its reach around the world. However, barriers could occur when a message had to cross from one national jurisdiction to another. To overcome this, agreements were made between countries. In 1865, 20 European states signed a treaty to harmonise telegraph services: this was the birth of the International Telecommunication Union **(ITU),** which last year celebrated 150 years. The ITU is based in Geneva, Switzerland. Today, the organisation is a United Nations' specialised agency for information and communication technologies. *Its members include 193 countries and it brings together more than 700 sector members and associates from industry/ private-sector companies, international and regional organisations, as well as more than 150 from academia.* **One of the ITU's most important tasks is to allocate and coordinate the global use of radio spectrum** and orbits for satellite use. A key part of this work is organising the World Radiocommunication Conference **(WRC)** every four years. The next one will take place in 2019. While the ITU itself has a long history, the WRC format was born in 1992. Prior to that, periodic World Administrative Radio Conferences **(WARCs)** were conducted to cover specific agendas concerning particular radio services. However, from 1992 onward, changes in the ITU constitution were made to convene regular conferences every three to four years. The change was made to keep up with rapid technological developments. This resulted in opening the door to new applications. Certain milestones [1] in this path were:

(a) 1865—20 European states sign a treaty to harmonise telegraph services

(b) 1992—WRC format is born

(c) 2015—ITU celebrates 150th-year anniversary

(d) 2019—The next WRC

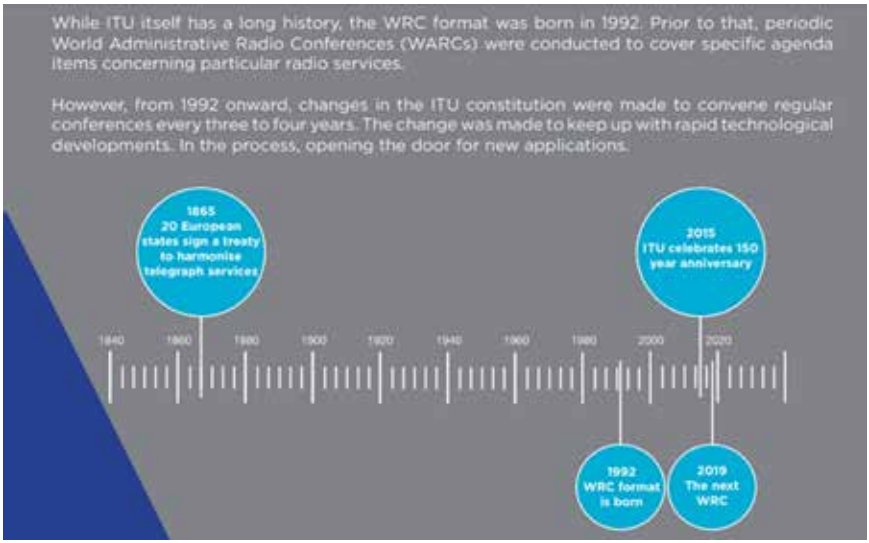


Figure 3.1 Important milestones in ITU

World Radio-communication Conferences (WRC)

World Radio-communication Conferences **(WRC)** are held every three to four years. It is the job of the WRC to review, and, if necessary, revise the Radio Regulations **(RR)**, the international treaty governing the use of the radio-frequency spectrum and the geostationary-satellite and non-geostationary satellite orbits[2]. Revisions are made based on an agenda determined by the ITU Council, which takes into account recommendations made by previous world radio-communication conferences. The general scope of the agenda of world radio-communication conferences is established four to six years in advance, with the final agenda set by the ITU Council two years before the conference, with the concurrence of a majority of Member-States. Under the terms of the ITU Constitution, a WRC can:

(a) Revise the RR and any associated frequency assignment and allotment plans;

(b) Address any Radio-communication matter of worldwide character;

(c) Instruct the Radio Regulations Board (RRB) and the Radio-communication Bureau, and review their activities;

(d) Determine questions for study by the Radio-communication Assembly and its study groups in preparation for future Radio-communication Conferences.

In essence, WRCs decide what and how spectrum and satellite orbits can be used by all radio-communication services, including mobile networks {or International Mobile Telecommunications **(IMT)**}. Favourable decisions regarding access to spectrum for mobile services help lay the groundwork for connecting millions more. For example, the World Radio-communication Conference 2015 (WRC-15) decided to make 700 MHz a globally harmonised band. This was a key step in making mobile broadband available to millions more.

On the basis of contributions from administrations, the Radio-communication Study Groups, and other sources (vide Article 19 of the Convention (Geneva, 1992)) concerning the regulatory, technical, operational and procedural matters to be considered by World and Regional Radio-communication Conferences, the Conference Preparatory Meeting **(CPM)** shall prepare a consolidated report to be used in support of the work of such conferences. WRCs are organized by the International Telecommunications Union **(ITU)**. These are held every 4-5 years for about 3-4 weeks and attended by over 3,000 delegates. It is job of the WRC to review and revise the Radio Regulations, the international treaty governing the use of the radio-frequency spectrum and satellite orbits.

Radio Regulations (RR). The Radio Regulations are the end product of the WRCs. They are international treaties that **are binding upon ITU member-states.** They define frequency allocations,

technical and regulatory conditions for use of spectrum by a given service. Procedures for coordination are included in the regulations, which helps ensure compatibility. The Radio Regulations help prevent and resolve cases of harmful interference.

The International Telecommunication Union (ITU)

The ITU was founded in 1865. It is an international organisation, an organ of the UNO, within which governments and the private sector coordinate global telecommunication networks and services. It has a General Secretariat and three wings or sectors which are:

(a) Radio-communication Sector **(ITU-R)** or (Secretariat BR), which looks into standardization and global spectrum management.

(b) Telecommunication Standardisation Sector **(ITU-T)** or (secretariat TSB) which addresses network and service aspects.

(c) Telecommunication Development Sector **(ITU-D)** or (secretariat BDT) which looks into assisting implementation and operation of telecommunications in developing countries.

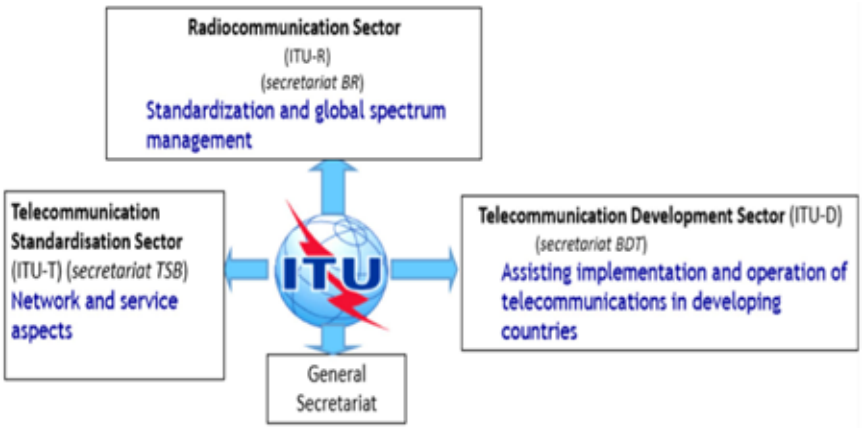


Figure 3.2: Structure of the International Telecommunication Union

ITU - World Radio Conferences Process

The WRCs are both the end of a cycle and the beginning of a new one. The agenda is decided at the previous conference together with a preliminary agenda for the subsequent one. It is open to as many issues as agreed upon by the participants. Here we take a look at the most important part of the preparation.[2]

The Conference Preparatory Meetings (CPM). The preparatory process starts and ends with a Conference Preparatory Meeting. They are there to make the decision-making at World Radiocommunication Conferences as informed as possible. The 'Final Report' of the CPM outlines options for supporting or opposing the various WRC agenda items under consideration. The CPM Management Team and CPM Steering Committee make sure that work goes according to plan. The first meeting takes place immediately following each WRC and the second about six months before the next conference. It goes without saying that the content of the Final Report plays a key role in what gets decided at the WRCs. For the World Radio-communication Conference 2019 (WRC-19) cycle, CPM19-1 was held in Geneva from 30 November to 01 December 2015. Participants from about 85 member-states and sector members met to organise and coordinate the conference preparatory studies for WRC-19. CPM19-2 will be held in 2019, before WRC-19.

These studies undertaken by ITU-R Study Groups serve as inputs for compiling the ITU-R Reports and Recommendations and for the CPM Report. In addition to this, there are Proposals (submitted by individual administrations or nations), Common Proposals (submitted by regional bodies) and the Directors Report. All serve as inputs to the WRC (World Radio Conference), where decision-making is arrived at by consensus. The Revised International Treaty (Radio Regulations) or RR is then published. The chart below gives the schematic description of the World Radio Conferences Process at the ITU. [1] [2]Studies on various topics are undertaken by ITU-R

Study Groups, which are listed as under and also explained pictorially at Figure 3.4:

(a) SG-1—Spectrum Management

(b) SG-3—Propagation

(c) SG-4—Satellites

(d) SG-5—-Terrestrial Services

(e) SG-6—Broadcasting

(f) SG-7—Science Services

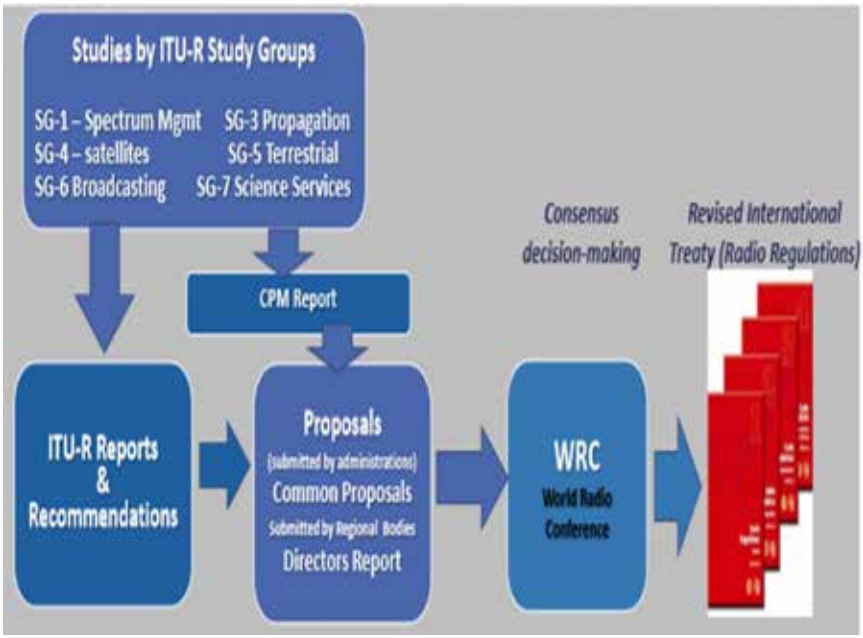


Figure 3.3: Description of the World Radio Conferences process at the ITU

ITU-R Technical Study Groups. The ITU-R Study Groups play a key role in the preparatory process. They guide the work done to prepare the technical bases for decisions at the WRCs. There are six groups that cover different areas.[3][4] According to the ITU, more than 4,000 specialists from administrations, the telecommunications

industry as a whole and academic organisations across the world, participate in the work done by these groups.

Figure 3.4: Scope and charter of various study groups

Study Group 5 (SG-5)

SG-5 focuses on Terrestrial Services and is **of special significance to the Armed Forces.** It is currently split into three Working Parties **(WPs)** and one Task Group **(TG).** WPs are regular parts of this study group, while the TGs are formed with a specific purpose. Once the task is completed, they are disbanded. TG 5/1 was formed to carry out studies on the WRC-19 agenda item 1.13, which considers mobile allocations for certain frequency bands above 24 GHz. The addition of mobile allocations for high spectrum bands will help increase speeds significantly, but short propagation makes them a challenging proposition. [3] [4] It may also improve the opportunity for sharing between different technologies.

The task group will conduct sharing and compatibility studies to see how well a mobile network in these bands could exist alongside, for example, satellites. Based on the studies, it will also write the section of the CPM report to provide technical basis on this important topic.

The group met for the first time in May 2016 to agree on a structure, develop a work plan and consider contributions. The structure is made up of four working groups that focus on different bands within the range covered by Agenda Item (AI) 1.13. To complete the work, TG 5/1 had met another three times in 2017 and once or twice in 2018.

Importance of Regional Bodies in WRC Process

The six regional groups (APT, ASMG, ATU, CEPT, CITEL and RCC) all play an important part in the work. ***For anyone who wants to influence the decisions made at the WRC, national and regional preparations are important.***[5] [6] Regional groups feed into the majority of the work completed ahead of each conference. These six regional bodies are:

(a) APT— Asia-Pacific Telecommunity

(b) ASMG—Arab Spectrum Management Group

(c) ATU—African Telecommunications

(d) CEPT—European Conference of Postal and Telecommunications Administrations

(e) CITEL—Inter-American Telecommunication Commission

(f) RCC—Regional Commonwealth in the field of Communications

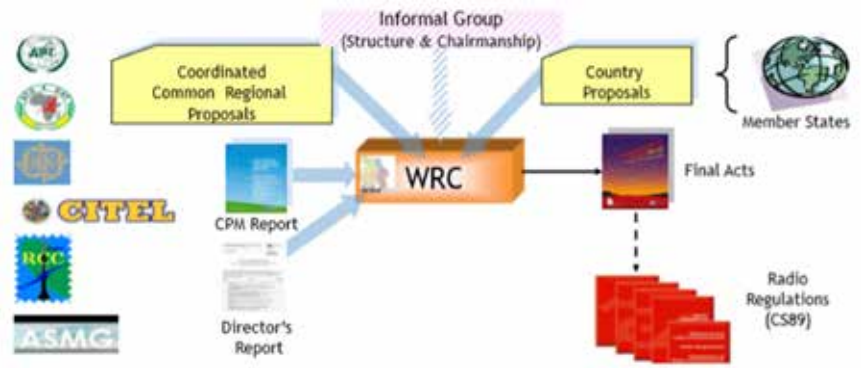


Figure 3.5: Role of regional bodies in WRC process

Regional Preparations: Asia-Pacific Telecommunity (APT)

15. APT has 38 Members (countries), 04 Associate Members and 137 Affiliate Members. The positions of the regional groups are informed by the work done at a national level. As regards India, the views of the **Indian administration** are put up to the APT and from there they are sent to the ITU.[5] [6] This is how Swedish regulator Post – och Telestyrelsen (PTS) presents its preparatory meetings on the organisation's website:

"Representatives from governments, businesses and organisations are all invited to participate, to submit information and views on the positions and proposals of each item on the WRC agenda. All interested parties are welcome to attend the meetings. The results of these meetings are used for developing Swedish positions and proposals for the European preparations. To sum up, here are three reasons why getting involved on a national basis, at an early stage, is a good idea:

- You can submit proposals via countries or to regional groups the latter of which tends to have a lot more weight than individual country proposals;
- You participate in national discussions with other stakeholders, making it easier to anticipate discussions at the ITU and regional groups; and
- At the end of the day, the **votes of individual countries determine the decisions at the WRC.** For industry participants, access to national delegations gives them a chance to influence national positions as well as to have "behind-the-scenes" discussions.

The ITU-R Inter-Regional Workshops. Another integral part of preparations ahead of the WRC is the Inter-Regional Workshops. Participants exchange views and hopefully obtain a better understanding of the common views, positions and/or proposals.[7]

Each WRC cycle includes workshops organised annually, with the last one taking place just before the conference.

National Level Organisations and Preparations

In India, the Wireless Planning and Coordination (WPC) Wing of MoC does the task of National Spectrum Manager. The WPC Wing of the Ministry of Communication (previously under the Ministry of Communication & Information Technology), created in 1952, is the national nodal agency of the Government of India and is responsible for planning, regulating, and managing the limited resources of Radio Frequency (RF) spectrum and associated satellite orbits, including geo-stationary satellite orbits as well as licensing of wireless stations in the country under the Indian Telegraph Act 1885 (ITA 1885) and the Indian Wireless Telegraphy Act 1933 (IWTA 1933), as statutory requirement.[8][9] It caters to the needs of all wireless users in the country, government or private, security or non-security. The WPC is also the national agency for all matters related to the radio communication sector of the International Telecommunication Union (ITU) and Asia-Pacific Tele community (APT) and is responsible for treaty obligations on behalf of the Government. The WPC is headed by a Wireless Advisor, who holds the rank of an Additional Secretary to the government and reports to the full-time Telecom Commission member in charge of Technology. Besides, various groups in WPC Wing headquarters, WPC has five Regional Licensing Offices working at Delhi (RLO-North), Mumbai (RLO-West), Chennai (RLO-South), Kolkata (RLO-East) and Guwahati (RLO-North East).18. There is also a sector regulator, the Telecommunications Regulatory Authority of India (TRAI), which is an independent regulatory body set up by the Government of India. Apart from tariff and quality of service regulation, the TRAI plays a recommendatory role to the policy maker, the DoT of the Government of India. It enables consultation with all concerned stakeholders on important policy issues including pricing and

methodology of assignment of spectrum and subsequently submits its recommendations either *suo moto* or at the request of the DoT. The TRAI also provides recommendations and tariff regulation for the Information and Broadcasting sector.[8][9] In many cases, there is a huge delay and even abandonment of recommendations by the policy maker.

The inputs to the WPC are provided by various government and private organisations that are using spectrum and from the industry. The major government organisations are Defence, Doordarshan, Airports Authority of India (AAI) and ISRO. The *Joint Communication Electronics Staff* ***(JCES)*** *in* ***HQ IDS*** *functions under the ICT Division of the Operations Branch of HQ IDS. JCES does the task of the Defence Spectrum Manager;* it takes inputs from the Service HQs **(SHQs)** and represents the interests of Defence to the WPC. The WPC schedules meetings of the National Preparatory Committee **(NPC)** on various issues under deliberation by the Working Parties **(WPs)** of Study Groups **(SGs)** of the ITU and National Working Groups **(NWGs)** are formed generally on the same lines as the WPs of the SGs at the ITU.[10] It is endeavoured to arrive at a consensus at the national level on the view to be presented on the said issue under deliberation. These inputs also serve as useful inputs for reviewing the NFAP when required. This national point of view is then presented at the regional forum to garner further support before being sent to the ITU. In certain circumstances, the national point of view of each administration (like that of India) may be sent directly to the ITU. In view of the long timelines and deliberate process, it is thus imperative that all stakeholders plan in advance and work accordingly to ensure that decisions favourable to their interest are taken at the ITU. The WRC Cycle [1][2][10] is depicted in Figure 3.6 below and the interaction with the WRC at the Regional/National level is depicted in Figure 3.7.

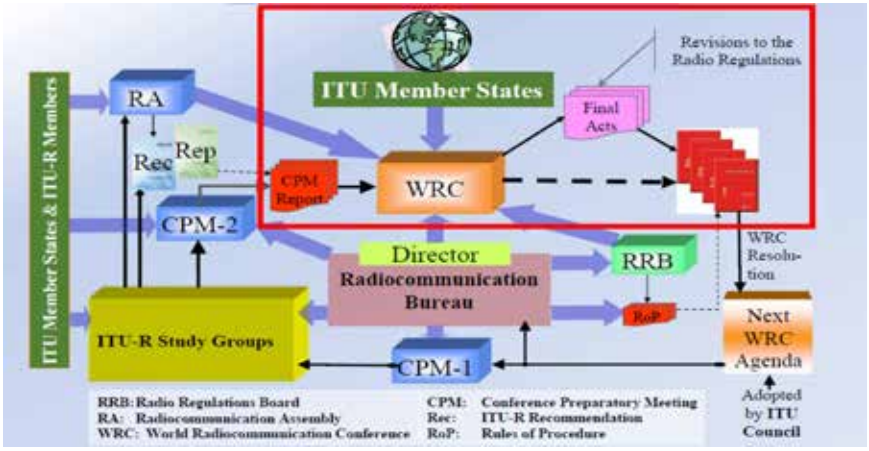


Figure 3.6: The WRC cycle

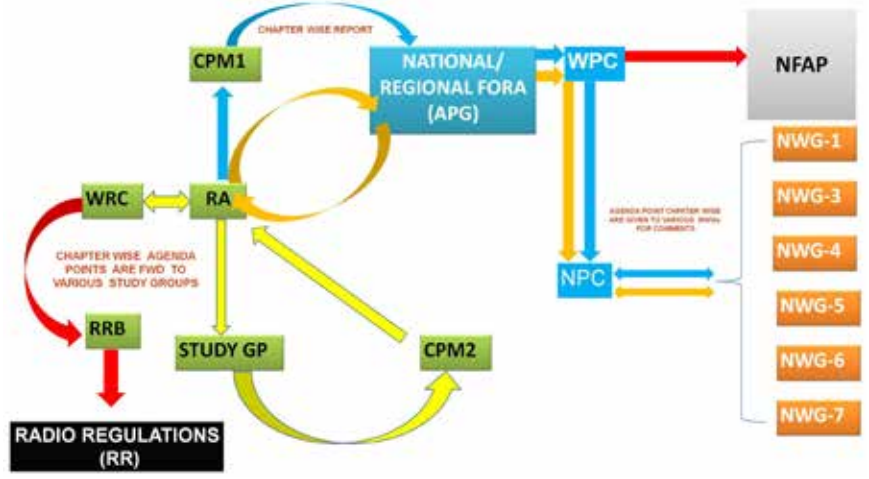


Figure 3.7: WRC & APG/ WPC interaction

Attending the WRC: How Decisions Are Taken

The pre-preparatory process is a means to an end; to get ready for the WRC meeting. The participating countries have four weeks to reach a consensus on the different agenda items. *To understand how WRC decisions are taken, it is important to understand the conference structure.* The structure as well as the chairmanships are discussed

within an **'informal group'** in the run up to the conference. Anyone can take part in this process, but usually people who are really involved in the process participate. It is called an 'informal group' because the participants express their views as individuals and not as representatives of a country.--

Conference Structure. The Chairs and Vice Chairs for the committees are proposed in this informal group based on factors such as background, experience and where the candidates are from, with a balance between different regions kept in mind. The 'informal group' produces a document that is discussed and approved with or without changes by the heads of the country delegations on the eve (usually a Sunday) of the conference. The chairman of the WRC is confirmed at this meeting together with the structure of the WRC. There are normally six committees, ranging from the Steering Committee chaired by the conference chair to others that deal with the agenda items, conference budget issues and credentials of the member-states.

The chairman of the conference is responsible for the outcome of the WRC and chairs the plenary. The actual WRC workload is divided among a number of committees and working groups. The Steering Committee coordinates all matters connected with the smooth execution. It plans the order and number of meetings. There are also committees that handle budget control and credentials. However, the most important ones are the committees that handle the actual agenda items. At WRC-15, there were three, with each one split into smaller working groups to handle the agenda items more efficiently. Keeping track of these is important because ***participating in working groups and committee meetings is the most effective method of influencing conference outcomes.***

Once the official structure has been decided, the main work of the WRC begins through the Working Groups, Sub-Working Groups **(SWGs)** and sometimes smaller Drafting Groups **(DGs);**

[3] the number growing larger as the Conference goes on. Weekends and evenings are largely forgotten. Industry lobbying groups, regional meetings and sub-regional meetings all take up time in a high-pressure month. Daily country delegation meetings each morning are crucial for coordination. Deals are done over coffee and in corridors as well as in the main meetings. Towards the end of the conference, the plenary meetings—full of thousands of people—go on late into the night; vital breaks in between them are used for rapid coordination between key countries to find vital harmonised consensus.

Reaching Consensus. Decisions are taken when consensus on an issue has been reached through a delicate balance of compromise by differing countries. Each agenda item is discussed by the working groups in order to bring differing views closer together. This is then brought through the committees until a balanced agreement has been reached. The final sign-off is given by the plenary. If a conference chair thinks a certain issue is especially complicated, he or she can decide to manage it directly by creating an ad-hoc group of the plenary. The starting point for discussion is the ***input documents from the six regional groups***, which is why it is so ***important to get involved in the regional preparations.*** If the influence is positive in this part of the decision-making process, a lot of the work is already done. In addition to regional documents, single countries or a group of countries can join forces to submit their own input. This is an opportunity for individual countries to make their voices heard, which is particularly significant if their views differ from the regional groups they participate in.

Private sector members and organisations can contribute information papers. The papers are also allowed to be presented at the conference, as long as the chair of the committee agrees to it. Again, the input documents are where the discussion to reach consensus starts. *At the conference, for each agenda item, each region appoints*

rapporteurs which present his or her region's take. On the sidelines, the regional groups negotiate and compromise on their respective positions. Member-states, supported by industry, work throughout the month to achieve harmony and consensus. This is vital to support many communications services, including mobile. Where differences remain, issues are escalated to higher level meetings. And while the end of the WRC is always a busy time trying to find a balanced consensus, the meetings have enjoyed high success rates in the past.

The 'Final Acts' are a record of the decisions taken at the WRC. They are made up of new and revised provisions of the Radio Regulations as well as the new and revised *Resolutions and Recommendations* approved by the conference. A few tips on how to succeed in reaching consensus, as listed in the ITU website, are as given below:

(a) *Advocate positions as much as possible at national and regional levels* before the conference;

(b) Find as much consensus as possible before the conference, and present that to regulators (as opposed to operators or vendors going to regulators individually);

(c) Familiarise yourself with the process and structure of the conference to make it easier to follow the agenda items;

(d) Know who you can ask for help on important issues;

(e) Keep track of who is on your side and even more importantly, who is not, on each issue; Getting to know the opposition and what can be offered is the key;

(f) Have fall-back positions ready if the optimum outcome cannot be reached;

(g) Do not assume that decisions are just rubber stamped by the plenary during the last couple of days; and

(h) Manage energy levels. The WRC is a marathon, not a sprint: prioritising is the key to a successful outcome.

Activities Post WRC

As important as Radio Regulations are, they are only the first step. **National Band Plans** are needed to **dictate how the frequencies can be used**. Spectrum is a finite resource essential for so many vital communication services, but it holds no value until its use is fuelled by investment. Timing is the key to a successful spectrum roll-out. Too slow, and the market cannot access the spectrum in a timely manner, and consumers will suffer. Too quick, and the ecosystem will not be ready and the financial investment will be difficult to manage for mobile operators. To help regulators and governments assign spectrum detailed by the radio regulations, the GSMA's Spectrum Group suggests a process by which this can happen. [1] [2][7] [10] The process is split into four steps:

(a) **Strategic Analysis.** The evolution of consumer and technology trends impacts spectrum requirements and needs to be taken into account when thinking about spectrum demands;

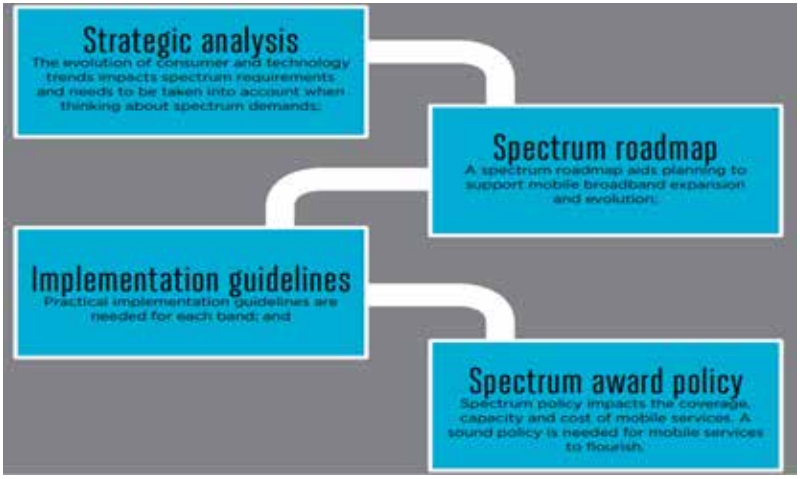


Figure 3.8: Suggested steps for evolution of national band plan

(b) **Spectrum Roadmap.** A spectrum roadmap aids planning to support mobile broadband expansion and evolution;

(c) **Implementation Guidelines.** Practical implementation guidelines are needed for each band; and

(d) **Spectrum Award Policy.** Spectrum policy impacts the coverage, capacity and cost of mobile services. A sound policy is needed for mobile services to flourish.

Importance of WRCs

Rapidly increasing data usage is putting pressure on spectrum availability; thus planning is needed to make sure we have sufficient spectrum for the future. The outcome of the WRC is the single-most important factor determining the future availability of spectrum. The ***WRC will make decisions on how spectrum is used during the next couple of decades***. Spectrum identified at the WRC will not become available immediately. In some cases, its commercial use has taken ten years or more. Where countries have an IMT/mobile broadband identification, its use is optional. However, countries should make efforts to give themselves that flexibility by identifying those bands for IMT use, **after safeguarding the essential services impinging on the security** and sovereignty of the nation. To the extent possible, governments/national stakeholders in the WRC process should try to ensure the mobile industry in their country is supported to maximise broadband, ICT and thus economic growth and leverage and to enhance the modernisation of its Armed Forces.

World Radio Conference 2019 (WRC-19)

WRC-19 will be held at Sharm-al-Sheikh In Egypt from October 28, 2019, to November 22, 2019. It is expected to be attended by over 3,500 regulators, ministers and wireless Industry leaders from around the world. A strong Indian participation, estimated at over 20-30 delegates from industry and government is expected to

participate in the WRC-19. ***The same must have representation from the Defence also***. The final preparatory meeting for the conference was held in Geneva, Switzerland from 18-28 February, 2019, which finalized the CPM report. The Asia-Pacific Telecommunity held its 4th preparatory meeting in Busan, Korea, from 7 to 12 January 2019 to update the APT preliminary views and also propose changes to the draft CPM report. The WRC-19 preparation milestones[7] [10] and the WRC-19 Preparatory Activities in Asia Pacific by APT are as shown below:

Figure 3.9: WRC-19 preparation milestones

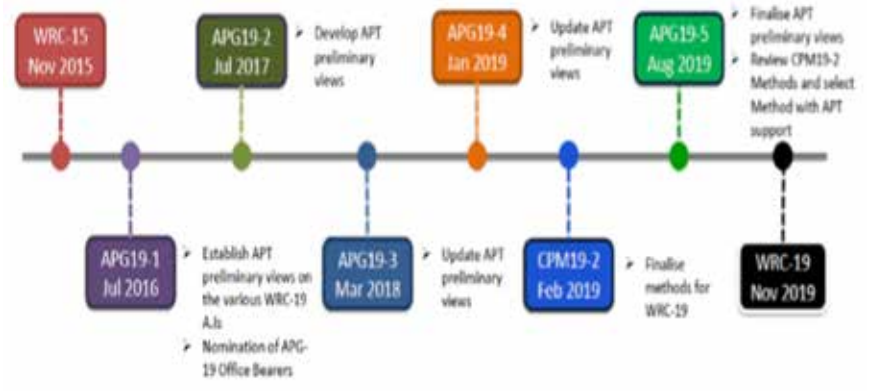


Figure 3.10: WRC-19 preparatory activities in Asia-Pacific by APT

Key Issues For WRC-19. Though there are over 30 agenda items in the CPM report submitted for WRC- 19, the important issues for the conference are listed as under:

(a) Spectrum for 5G in mm wave bands above 24 GHz band.

(b) Spectrum for *Earth Stations in Motion* **(ESIM)** on board ships, aircraft, trains, etc.

(c) Global Aeronautical and Maritime Distress and Safety Systems **(GAMDSS).**

(d) Additional 5 GHz spectrum for WiFi.

(e) Spectrum for Met satellite and Earth Exploration-satellite services in 400 MHz.

(f) Maritime Mobile-Satellite Service **(MSS)** allocations for VHF data exchange systems.

(g) Spectrum needs for Telemetry, Tracking & Command **(TT&C)** in space operations.

(h) Spectrum requirements for High-Altitude Platform Stations **(HAPS).**

Structure of the CPM report to WRC-19. The CPM report Includes a summary of the studies and methods to resolve each of the 30 agenda items. [2][7] [10] The CPM report is structured in six chapters as listed below:

Ser No	Chapters of draft CPM report	WRC-19 Agenda Items
(a)	Land , Mobile and Fixed Services	1.11,1.12,1.14,1.15
(b)	Broadband applications in the mobile service	1.13,1.16, 9.1 (9.1.1, 9.1.5 and 9.1.8)
(c)	Satellite services	1.4, 1.5, 1.6 & 7 9.1 (9.1.2, 9.13 and 9.1.9)
(d)	Science Services	1.2, 1.3, 1.7
(e)	Maritime, Aeronautical and Amateur services	1.1, 1.8, 1.9.1 and 1.9.2 1.10, 9.1 (9.14)
(f)	General Issues	2.4, 9.1 (9.1.6, 9.1.7), 10

Conclusion

The defence forces were holding the majority of the spectrum till 2006. However, with the growing demand primarily for mobile telephony (especially 2G and 3G services) and digital TV broadcast, a need was felt to offset Spectrum currently held with the defence forces for commercial use which led to a review of the National Frequency Action Plan (NFAP). The defence spectrum requirement needs to be judiciously managed and aligned at the national, regional and global levels, for ensuring efficient and interference- free spectrum utilisation. In view of the ongoing contest for spectrum allocation for commercial applications, it is necessary that defence must be aware of and have an understanding of the organisations and processes for regulating spectrum at the global, regional and national levels and all the ***Indian delegations for WRC and APG, must have representation from the Defence also,*** to ensure optimal projection of the spectrum requirements of the Armed Forces .

4

RF Spectrum Allocation Process in India

"India may be one of the world's biggest telecom success stories, but when it comes to quality of service, its mobile-telephony sector portrays a picture which is on the path to maturity. Despite billions of dollars of investments over the past decade, the world's fastest-growing telecom market is still grappling with inadequate infrastructure at certain rural locations. Added to this are the tariff wars among the Telcos, which have adversely affected their financials.

Introduction

Radio frequency spectrum is a limited natural resource. The word 'Spectrum' basically refers to a collection of various types of electromagnetic radiations of different wavelengths. In India, allocation of spectrum to various services has been given in NFAP which covers frequency ranges from 9kHz to 3000 GHz and are being used for different types of services like fixed communication, mobile communication, broadcasting, radio navigation, radio-location, fixed and mobile satellite service, aeronautical satellite service, radio navigational satellite service, etc. Some of the important and typical characteristics of the radio frequency spectrum are:

(a) Radio frequency spectrum does not respect international geographical boundaries as it is spread over a large terrestrial area.

(b) Use of radio frequency spectrum is susceptible to overlapping interference and requires the application of complex engineering tools to ensure interference-free operation of various wireless networks.

(c) Unlike other natural resources, radio frequency spectrum is not consumed upon its usage. It is wasted whenever it is not used optimally and efficiently. Radio frequency spectrum usage is therefore to be shared amongst the various radio services and must be used efficiently, optimally and economically in conformity with the provisions of national and international laws.

(d) The limitation of the radio frequency spectrum is mainly due to the following factors:

  (i) Propagation characteristics of different types of radio waves.

  (ii) Availability of technology and equipment for different types of radio frequency spectrum applications.

  (iii) The suitability of frequency bands for specific applications.

Spectrum Management at International and Regional Level

All nations share the electromagnetic spectrum and reserve their right to its unlimited use. However, for international telecommunications, cooperation to support trade, transportation, communications, and mutual protection against interference, they have agreed to an International Telecommunications Convention. This serves as the basic instrument of the *International Telecommunications Union*

(**ITU**) and its supporting bodies. The United Nations recognizes the ITU as the specialized agency in the telecommunications field. The ITU maintains cooperation to improve all telecommunications. It allocates the international radio frequency (RF) spectrum, registers frequency assignments, and coordinates resolving interference. Upon ratification by member-nations, **ITU regulations have treaty status**. Each ITU member-nation imposes regulatory measures within its administration. These measures must comply with the current Radio Regulations (RR) unless expressly excluded either by footnotes or by special arrangements.

The ITU Organization

The Plenipotentiary Conference is the supreme agency of the ITU. It formulates general policies, establishes budgetary guidelines, elects members, and concludes agreements between the ITU and other international communications organizations. It has three organizations: the *World Radio Conference* **(WRC)**, the *International Frequency Registration Board* **(IFRB)**, and the *International Radio Consultative Committee* **(CCIR)**.

WRC may deal with all the radio communications services, or it may deal with specific radio communications services such as space, maritime, or aeronautical. Each WRC updates the *Radio Regulations* **(RRs)** which allocate radio spectrum use on a worldwide basis except where regional requirements differ and are agreed. Figure 4.1 shows the three recognized regions.

In addition, the tropical area centred on the equator has additional provisions to offset its higher electrical noise.

The IFRB records ITU member-nation frequency assignments. It advises the WRCs and member-nations on technical matters on harmful interference and radio spectrum use. The IFRB serves as the office of record of frequency assignments in priority and adjudicates interference conflicts among member-nations. The CCIR provides

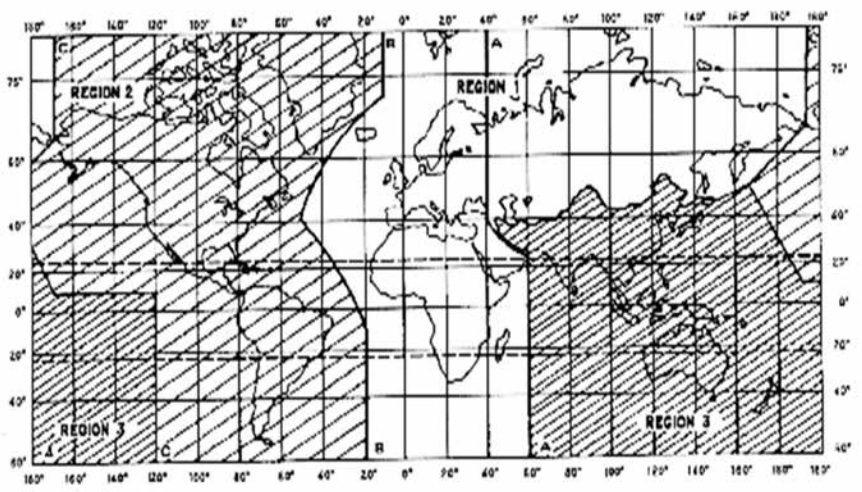


Figure 4.1: The three recognized regions as per ITU

technical criteria on frequency sharing and examines technical and operational questions about international radio use. It also addresses technically related questions pertinent to ITU member-nations and forthcoming WRCs. The findings of the CCIR serve a significant influence on the state-of-the-art and as a basis for RRs. However, these findings are recommendations rather than having an obligatory treaty status.

Spectrum Management at Regional Level: Asia Pacific Telecommunity (APT)

The APT is an organisation of governments, telecom service providers, manufacturers of communication equipment, research and development organisations and other stakeholders active in the field of communication and information technology and serves as the focal organisation for communication and information technology in the Asia Pacific region. The APT now has 38 Members, 04 Associate Members and 137 Affiliate Members. Throughout the years, the APT has been able to help members in their preparation for global conferences such as the *World Telecommunication Development*

Conference (WTDC), WRC, World Summit on Information Technology (WSIS), and the ITU meetings as well as promoting regional harmonization for these events. The *APT Conference Preparatory Group for WRC* (APG) is an important activity of the APT. The APG was started in 1996 with the objective of harmonizing views and developing common proposals from the Asia-Pacific region for the World Radio Conference (WRC). The main objective of the APG is to take regional preparation to harmonize the views of the members and to develop common proposals for submission to the ITU World Radio Conference (WRC).

Spectrum Management at National Level

The *Wireless Planning & Coordination* **(WPC)** Wing of the Ministry of Communications, created in 1952, is the National Radio Regulatory Authority responsible for Frequency Spectrum Management, including licensing, and caters to the needs of all wireless users (government and private) in the country. It exercises the statutory functions of the Central Government and issues licenses to establish, maintain and operate wireless stations. It is divided into major sections like *Licensing and Regulation* **(LR)**, *New Technology Group* **(NTG)** and *Standing Advisory Committee on Radio Frequency Allocation* **(SACFA)**. SACFA makes the recommendations on major frequency allocation issues, formulates frequency allocation plans, makes recommendations on the various issues related to International Telecom Union (ITU), sorts out problems referred to the committee by various wireless users, provides site clearance of all wireless installations in the country, etc. Figure 4.2 shows all the uses of radio spectrum that are managed by services. Exceptions to these allocations may be footnotes for specific countries or reservations made by that country at the WRCs.

The *Telecommunication Regulatory Authority of India* **(TRAI)** was set up by an Act of Parliament in 1997. It acts as an independent

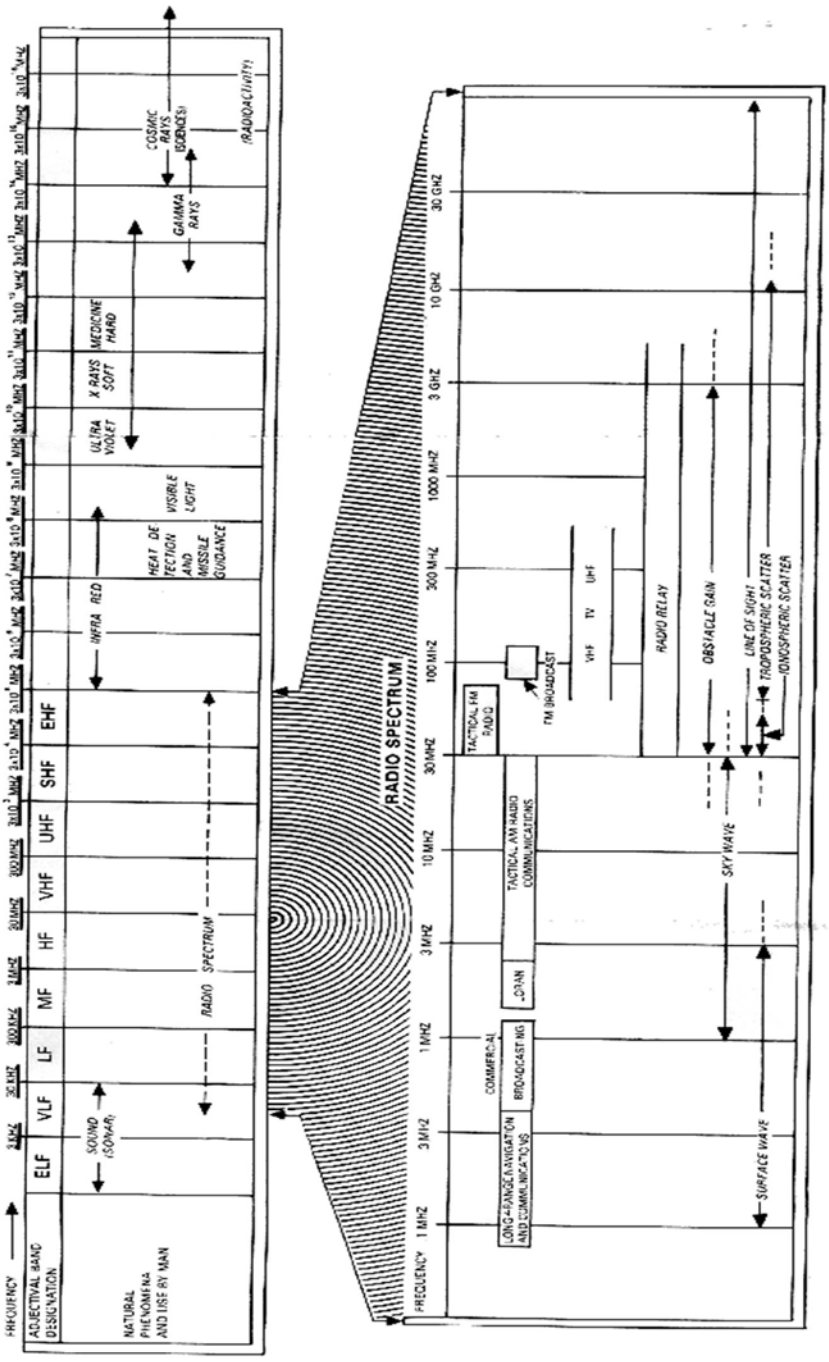


Figure 4.2: The uses of radio spectrum that are managed by services

regulator of the business of telecommunications in the country. Its mission is to create and nurture such conditions that encourage the growth of the telecommunications sector in India so that the country can play an important role in the world telecommunications society. The main objective of TRAI is to form a transparent and fair policy environment that encourages fair competition. The Authority recommends the timing and need for the introduction of a service provider that is new, ensures successful inter-connection and technical compatibility between various service providers, and suggests the conditions and terms on which licences would be provided to a service provider.

National Frequency Allocation Plan

The *National Frequency Allocation Plan* **(NFAP)** forms the basis for development and manufacturing of wireless equipment and spectrum utilization in the country. It contains the service options in various frequency bands for India and also provides the channelling plan in different bands. Some of the typical frequency bands allocated for certain types of radio services in India in various areas are as given below:

Sr. No	Radio Service	Frequency Band
	Radio Navigation	9 – 14 KHz
	Mobile (Distress & Calling)	495 – 505 KHz
	Broadcasting	526.5 – 1606.5 KHz
	Maritime Mobile	2065 – 2107 KHz 2170–2178.5 KHz 2190.5 – 2194 KHz
	Fixed, Mobile, Broadcasting Radio Astronomy	610 – 806 MHz
	Mobile, Fixed, Broadcasting	890 – 960 MHz
	Mobile Satellite	942 – 960 MHz
	Radio Location	1350 – 1400 MHz
	Mobile, Fixed, Space operation, Space research	1710 – 1930 MHz

Table 4.1: Frequency bands allocated for certain types of radio services In India

Spectrum And Mobile Telephone Services

Mobile telephone service providers in India use GSM and CDMA technologies. GSM technology works in the frequency bands of 900 and 1800 MHz and CDMA technology works in the 800 MHz band. 800, 900 and 1800 MHz bands were earlier allotted to the defence services for their mobile communication usage. However, upon the launch of mobile communication services for the public, coordination was sought from the Ministry of Defence **(MoD)** to make the spectrum available for mobile services. Since mobile communication technologies provide international roaming facilities, it is essential to allocate spectrum in the common bands which are being used the world over. Also, the mobile handsets being used is imported hence conform to the GSM 900/1800 bands. If radio frequencies are allotted in other bands then handsets will not be compatible with it and new handsets will have to be developed which will be costlier leading to a rise in the cost of mobile communication services.

Initially, as per global norms, **35 MHz** spectrum in 900 MHz band (880–915 /925–960 MHz) and **75 MHz** in the 1800 MHz band (1710–1785/1805–1880 MHz) was earmarked for Cellular (GSM) services. However, in India, the 900 MHz and 1800 MHz bands were being used by Defence for their operational use. Hence in India, only 25 MHz was opened up in the 900 MHz band and in that portion also , government agencies were using 4-5 MHz of the said band (for example, for railway train safety systems). The minimum amount of spectrum required for launching GSM services is 2 x 4.4 MHz for TDMA having a carrier of 200KHz. 1.8 MHz and it was added on to meet the additional requirement of spectrum by Telecom Service Providers (**TSPs**) (without paying any additional amount). This brought the total requirement of spectrum for each operator to 6.2 MHz (4.4+ 1.8) for launching cellular (GSM) services with TDMA. So effectively, only three (03) telecom operators could be adjusted in this band with 6.2 MHz each being assigned to each

of them. Later, in 2001, when the requirement for introducing a fourth telecom operator was felt, at that time DoT again approached Defence for spectrum in the 1800 MHz band. The Ministry of Defence then decided to vacate some spectrum in the 1800 MHz band to accommodate the fourth telecom operator. This spectrum was however vacated in small parts by Defence and auctioned to the fourth operator by DoT, as and when spectrum was available. The value of the spectrum varied for each telecom circle but the overall average value at that time was Rs. 1,658 crore for 6.2 MHz or Rs. 267 crore per MHz.

A CDMA carrier requires 1.23 MHz (30 KHz X 41 = 1.23 MHz). A gap of 300 KHz or 600KHz is also required to cater for if two carriers or four carriers are together. For wide bandwidth, normally four carriers are taken together. For CDMA services, 20 MHz spectrum in the 800 MHz band (824–844/869–889 MHz) was available. In this 20 + 20 MHz spectrum, 14 CDMA carriers of nominal 1.23 MHz each (or of 1.25 MHz each, considering the gap bandwidth) are possible for assignment to service providers. Spectrum for the roll-out of 3G services (voice, data and video) was to be allotted through e- auction in the 2.1 GHz (1920–1980 /2110–2170 MHz) band. However, the spectrum required for the launch of 3G services was at that time yet to be vacated by the Defence Services. The Defence Ministry had agreed to a spectrum vacation timetable. The Ministry of Defence (MoD) then signed a memorandum of understanding **(MoU)** with the Ministry of Communication & IT **(MoC&IT)**, agreeing to vacate spectrum needed for 2G and 3G licensees over a three-year period. The defence forces agreed to initially release 10MHz of spectrum suitable for 3G services, and a further 5MHz for 2G services with immediate effect. The MoD agreed to subsequently release the remainder of its spectrum in a phased manner upon completion of a fibre-optic network (called Network for Spectrum or **NFS**), being built for it, by the state-owned Bharat Sanchar Nigam Ltd (BSNL)

and the Mahanagar Telephone Nigam Ltd (MTNL). For the new network, these two telcos were required to install around 40,000 km of Core Network and 20,000 km of Access Network of fibre-optic cable, connecting 219 Army stations, 33 Navy stations and 162 Air Force stations across the country.

Spectrum Allotment Procedure

SN	Telecom Circle Name	Circle Type
1	Delhi Metro Telecom Circle	Metro
2	Mumbai Metro Telecom Circle	Metro
3	Kolkata Metro Telecom Circle	Metro
4	Gujarat Telecom Circle	A
5	Karnataka Telecom Circle	A
6	Tamil Nadu Telecom Circle	A
7	Andhra Pradesh Telecom Circle	A
8	Maharashtra Telecom Circle	A
9	Haryana Telecom Circle	B
10	Punjab Telecom Circle	B
11	Kerala Telecom Circle	B
12	Rajasthan Telecom Circle	B
13	West Bengal Telecom Circle	B
14	Uttar Pradesh (West) Telecom Circle	B
15	Madhya Pradesh Telecom Circle	B
16	Uttar Pradesh (East) Telecom Circle	B
17	Bihar Telecom Circle	C
18	Northeast Telecom Circle	C
19	Assam Telecom Circle	C
20	Orissa Telecom Circle	C
21	Himachal Pradesh Telecom Circle	C
22	Jammu & Kashmir Telecom Circle	C

Figure 4.3: The 22 telecom circles in India

(**Note:** Goa, Andaman and Nicobar Islands and Lakshadweep Islands are, respectively, parts of Maharashtra, West Bengal and Kerala Telecom Circles)

Any telecom company that wants to offer services in any of the 22 telecom circles in India, as explained in Figure 4.3 above, must purchase a **Unified Access Services Licence (UASL)** to operate in that circle. **ASL** was converted to Universal **Licence (UL)** after the

2012 Supreme Court decision on the 2G fraud delinked spectrum from licences. The UAS, introduced in November 2003, is valid for a period of 20 years, which can be extended by an additional 10 years once, per licence per circle. [11] As per the earlier policy, a mobile network operator who was awarded a licence to operate in any of the 22 telecom circles in India was allocated frequencies in that circle for a fixed period. After the expiry of the licence, the company was required to bid again to renew the licence. Only in certain cases were licences awarded Until **Further Notice (UFN)**. The new telecom policy was announced by the Government in 2011. As a result, when an operator renews its licence, it must also pay separately for spectrum. [12] The NTP 2011 has since been replaced by the National Digital Communication Policy **(NDCP)** of 2018.

Spectrum auction *in the real sense* was carried out only in 2010. Prior to that, only licenses were auctioned (until 2001), with spectrum bundled with it. Thus, it can be said that the *first telecom spectrum auction in India was held in 1994*. As per industry experts, this auction was a *beauty contest* as various telcos displayed their portfolios and offerings for rolling out cellular services in the country. Auctions were held again in 1997, 2000 and 2001. Spectrum in the 900MHz band was auctioned in all these years except in 2001. In 2001, the licence was bundled with 2x4.4 MHz of spectrum in 1800 MHz band. It can thus be said that the 1800 MHz band spectrum was auctioned for the first time in 2001. Following the 2001 auction, the Government abandoned the practice of auctions in favour of an administrative allocation model. The larger aim was possibly to develop India's telecom infrastructure. [13] The final allocation of 900 MHz took place in 2004, through the new model. This policy resulted in spectrum being allocated at far lower prices than had been done through auctions.

Thus in the case of licensed telecom service providers, spectrum was initially allotted in accordance with the relevant provisions of

the service licence agreements. Initially, the Government promoted additional free spectrum if TSPs could achieve a certain target number of subscribers However, due to an exponential increase in the number of mobile subscribers, additional spectrum was required by the mobile operators. Serving a larger number of subscribers requires either a larger amount of spectrum or an increase in the number of base stations. Therefore, additional spectrum is required at some stage as a techno-economic solution to meet the growth of mobile services. The Department of Telecommunications had evolved guidelines for the allotment of extra spectrum, based on the justification and fulfilment of the prescribed criteria. The subscriber-based criteria have been formulated taking into account the demographic characteristics of different categories of service areas, average traffic per subscriber, number of base stations in a specified area, etc. Spectrum is allotted subject to completion of coordination and availability at a particular location. The utilisation of spectrum for commercial purposes began with the release of a limited amount of spectrum in 1994 and later in1995.

The first auction was held in 1994. The government divided the country into 23 telecom circles (*subsequently reduced to 22 telecom circles, as at present*) and awarded licences and spectrum to two operators per circle. In the **four** metro circles—Chennai, Delhi, Kolkata and Mumbai—the DoT fixed several prerequisites for potential bidders in order to participate in the auction. (Chennai metro circle has since been merged into the Tamil Nadu telecom circle). The criteria included financial resources, reliability, and investment in research, as well as specific details such as rate of network rollout, pricing, quality, and competitiveness. [14]. The management of spectrum in the country until 2007-2008 can thus be divided into the following four stages, as brought out in the succeeding paragraphs.

First Stage – Auctioning Scarce Spectrum (1995-2003)

The Indian Government auctioned licences with a 2×4.4 MHz of start-up spectrum from the 900MHz band Global Systems for Mobile (GSM) based mobile services in 1995, for the remaining 19 telecom circles (except the 04 Metro Circles). Two operators were selected for each **Licence Service Area (LSA)**. The Government possibly assumed that no Indian company at that time had the financial resources and technical knowledge to provide large-scale mobile services. Thus, in these circles, the Government required that all potential bidders have a foreign partner in order to be eligible. [24] [25]. However, one firm was awarded multiple licences. Thus, besides raising concerns about the possibility of a monopoly if a single company secured multiple licenses, the process exposed unforeseen problems with the design and rules of the auction. The auction rules were altered to prohibit a single company from operating in more than three circles. The auction for the 900 Mhz band was held again under the new rules. [24]

Service Area	**Subscriber base* (in lakhs) supported by GSM spectrum in MHz. (eligibility for allotment of next step)**										
	2X 4.4	2X 6.2	2X 7.2	2X 8.2	2X 9.2	2X 10.2	2X 11.2	2X 12.2	2X 13.2	2X 14.2	2x 15 @
Metro Service Areas	5	15	18	21	26	32	40	48	57	65	
Telecom Circles as Service Area Category 'A' & B	8	30	41	53	68	82	90	98	107	116	
Category 'C' Circles	6	20	31	42	52	62	70	78	87	96	

Table 4.2: Subscriber base (in lakhs) supported by GSM spectrum in MHz*

During the spectrum auctions which were held again in 1997 and 2000, state-owned operators MTNL and BSNL were both allocated 2 × 4.4 MHz of start-up spectrum in the 900 MHz band to commence GSM services.[24]. Thus, the third operator licence was awarded along with 2 × 4.4 MHz of start-up spectrum in the 900 MHz band. The fourth operator licence was issued in 2001 using a three-stage auction procedure [14]and a start-up spectrum of 2 × 4.4 MHz in 1800 MHz was given to the winning bidder. In addition to the entry fees, licensees were required to pay a percentage of annual revenue as spectrum charges.

Further allocation of spectrum beyond the start-up spectrum levels was based on availability and justification and attracted additional revenue share as spectrum charges. The contractual rights of spectrum holders were incrementally established through a series of government orders. In 2002, the subscriber-linked spectrum allotment procedure referred to as **Subscriber Based Norms (SBN)** was introduced, which laid down a road map up to allotment of 2 × 12.5 MHz of spectrum per operator in each LSA.

Second Stage – Wireless in Local Loop (WLL)(2003-06)

During 2000-01, the government also liberalised the **Basic Telecom Services (BTS)** market, which provided traditional landline based services. In 2000, BTS operators approached the Government with a proposal to provide *Local Access Loop* (or Wireless in Local Loop or **WLL** as it was popularly referred to) at a much lower cost using the alternative **Code Division Multiple Access (CDMA)** wireless technology. After a couple of years of litigation between the BTS and GSM mobile operators, the Indian Government announced **Unified Access Service (UAS)** licences in November 2003 that allowed basic service licence holders to provide full mobility based services with a stipulated entry fee based on the bid price paid by the fourth operator in 2001. The fixed fee based licence (as opposed to auction based) theoretically allowed any number of mobile licences to be provided

and implicitly de-linked spectrum allocation from licensing. Though firms were awarded licences after paying the required entry fee, they were given start-up spectrum only as and when available. Following the entry of two or three CDMA-based mobile operators in each LSA, one or two new firms also paid the stipulated entry fee and got licences to operate GSM services in certain LSAs.

In 2005, the Telecommunications Regulatory Authority of India **(TRAI)** reviewed the spectrum allocation process taking into account spectrum availability and efficient techniques for utilisation of assigned spectrum. The TRAI stated that the spectrum held by the GSM and CDMA operators was well below international averages. (This could possibly have been the reason for the drop in quality of services at times). It was recommended that existing operators be given adequate spectrum before considering allocating spectrum to new service providers especially since "there is adequate competition in almost all service areas". TRAI continued to maintain that there was a shortage of 2G spectrum. The entitlement of incumbents naturally extended to future 3G spectrum since in a spectrum-scarce environment, 3G could be considered as an extension of 2G[1]. It also followed that the scarce resource of spectrum need not be spread too thin. Table 4.3 shows the revised subscriber base* (in lakhs) supported by CDMA Spectrum in MHz.

Service Area	**Subscriber base * (in lakhs) supported by CDMA spectrum in MHz. (eligibility for allotment of next step)**				
	2X2.5 MHz (2 carriers)	2X3.75 MHz (3 carriers)	2X5 MHz (4 carriers)	2X6.25 MHz (5 carriers)	2X7.5 MHz (6 carriers) @
Metro Service Areas	5	20	30	50	
Telecom Circles as Service Area for Category 'A' and 'B' circles	8	50	80	100	

Service Area	Subscriber base * (in lakhs) supported by CDMA spectrum in MHz. (eligibility for allotment of next step)				
	2X2.5 MHz (2 carriers)	2X3.75 MHz (3 carriers)	2X5 MHz (4 carriers)	2X6.25 MHz (5 carriers)	2X7.5 MHz (6 carriers) @
Telecom Circles as Service Area for Category 'C' circles	6	40	60	80	

Table 4.3: Revised Subscriber base (in lakhs) supported by CDMA Spectrum in MHz*

Third Stage – Stricter Criterion for Allocation of Spectrum (2006-08)

As technology progressed, it began to be believed that if used maximally, spectrum held by incumbents was sufficient to meet their immediate requirements. Meanwhile, additional spectrum was also being vacated by the Defence. As a result, in keeping with the principle of maximal usage of spectrum, new Subscriber Based Norms **(SBN)** were defined, incumbents kept out of fresh allocations, 3G treated as a separate service from 2G and the cap on the number of operators removed. As mentioned in the TRAI recommendation on 3G spectrum [TRAI 2006], "the Defence Services have agreed to vacate 2 × 20 MHz in the 1800 MHz band, in addition to 25 MHz in the 2.1 GHz UMTS band. The availability of additional spectrum in the 1800 MHz band provides sufficient room for growth of 2G services for the medium term." Therefore, "the authority has recommended that the government should not treat the allocation of 3G spectrum in continuation of 2G spectrum". The TRAI (2007) recommendation that no cap be placed on the number of telecom access providers in the country allowed more new firms to enter the market by paying the low entry fee.

Fourth Stage – Policy on 3G (2008)

The government announced the policy for 3G mobile services in August 2008. In line with the TRAI's recommendation [TRAI 2006],

it opted for a simultaneous ascending auction for allotment of a start-up spectrum of 2×5 MHz in the 2.1 GHz band with specified reserve prices for different categories of LSAs. It may be noted that 2×5 MHz is the minimum carrier requirement for providing 3G services using **Wideband Code Division Multiple Access (WCDMA)** technology in the 2.1 GHz band. The 3G policy also states that 2×1.25 MHz carriers will be allotted to UAS licensed CDMA operators at a price equal to the highest bid received for the 2.1 GHz band, pro-rated for 2×1.25 MHz.

Period of Growth In Indian Telecom Sector

Post 2008, there was a boom in the Indian telecom sector and it was on the upswing. A large number of telecom spectrum auctions were carried out during 2010-2016, which have been summarized in the subsequent paragraphs. In 2010, 3G and 4G telecom spectrum were auctioned in a highly competitive bidding. The successful bidders were awarded spectrum in September and Airtel was the first private operator to launch 3G services in India.[26] Airtel, Idea, Reliance Communications, S Tel, Tata Teleservices and Vodafone Essar participated in the auction. Though BSNL and MTNL did not participate in the auction, they were also awarded spectrum. [27] BSNL paid the Government Rs. 101.87 billion (equivalent to Rs. 170 billion or US$ 2.4 billion in 2018) for spectrum in 20 circles and MTNL got spectrum for 3G services in two circles, Delhi and Mumbai.[28] The Government earned Rs. 677 billion (equivalent to Rs. 1.1 trillion or US$ 16 billion in 2018) from 3G and broadband wireless spectrum auctions which generated a revenue of Rs. 385 billion (equivalent to Rs. 650 billion or US$ 9.0 billion in 2018) for a total revenue of Rs. 1,062 billion (equivalent to Rs. 1.8 trillion or US$ 25 billion in 2018) from both auctions. The 2010 auction took place over 34 days and consisted of 183 rounds of bidding. The most expensive telecom circle was Delhi at a price of Rs. 33,169 million per operator. The five most expensive circles were Delhi, Mumbai,

Karnataka, Tamil Nadu and Andhra Pradesh. They accounted for 65.56 per cent of the total bids.[28][29]

2012 Spectrum Auction. In 2012, the DoT auctioned 2G spectrum in both GSM and CDMA bands. The Government put on sale 271.25 MHz of spectrum.[30] The 1800 MHz and 800 MHz bands were being used for GSM and CDMA services, respectively. Eleven blocks having 1.23 MHz each in the 1800 MHz frequency band were auctioned, except in Mumbai and Delhi, where only eight blocks were available. Three of the 11 blocks in each circle were reserved for new telecom players or operators whose licences had been cancelled by the Supreme Court on 02 February 2012, following the 2G spectrum case. New players and companies affected by the Supreme Court verdict were required to win at least four blocks in each circle to start or continue their operations in that circle. Existing players whose licences were not affected by the Supreme Court verdict could bid for only two blocks in each circle. This applied to all circles of Airtel and Vodafone, and in some circles for Idea.[31] Three blocks of 1.25 MHz frequency each in the 800 MHz band were also available for auction.[32] Initially, only Videocon Telecommunications Limited and Tata Teleservices (Tata DoCoMo CDMA) had applied to participate in the auction for spectrum in 800 MHz band (CDMA). Both companies however withdrew their applications before 05 November, the last date for withdrawal. Videocon was announced as a pre-qualifier in the bidding process by the DoT on 29 October, but withdrew its application on 02 November.[33] Tata Teleservices was also announced as a pre-qualifier on 29 October, but withdrew its bid later. The withdrawals meant that there were no bidders left and the CDMA spectrum auction was subsequently cancelled.[34] The final list of bidders was announced on 06 November. This was followed by a mock auction on 07 and 08 November and the e-auction of 1,800 MHz band began on 12 November.[35] The companies that

participated in the auction for spectrum in 1800 MHz band (GSM) were Airtel, Idea, Vodafone, Videocon, Telewings, TATA.

The auction took place over two days (12 Nov 2012 to 14 Nov 2012) and consisted of 14 rounds. The government received bids worth a total of Rs. 94.07 billion (US$ 1.3 billion), far lower than its target of Rs. 280 billion. No one bid on the India-wide spectrum, which had a reserve price of Rs. 140 billion.[36] Bids were tendered for 102 of the 140 blocks being offered. Delhi, Mumbai, Karnataka and Rajasthan circles did not receive any bids. The erstwhile Minister of Communications and Information Technology **(MoC&IT)** Mr. Kapil Sibal had said that there would be an auction for the unsold spectrum and the procedure to be followed for that auction would be decided in another few weeks. [37][38]

2013 Spectrum Auction. In the 2013 spectrum auction, the Government planned to auction 50 MHz of airwaves in the 1800 MHz band and 76.25 MHz of spectrum in the 800 MHz band.[39] The Government put CDMA spectrum worth Rs. 64 billion (US$ 890 million) up for auction[30][31] and fixed the price of 900 MHz, two times higher than that of 1800 MHz.[42] DoT issued a notice inviting applications for spectrum auction on 30 Jan 2013, and the last date for submitting applications was 25 February 2013.[43] The auction for all three bands was planned to begin on 11 March 2013. However, no bidders expressed interest in the 1800 MHz and 900 MHz bands and, as a result, the auction for them was postponed indefinitely. The auction for spectrum in 800 MHz band proceeded as planned on 11 March.[44] No company tendered bids for spectrum in 1800 MHz and 900 MHz bands. The **sole bidder** for spectrum in the 800 MHz band was **Sistema Shyam Tele Services Limited (SSTL)**, under the brand name **MTS**.[45] The extremely high reserve price was possibly the reason why there were initially no bidders for this high value spectrum. Vodafone Group's CEO Vittorio Colao had stated, "The problem is that in India there is a misperception of what is the value

of spectrum. The reserve prices are set too high. India has very low prices and very low revenues so we cannot afford to pay high price for spectrum. We have told them [Indian Government] a number of times that the order of magnitude that they have in mind just does not make sense".[42]

The auction was held on 11 March and lasted little over four hours.[46] Auction rounds were scheduled to begin between 0900 and 1900 hrs IST.[40] Table 4.4 shows the prices per block for each of the 11 telecom circles in which spectrum was put up for auction. The successful participant in the auction, MTS, won spectrum in eight circles and did not bid for three circles. No spectrum was put up for auction in the remaining circles of India.[47]

Circle	Delhi	Gujarat	Karnataka	Kerala	Kolkata	Mumbai
Price/ Block in Rs/US$	Rs. 4,505 million ($ 63 million)	1,462 million ($ 20 million)	2,146 million ($ 30 million)	425 million ($ 5.9 million)	739 million ($ 10 million)	No bid
Circle	Tamil Nadu	UP (West)	West Bengal	Maharashtra & Goa		UP (East)
Price/ Block in Rs/US$	Rs. 1,989.6 million ($ 28 million)	Rs. 698 million ($ 9.7 million)	Rs. 168 million ($ 2.3 million)	No bid		No bid

Table 4.4: Prices per block for 11 Telecom Circles in which spectrum was put up for auction

2014 Spectrum Auction. In 2014, the DoT auctioned spectrum in the frequency range of 900Mhz and 1800 MHz. The telcos that participated were Airtel, Vodafone India, Idea, Aircel, Reliance Communications, Reliance Jio, Tata Teleservices and Telewings. The telcos primarily intended to use this to provide 2G services and augment it with 3G in certain circles. The winners were awarded spectrum in February. The Government earned Rs. 612 billion (US$ 8.5 billion) from the auction. It put on sale 307.2 MHz of 1800 and

46 MHz of 900 MHz-wide spectrum. The licences are valid for 20 years. Vodafone and Bharti were already using 900 MHz frequency and had to renew before their licence expired in November 2014. Reliance Jio, the only company to have all-India 4G licence entered into voice service and won in 14 circles in 1800 MHz frequency. [48] Companies also planned to provide 3G and 4G services on the spectrum.[49] The auction took place over 10 days and consisted of 68 rounds of bidding. The most expensive telecom circle in both 900 and 1800 MHz frequencies[50] was Delhi at a price of Rs. 7,409.6 million and Rs. 728 million per operator. Delhi and Mumbai together accounted for 57 per cent of the total bids.[51][52]

2015 Spectrum Auction. The 2015 spectrum auction concluded on March 25 after 19 days and 115 rounds of bidding.[53] Spectrum in the 800 MHz, 900 MHz, 1800 MHz and 2100 MHz bands was auctioned. The telcos that participated in the auction were Airtel, Vodafone India, Idea, Aircel, Reliance Communications, Reliance Jio, Aircel, Tata Teleservices and Telewings Communication Services. The Government accrued a total of Rs.109,874 crore (US$15 billion) [54] from the auction. Approximately, 11 per cent of the spectrum available for auction remained unsold.[55]

2016 Spectrum Auction. The 2016 spectrum was held from 01 October 2016. This was facilitated to a large extent by the harmonization of frequency spectrum in the 1800-2100 MHz band, during which the defence and commercial telecom operations shifted to their respective portions of this band. This mammoth exercise was carried out over a period of five-six months , in five phases , covering all the 22 telecom circles or Licensed Service Areas (**LSA**). A considerable amount of contiguous frequency spectrum was freed and made available for auction. A total of 2354.55 MHz of spectrum ranging across the seven bands of 700 MHz, 850 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz was put up for sale across 22 different circles. *This was the first auction*

in India in which 700 MHz band spectrum was put on auction.[56] Bharti Airtel, Vodafone, Idea Cellular, Reliance Communications, Tata Teleservices, Aircel and Reliance Jio had applied to participate in the auction. Telenor did not participate.[57] Only 40 per cent of the spectrum put up for auction was sold as the telcos reportedly said that the base price was high.[58]

2017 Spectrum Auction. In 2017, the Government initiated auction of 5G spectrum for the first time. Spectrum in bands over 3000 MHz (3300 to 3600 MHz) were proposed be sold. Previously unsold spectrum in the bands700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz was also to be auctioned.[59] 700 MHz spectrum especially had an extremely high reserve price (USD 1 bn per 5 MHz, which was possibly the reason why there were no bidders for this high value spectrum. Though TRAI completed consultation with stake holders, no further action had happened probably because of the industry's demand to push back the spectrum sale.[60]

2018 Spectrum Auction. In 2018, in view of the extremely high reserve price of spectrum, which possibly resulted in there being no bidders for certain high value spectrum, the Government was expected to lower the price of the 700 Mhz band, which remained completely unsold in 2016. The Government's focus was expected to be on 5G bands. Telecom regulator TRAI had recommended the 700MHz, 800MHz, 900MHz, 1800MHz and 3300-3600MHz bands be auctioned as 5G bands.[61]

Issues Meriting Deliberation

Optimal versus Maximal Use of Spectrum. The formulation of spectrum policy in India began under conditions of very limited availability of spectrum. In the initial phase, the policymakers' requirement of maximal usage of spectrum with the associated SBN was justified. However, as spectral efficiency increased and

additional spectrum was released, more nuanced definitions of efficiency needed to be applied in order to promote the growth of the industry. The single-minded agenda on maximizing the number of subscribers per unit of spectrum ignores the importance of efficiently using other inputs like *Base Transceiver Stations* (BTSs). The specific interpretation of technical efficiency used by the Government has resulted in high re-use of spectrum and hence, more BTSs and cell towers. In some circles, the inter-site distance between cell towers is less than 100 metres, which is one of the lowest in the world leading to iron-clad structures clogging some of the cities. This implies that unit costs decline with an increase in the scale of operation, at least over the range of subscriber-minutes observed in the industry to date. In view of this, the policymakers should allow accumulation of spectrum, where such accumulation leads to lower costs without increased threat of cartelisation. This would allow operators to integrate operations and aggregate spectrum holdings to take advantage of economies of scale.

Efficient Use of Mobile Infrastructure. Underutilisation of BTSs leads to an increased demand for spectrum. There are several new technologies to ensure optimal yield from BTSs. They include:

(a) Implementation of in-building solutions such as Femto-cell to improve the efficiency of BTSs;

(b) Single antenna interference cancellation that can improve downlink bandwidth of GSM networks without changes to network configurations; and

(c) Utilisation of smart antenna arrays that can confine channels to narrow beams thus improving capacity gain.

The Government should monitor the optimal use of base stations in the same way it monitors the use of spectrum. Prescribing SBN for BTSs is one possible option, though challenges of administering and monitoring would need to be addressed. Further, the Government

must do more to promote infrastructure sharing. While it has allowed both passive (towers, rental places) as well as active (antenna, feeder cable, node B, radio access network and transmission systems) infrastructure amongst service providers in order to effectively use the radio access network infrastructure, incentives in the form of lower regulatory levies need to be provided to improve adoption, thus improving the efficiency of the **Radio Access Networks(RANs)**.

Spectrum Pricing. The Government had chosen to provide the UAS licence for up-front fixed fees along with a revenue-sharing agreement. The revenue share of the Government is increased by a percentage point on every fresh allocation of spectrum. SBNs are used to determine eligibility for fresh spectrum. The fixed fee has been benchmarked to the fee paid by the fourth cellular operator in the auction of 2001. A benchmarked price is appropriate only if the object being sold (in this case, a licence) is the same and market conditions are similar. The fee paid by the fourth operator in the auction process was specifically for a **Cellular Mobile Telephone Service (CMTS)** licence along with start-up spectrum. The UAS allows the licensee to provide access services using non-spectrum related technologies such as wire line service as well. As per the guidelines of the UAS licence, *The unified access services cover collection, carriage, transmission and delivery of voice and/or non-voice messages over licencee's network in the designated service area and includes provision of all types of access services. The access service includes but not limited to wire line and/or wireless service including full mobility, limited mobility and fixed wireless access*. The UAS licence is therefore a super set of the CMTS licence and its price cannot be equated with the price paid for a CMTS licence. Further market conditions in 2003, and even more starkly, in 2007, were quite different from those in 2001. Let alone factoring the increased value of spectrum in the booming telecom sector, the Government possibly did not factor in inflation to arrive at the 2003 and 2007

prices. Inappropriate benchmarking had resulted in under-pricing of spectrum during that period. Under-pricing spectrum leads to a tendency of hoarding and, therefore, should be avoided. The confusion regarding the CMTS and UAS licences has cut both ways since UAS licencees providing CDMA services and applying for a GSM licence in 2007 had to pay exactly the same amount that they had paid when they were issued the CDMA-UAS licence. In fact, as per the above argument, only the charge for GSM spectrum should have been levied. Though UAS implicitly separated licensing from spectrum, licence fee needs to be separated from spectrum fee for pricing both licences and spectrum appropriately (in case a fixed fee method is chosen).

Regulatory Certainty. Telecommunication licences should balance regulatory certainty with the flexibility necessary to address future changes in technology, market structure and government policy. The fixed fee is paid by the UAS licensees without any firm guarantee on the date of allocation. It therefore involves a promise to allocate spectrum at an uncertain point in the future. Further, the SBN represents a very complicated future contract in spectrum with an additional clause of the seller having the right to renegotiate the terms by strengthening the SBN. This contract was very non-transparent and difficult to convert into monetary terms for the purpose of decision-making by the involved parties. Moreover, there was no injunction on the regulator for an orderly step-by-step change of SBN in response to technological changes. Thus, the government decision on strengthening of SBN by an order of six to 15 times increased the price of spectrum from nil to infinity (since the incumbents became ineligible for fresh allocation). This did not represent a very conducive environment for business decision-making. In addition **three important regulatory decisions,** *which totally altered the telecom scenario* were ***Spectrum Sharing and Trading, Liberalisation of Spectrum*** and ***Harmonization***

of spectrum. These policies have changed the game a lot leading to mergers and acquisitions, consolidating the market to current situation of four stable (as of now) telecom operators. This situation is akin to what prevails in other developed nations and is likely to remain. Due to harmonization of spectrum , it became more effective and valuable for deploying next generation technologies. More on these in the subsequent paragraphs.

Spectrum Liberalisation. Till 2008, spectrum had been assigned in 800 MHz or 900/1800 MHz bands depending upon whether licensee was deploying CDMA or GSM technology. Therefore, the spectrum assigned in 800/900/1800 for 2G mobile services was bound with the technology chosen by the licensee. There was however no such restriction on the spectrum which was assigned through auction. Therefore, spectrum assigned through auctions is liberalised spectrum. Administratively assigned spectrum in 800 MHz, 900 MHz and 1800 MHz was un-liberalised spectrum. At the time of expiry of validity of licence period (20 years), it was put to auction. All the bidders were treated alike and there was no reservation of spectrum for incumbents, made in 900/1800 MHz band nor was any priority given to them. After auction, spectrum assigned in 800/900/1800 MHz was liberalised spectrum. TSPs holding administratively assigned spectrum were permitted to convert their spectrum holding to liberalised spectrum by paying the market-determined price pro-rated for the balance licence period.

At the start, the price of spectrum liberalization was set in line with the most recent reserve price recommended by TRAI. This was to be the provisional price and any balance was to be paid by the operator after the market price had been derived from past auctions. In case of non-availability of auction-determined prices (which was the case in many circles), the comparable price to be charged for liberalization was decided by the Government after completion of future auctions. In this fashion, spectrum in 800/900/1800 MHz was

converted into liberalised spectrum in phases. This allowed telecom operators to use any technology to deliver mobile services like 3G and 4G. Besides, they were able to introduce new technologies and share and trade it with other operators for its efficient use. Spectrum liberalisation also helped operators increase the efficiency and quality of services

Spectrum Harmonisation. Spectrum harmonisation refers to uniform allocation of radio frequency bands across regions and de-conflicting commercial requirements and those of Defence, especially in border areas, where Defence holds the radio waves. Harmonisation leads to usage of bands in contiguous blocks leading to efficient utilisation of spectrum. Harmonisation was required to be carried out as it could have facilitated additional 3G airwaves for commercial use. The Cabinet in January 2015 had approved setting up a 'Defence Band', by which it was making available the remaining airwaves (apart from using spectrum for its own use) for commercial use in areas like telecom and broadcasting. The Cabinet had also approved swapping of 15MHz of 3G spectrum between the Defence and Telecom ministries. However, the required spectrum bands were required to be harmonised before being made available for commercial use, because the same were being actively used by the commercial and Defence agencies. There was thus *a requirement to migrate the live commercial and Defence links into their respective portions of the now delineated portions of the 1800MHz to 2100 MHz band*, as without this the upcoming auctions due in 2016 would not have been possible. The same was carried out in five stages and was achieved over a period of five months. This thus facilitated the conduct of the spectrum auctions, which made available additional 3G airwaves for commercial use.

Number of UAS Licences Issued. Though at present **UASL** does not exist and is now called Unified Licence **(UL)**, yet in 2007-08 the same was in vogue and hence the need to explain it. The UAS

licence regime (or UL in the present context) de-linked licence from spectrum in the sense that it allowed the possibility of giving licences without present availability of spectrum. However, it included a promise to provide 2×4.4 MHz of start-up 2G spectrum "as and when available". In 2007-08, the Government could not properly take into account the availability of 2G GSM spectrum while granting licences. In theory, the maximum available GSM spectrum in the 900 and 1800 MHZ bands was 100 MHz. In practice, in India, only 60-70 MHz could at that time be used. Over 40 MHz was already in the possession of incumbents. The remainder was insufficient for even the start-up needs of the six to nine new entrants, let alone the incremental spectrum required thereafter. The Government can possibly be faulted for not restricting the total number of licences granted (or alternatively, not de-linking licence from spectrum) based on its knowledge of spectrum availability.

Policy on 3G. The migration from 2G to 3G requires the setting up of new infrastructure by operators and the purchase of 3G compatible handsets by end users. 2G services can continue to be provided using 3G spectrum and equipment, but 3G services cannot be provided in a 2G environment. The Government at that time viewed 3G as a high value service distinct from 2G and formulated allocation policies accordingly. The policy announcement on 3G spectrum marked the culmination of almost three years of waiting following the TRAI recommendations on allocation and pricing of spectrum for 3G presented on September 27, 2006. The delay in the 3G policy was in a sense responsible for the rush for licences in 2007, when entrants, unsure of the 3G allocation, rushed to get 2G spectrum that was promised along with the UAS licence.

Seen independently of the policy legacy, the **3G policy had several salutary features**. These include the *separation of the licence from the spectrum, the choice of an auction mechanism to reveal the current market value and the opening of doors to foreign participants*.

However, the under-pricing of 2G spectrum in 2007 and the auction determined price of 3G spectrum in 2008 resulted in a new entrant to the Indian market paying much higher prices for entry through the 3G route as opposed to entry through the 2G route. While we may overlook the case of global entrants, who have deeper pockets than their Indian counterparts, we cannot turn a blind eye to UAS licence holders who would not have been able to get the promised 2G spectrum due to non-availability and therefore had to bid for 3G spectrum to be able to provide even voice services. Regarding the details of the auction procedure recommended, TRAI advocated that the lowest bidder in each stage of the auction be placed on the waiting list for spectrum. However, it also mentioned that the size of the wait list should take spectrum availability into account.

It was imperative for the Government to limit the length of the wait list in order to avoid the impasse in the allocation of 2G spectrum. In case of 2×1.25 MHz carrier in 800 MHz, TRAI recommended a single stage auction if more UAS-licensed CDMA operators were interested. TRAI also explicitly specified that the 2G subscriber base should not be taken into account for 3G spectrum allocation, as 3G is a different service from 2G. However, DoT policy states that 2×1.25 MHz be given to the operator having the largest 2G subscriber base. There appeared to be an inconsistency in the method of allocation stated by TRAI and DoT where the latter appears to have apparently flouted its stated policy of treating 2G and 3G as distinct services. The 3G policy announcement was silent on the road ahead after the last allocation. A clear road map of spectrum availability, use of the auction mechanism for allocation, and rationalization of the subscriber-based norms to serve as a low hurdle of eligibility to participate (as opposed to requiring maximal usage) would have been more appropriate.

Technology Neutrality. The introduction of CDMA-based mobile services during 2001-03 was clouded by the legal battles

between the incumbent GSM and BTS operators. Given their defensive position and the prevailing paradigm of maximal usage, the *CDMA mobile service providers were allotted a lower start-up spectrum block (2.5 MHz as compared to 4.4 MHz for GSM) as they were considered more efficient.* Parity was established between the two technologies in terms of the number of subscribers each could reach with the spectrum allotted to them. The definition of parity was **tantamount to handicapping a more efficient player** by restricting access to a necessary resource. In an environment where maximal usage is no longer relevant, the correct definition of parity is "equal access to resources" to be used as inputs. Such an approach would create a truly level playing field in which the respective technologies would be able to compete. Promoting such competition would also economize the use of spectrum. The only qualification to this conception of parity could be the threat of monopoly power. However, if anything, the strengthening of CDMA service could increase competition in an industry that is currently largely dominated by the GSM players. As per TRAI recommendations, both types of operators should have the same amount of start-up spectrum and be held to the same subscriber-based norms.

Level Playing Field. As pointed out by TRAI, the ratio between actual subscriber base and subscribers that should be serviced as per the SBN is much larger for private operators compared to government operators, indicating that private operators are having to stretch spectrum much more than government operators. In some LSAs, this ratio is even less than one for some government operators, indicating that these government operators were given spectrum despite not meeting the SBN.

Spectrum Usage Charges (SUC). The spectrum assets given by the Government to the telecom operator are used by him to generate revenue and the Government levies SUC from the operator. In addition, some percentage of the revenue earned is given by the

telecom operator to the Government and the balance available with the telecom operator (after paying the licence fee and SUC) is called the **Adjusted Gross Revenue (AGR)**. A portion of the AGR is also given by the telecom operator to the Government as his contribution to the **Universal Service Obligation (USO)** fund and another portion of the AGR goes towards payment of taxes. The telecom operators often raise this as a matter of double taxation and the issue is under mediation with the Government. The USO fund to the tune of Rs. 40,000 crore is available with the Government which can be gainfully used for improving the telecom services and infrastructure, especially in areas with poor tele-density and in rural areas. The USO fund could also be tapped by Defence for seeking improvement of the civil telecom services and infrastructure in the border areas, especially those with poor tele-density.

4G and 5G Spectrum Auctions

The telecom industry has invested considerable capital expenditure but of late the revenues have reduced and the telcos are facing challenges in managing payments. To provide partial relief to them, the Government has agreed to accept deferred payments. The auction of the spectrum, specially targeted towards provisioning of 4G and 5G services, is also likely to be held in late 2019. Both these measures will give more time for the financially stressed telecom sector to stabilize fully as the industry is reeling under a debt of nearly Rs. 8 lakh crore. The TRAI has recently recommended the starting price for spectrum in 4G bands of 700 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz besides 5G airwaves in the 3300 MHz-3600 MHz bands. It has suggested that 8600 MHz of airwaves be offered to Bharti Airtel, Vodafone India-Idea Cellular and Reliance Jio Infocomm, to fetch over Rs. 5 lakh crore, if all the bandwidth offered is sold at the reserve price. The DoT is to take the final decision on the pricing and timing before sending it to the Union Cabinet for approval. DoT would want to

possibly avoid a situation where airwaves, especially the 5G ones as well as the ones in the premium 700 MHz band, whose starting price was reduced 43 per cent from the last sale remain unsold once again as that would adversely impact the roll-out of 5G services in the country.

Conclusion

Spectrum policy in India, while having been very successful in nurturing the growth of industry, suffered from a lack of long-term vision and absence of a holistic perspective that considers all the relevant factors before taking policy decisions. The trajectory of spectrum policy in India has been marked by many flip flops: on SBN, spectrum pricing, 3G policy and competing technologies. The Spectrum Management Committee, set up by the Government in 1999 was to provide a blueprint for spectrum allocation and management. However, the committee was not very specific about using auctions as an allocation mechanism. To date, there are different mechanisms for allocating spectrum for various services. For the fourth cellular operator, spectrum and service areas were auctioned, while those providing WLL (LM) were to get the spectrum based on a fixed entry fee and it would be allocated on a first-come-first-serve basis, subject to completion of roll-out conditions. This would result in two services that require spectrum (incidentally in adjacent bands) to be treated differently. The resulting uncertainty was harmful for the industry. A clear defined, consistent policy is the need of the hour and the recently promulgated National Digital Telecom Policy **(NDCP)**-2018 and National Frequency Allocation Plan **(NFAP)**- 2019 are steps in the right direction. However, in view of the peculiar circumstances and operating conditions of the Armed Forces, special provisions for them need to be made in all such policies, which apparently might not appear to be commercially profitable in the short term, yet would be in the overall national interest in the long term.

5

Spectrum management for defence and analysis of the defence band

Introduction

Radio frequency spectrum and associated geostationary and other satellite orbits are limited national resources. Radio waves are susceptible to harmful interference and are international in character, since they cannot be confined to national boundaries. Like any other natural resource, it cannot be owned but can only be shared amongst various countries, services, users, technologies, etc. Assignment of frequencies is governed by international treaties formulated under the aegis of the International Telecommunication Union (ITU), which are signed and ratified by governments including that of India. Further, it is also subject to various other international agreements with other countries. The same has been explained at length in the previous chapters.

The Wireless Planning and Coordination **(WPC)** Wing of the Ministry of Communication, created in 1952, is the national radio regulatory authority responsible for frequency spectrum management including licensing and caters for the needs of all wireless users in the country, government or private, security or non-security. It is also the national nodal agency for all matters related to the ITU and Asia Pacific Telecommunity (**APT**) and is

responsible for treaty obligations on behalf of the Government of India. It also exercises the statutory functions of the Central Government and issues licences to establish, maintain and operate wireless stations as well as possess, develop and deal in wireless equipment in the country.

The defence services are one of the major users of frequency spectrum in the country not only for strategic and tactical communication **(comn)** networks but also for other operationally vital systems such as Surveillance, Navigation, Fire and Weapon Control, Target Acquisition, Missile Guidance, Electronic Warfare, etc. With the rapid development of telecom in the country, the overall telecom environment has been changing at an unprecedentedly fast pace. The speed at which new technologies and new telecom radio services are being introduced is further complicating the already complex problems of spectrum management. The demands of larger frequency bands both for civil and military use are on the increase.

Historical Background

The National Frequency Allocation Plan **(NFAP)** is a document prepared by the WPC, which outlines the plan for utilization of frequency spectrum by various users/for various services. NFAP -81 was prepared by the WPC in 1981 and was based on the concept of major users and general users. Major users were the ones who were permitted to plan their services and take action for development of required equipment in the identified sub-band on the condition that they would approach the WPC for Licence/Authorization before they commenced operation of any station. The major users were Defence, Doordarshan, Posts & Telegraph, Police, Railways and Meteorological Department. Any user other than a major user was a general user.

Due to the presence of Defence in certain bands as major users, the band was *informally referred to/named as Defence Band*.

The allocation from this band was primarily to Defence. The use of the defence band was restricted to the Services only, due to the manufacture of equipment **(eqpt)** from few sources and the requirement of eqpt and infrastructure not being too large.

The telecom services were not open to private service providers. Therefore, the spectrum was hardly an issue to be worried about. In addition, the requirement of SACFA clearance was minimal.

Transformational Developments

In the world, various communication **(comn)** technologies grew with time. These technologies **(tech)** came to India and hence demanded spectrum. Therefore, the demand for spectrum grew, thus curtailing the boundaries of major users. Due to the development of technology the world over, this tech was also introduced in India and adopted by Defence. The requirement of spectrum in Defence also proliferated.

The ITU earmarked the frequency spectrum for various new services at the international level. Telecom firms started production of eqpt for a particular service in the band specified by ITU.

In the meantime, the new telecom policy of 1999 was introduced in India. According to this policy, the civil services providers could set up communication **(comn)** Infrastructure in India after getting a licence from the WPC. They asked for spectrum to establish their comn infrastructure. The spectrum required was as per the ITU regulation.

NFAP 81 was reviewed and a new NFAP 2000 was in place in 2000. ***This NFAP removed the concept of major and general users.*** It removed the concept of the erstwhile (*informal*) Defence Band. In doing so, it however, protected the already earmarked allocation of spectrum. The frequency band was now based on the type of service, i.e., any frequency required **(reqd)** for a particular service would be earmarked from the band earmarked in the NFAP 2000.

NFAP 2002

NFAP 2000 was reviewed in 2002 and NFAP 2002 was formulated. Based on the NFAP, the freq allocation was being done as per service. The erstwhile Defence Band, however, protected by NFAP 2000 and NFAP 2002, was to be coordinated/vacated for the services earmarked in that band to grow. Therefore, these bands were being coordinated with other service providers in the national interest. It was perhaps appreciated that in the long run Defence would have to vacate the spectrum to let the earmarked service grow. Therefore, Defence needed to plan their comn requirement in order to get better technology, equipment for self-use and, in the process, let new telecom services grow in the country.

Due to a large number of players in the game of provisioning of communication, the cases for coordination of def spectrum and site clearance of SACFA increased manifold.

Technological development did not limit itself to the civil service providers but also influenced Defence. The comm infrastructure of Defence increased manifold and hence there was an increase in the reqmt of spectrum for Defence.

ITU recommended channelling plans as per the characteristics of the modern equipment available. Due to long procurement cycles, the Defence forces still held and used the age-old legacy equipment which was perhaps not spectrum efficient. As and when the Defence forces asked for freq allocations, WPC allocated frequency **(freq)** based on the IT channelling plans. The Defence forces had problems in using the newly allocated freq as they at times interfered with the allocations made in the past. Also, there were cases where the defence forces were historically using freq (since the time they had been major users), without proper formal authorization (as was now required under the revised NFAP) and this again interfered with the recently allocated freq. These issues needed to be examined by the Defence forces.

Studies/Boards Constituted

In order to deal with all the issues mentioned above, various boards were constituted. These were:

(a) Spectrum Management Committee (GoT)

(b) Joint Services Study Group constituted in September 2000.

(c) Spectrum Coordination Committee under chairmanship of VCAS in November 2002.

(d) Group of Ministers meeting September and December 2003.

Spectrum Mgt Committee: Group on Telecommunications (GoT)

The GoT constituted on the orders of the then Hon'ble Prime Minister in December 1998 formed a committee on **"Spectrum Management"**. It was headed by the then SO-in-C Lt Gen Prakash Gokhran. The committee submitted its report on 24 December 1998. The GoT report on Spectrum Management recommended that the Defence Band **(DB)** needed to be de-lineated and given primacy while formulating the National Frequency Allocation Plan – 2000 (**NFAP** - 2000). The report also emphasised the concept of the Defence Interest Zone **(DIZ)** along our international borders and areas of strategic interest in the hinterland, oceanic region and island territories, so that **during a hot war and low intensity conflict scenario,** our armed forces are able to maintain flexibility and agility in the use of spectrum and have freedom of operation of communication and non-communication equipment over the entire area in the DIZ. The GoT report was endorsed by the Standing Parliamentary Committee on Information Technology vide their reports Nos. 28 (2005-06) and 36 (2006-07), which recommended that the Defence Band and DIZ be identified and de-lineated. However, the same could not be immediately implemented and successive NFAPs were promulgated

without addressing the Defence Band/DIZ. The report mainly covered the following issues:

(a) Efficient spectrum utilization

(b) Spectrum Policies

(c) Transition path/road map for futuristic technologies

(d) Concept of Defence Interest Zone (DIZ) and protection of defence interest in the use of freq spectrum was highlighted

The report was accepted completely. It became the basis for the New Telecom Policy 1999 **(NTP99)** and subsequently for NFAP 2000. (The delineation of the Defence Band and DIZ which could not be immediately implemented, *was included as a fulfilment condition of triggers of spectrum release by Defence Services* as per the MoU later to be signed between MoD and MoC & IT on Project Network for Spectrum on 22 May 2009.

JSSG constituted in September 2000

A **Joint Service Study Group (JSSG)** was constituted in September 2000. It had members from all the three Services. The study group was to :

(a) Compile a Service-wise list of all radars.

(b) Compile a geographical area-wise list of static radars giving the band of freq being used. The freq were to be within few hundreds of MHz.

(c) Recommend methodology by which ex- post- facto earmarking of freq for radars could be obtained from WPC and have a WPC incorporated in the study.

(e) Bring on record the procedures that are followed by WPC to handle applications for freq assignments ensuring the security of information.

(f) Recommend suitable procedure for handling cases to make them a policy directive to handle cases of radars.

The JSSG in its findings stated certain problems. Some of them are:

(a) Most radars operate on several spot freqs spaced over a large band. Also, due to manual/auto freq ability, the spot in use changes while the radar is still in operation. Hence, particular spots for radars cannot be identified.

(b) In Russian-origin radars, the exact spot freq is not known.

(c) The Defence services were (and still are) reluctant in disclosing radar freq and the area of Ops as they are classified info and due to fear of jamming.

(d) A few of the radars do not have the freq formally authorised from WPC because they had been historically using the freq (since the time they had been major users), without proper formal authorization. Hence, it may lead to interference or jamming of own or other comn systems when they are opened/closed.

(e) Radars reqmt of freq band is large. This aspect hinders the civil or other usage of freq in most of the bands where radars are used.

The JSSG submitted its report on 13 October 2001. Some recommendations are:

(a) It listed freq bands loc-wise which were to be protected through NFAP.

(b) It recommended that a centralized record of Def radars be maint by JCES for interaction with WPC/SACFA.

(c) It also recommended that JCES act as a single window for coord with WPC.

Spectrum Coord Committee under Chairmanship of VCAS Nov 2002

A spectrum coord committee under the chairmanship of the then VCAS was constituted in November 2002. The terms of reference for this committee were:

(a) Cellular operators were to use the Def band for provision of their services. Three cellular operators for each state/Metro station were to operate in the GSM 900 band. The fourth cellular operator was to operate in the GSM 1800 band. Issues regarding the coord of freq spectrum for the fourth cellular op were to be dealt by this committee.

(b) The time frame and resources reqd for the replacement of outdated analog eqpt of the AF by modern digital eqpt for optimal utilization of spectrum.

(c) Examination and formulation of the methodology for the utilization of resources generated through the spectrum charges for the digitization of the eqpt in use by the IAF.

(d) Cellular operators had been coordinated to resolve certain Defence Band frequencies. Due to the coordination carried out, there were certain cases of interference reported by the IAF. The committee was to study the issues related to interference of cellular services with the Air Force Defence Network and evolve methods to avoid the same.

The committee was however unable to finalise its report. The last meeting (the third) of this committee was held on 04 Jan 2003 under the Chairmanship of VCAS. The following points were discussed:

(a) Issues relating to coordination of freq spectrum for the fourth cellular operator.

(b) Replacement of outdated analog eqpt by modern digital eqpt in order to ensure optimal utilization of spectrum, time frame and resources required for it.

(c) Examine and formulation of the methodology for utilization of resources generated through spectrum charges and licence fee for digitization of the eqpt in use by the IAF.

(d) Pending cases of freq clearance of the Services.

(e) Issues of Defence Interest Zone (DIZ).

(f) Authorization of radar freq.

(g) Spectrum reqmt for cellular, WLL, IMT 2000/34 services.

No more meetings were held by the VCAS committee and hence no final recommendations were submitted by it.

Group of Ministers Meeting Sep & Dec 2003

A meeting of the Group of Ministers was held under the chairmanship of Shri Jaswant Singh, Ministers of Finance and Company Affairs. The issues that were considered in this meeting were:

(a) Release of spectrum for the growth of Telecom sect.

(b) Enactment of the convergence bill.

(c) Ensuring adequate resource realization of NTP targets of rural telephones.

(d) Chart course for a universal licence (Unified Licensing Regime).

Spectrum issues affected the defence forces the most. The course to be taken for coordination of the defence spectrum, as mentioned in this meeting, has been enumerated below:

(a) **Short term.** Coord of 3.8 + 3.8 MHz in remaining areas of the country to be done within 06 months from September 2003.

(b) **Medium term**. Additional spectrum of 15 + 15 MHz to be released in 2-3 years time.

(c) **Long term**. Additional spectrum of 50 + 50 MHz to be released in 3-4 years time.

Genesis and Analysis of the Defence Band Promulgated In 2015

A series of high-level meetings (HLMCs) and inter-ministerial discussions and deliberations took place between 2003 and 2009. Prior to the spurt in commercial utilization of spectrum for cellular networks, the Defence forces were the major users of the entire electromagnetic spectrum starting from 2 KHz to 40 GHz. With the increase in demand of spectrum for commercial use, the necessity arose to clearly delineate the spectrum for Defence to ensure interference-free performance of Defence wireless systems. In accordance with international best practices, the idea of having an exclusive Defence Band was mooted in 2006. The basic purpose of creating the Defence Band was to ensure that the Defence spectrum requirements remained confined to exclusive portions of the spectrum, thus paving way for commercial wireless applications which was the need of the hour. A sustained and prolonged effort between the Defence Forces and the MoC led to identifying a mutually agreeable Defence Band (DB) and Defence Interest Zone (DIZ).

Implementation of MoU 2009 Between MoD and DoT. A MoU was finally signed between the MoD and MoC & IT on 22 May 2009 for vacation of 65 MHz of the spectrum (40 MHz in 2G and 25 MHz in 3G) in the 1700-2000 MHz band by the Defence forces. As per the MoU, DoT was in lieu to provide:

(a) An exclusive dedicated secure OFC-based network named '**Project Network For Spectrum (Project NFS)**,

(b) Promulgation of **Defence Band (DB)** and **Defence Interest Zone (DIZ)** and

(c) Waiver of spectrum charges for Defence usage. The 65 MHz of spectrum was to be released by Defence as per the five triggers/timelines agreed to between the two ministries.

Promulgation of DB & DIZ. After a prolonged and deliberate series of Inter Ministerial discussions spread over seven years, approval of the Defence Band and Defence Interest Zone was obtained from the Union Cabinet of India on 21 January 2015, which was later promulgated by MoC & IT on 12 March 15. With its promulgation, Defence now holds 12.5 GHz of spectrum amounting to 31.6 per cent of the total EM spectrum. In addition, area up to 50 KM along the IB/LC/LOC/LAC, area of CI/CT Ops and areas of strategic interest in the hinterland form part of the DIZ. In it, Defence will have overriding priority over other users during pre-hostilities/ operations. In addition, Wireless Planning and Coordination (WPC) will share all data pertaining to all spectrum allocations with Defence in DIZ. With the approval of Defence Band, seven (07) Joint Working Groups were also constituted as per the directions of the Union Cabinet to resolve certain Defence Spectrum-related issues in seven sub-bands out of a total 51 sub-bands. It was also directed to complete the process of harmonization of the 1700-2000 MHz band within one year of approval of the DB.

Release of Spectrum. 20 MHz of spectrum, i.e., 10 MHz each of 2G and 3G spectrum was released by Defence on signing of the MoU in 2009, as per the trigger. Another 20 MHz of spectrum, i.e., 10 MHz each of 2G and 3G spectrum was released by Defence on 31 August 2010. The balance 5 MHz of 3G spectrum was released by Defence on 31 December 14, which facilitated the conduct of auction of spectrum by MoC & IT in March 15. JCES Dte, HQ IDS took up the matter with the MoD for early harmonization of the 1700-2000 MHz band and for completion of all five trigger-bound actions by MoC & IT for project NFS.

Working Groups to Resolve Spectrum Issues in Def Band Document. With the approval of the Defence Band by the Union Cabinet on 21 January 2015, the Cabinet directed the setting up of a Working Group for 07 sub-bands out of total 51 sub-bands, to

resolve certain Defence Spectrum-related issues, which included either exact identification of frequency spectrum in a band or sharing of spectrum with other stakeholders like Doordarshan and Department of Space. Representatives of the MoD had been nominated in the subject Working Groups. The mandate of these seven Working Groups are as tabulated below:

Ser No.	**Frequency Band (MHz)**	**Mandate**
(a)	470-520	To provide recommendations on spectrum requirement for various service/applications in this band.
(b)	1215-1400	To provide recommendations on spectrum requirement for various service/applications in this band.
(c)	1427-1500	To provide recommendations on early identification of 3 carriers each of 8 MHz for Defence in this band.
(d)	1880-1900	To provide recommendations on coexistence of low power of cordless system with Defence operations in this band.
(e)	1765-1785/ 1860-1880	To provide recommendations on release of additional 15+15 MHz spectrum for telecom services in certain specified service areas.
(f)	2300-2400	To provide recommendations on identification of one chunk of 20 MHz spectrum for Defence in this band.
(g)	21.2-23.6 GHz	To provide recommendations on identification of 4 carriers each of 28 MHz for Defence in this band.

Multiple meetings for all the seven Working Groups have been convened, wherein Defence reps from JCES, HQ IDS have conveyed the existing assignments of Defence and its future requirements with conviction, to ensure that Defence interests are protected. Proceedings of five Working Groups, i.e., 1215-1400 MHz, 1880-1900 MHz, 1765-1785/1860-1880 MHz, 2300-2400 MHz and 21.2-23.6 GHz have been completed and signed by MoD reps (JCES,

HQ IDS). The proceedings of the 1427-1500 MHz Working Group have also been finalized in principle. However the proceedings of these six Working Groups have not yet been *formally promulgated* by the Ministry of Communication (MoC) and the same needs to be expedited. The remaining Working Group, i.e., 470-520 MHz is under deliberation and needs to be resolved keeping the interests of national security and of the Armed Forces in mind. The progress of these working groups needs to be closely monitored and expedited in the overall interests of the Armed Forces.

Harmonisation of 1700-2000 MHz Band

Harmonisation means de-conflicting defence and non-defence users by shifting their services to their respective share of spectrum in the 1700-2000 MHz band to avoid electromagnetic interference. On promulgation of the DB, the Cabinet had directed defence and non-defence users to shift to their respective shares of allocated bands by 23 January 2016, i.e., within a year of promulgation of the DB.

This involved the relocation of Defence and Telecom Service Provider **(TSPs)** frequency assignments to their respective share of spectrum, as directed by the Union Cabinet. In this regard, Defence had submitted its harmonization plan to MoC & IT, well within the timeframe. However the harmonisation process got slightly delayed due to non-availability of the harmonization plan of the TSPs with MoC & IT. On its receipt, harmonisation was carried out pan India in five stages, staggered over a period of five months, in all the 22 Telecom circles in the country. Post completion of the harmonization in October 2016, the balance 20 MHz of spectrum as part of NFS stood released.

Methodology For Management of Defence Band

Rationale for Defence Band. The rationale for creating a Defence Band has been the national endeavour to allocate part of the national

spectrum resources to the Defence Services, so that they can plan, develop, procure and operate systems so essential for the Defence forces for meeting any eventuality. Thus, a Defence Band has been identified mutually between the MoD and MoC & IT (now called MoC). The Defence Band covers the spectrum requirements of the Defence Services in the frequency bands up to 40GHz. However, in some sub-bands of the DB, some assignments of other ministries/ commercial services are present and would continue to exist till they are relocated outside the DB. The process of earmarking frequency for usage is done in three steps. The details and its connotation in the context of the DB are as follows:

(a) **Allocation**. Allocation of a frequency band implies entry in the table of frequency allocation of a given frequency band for the purpose of its use by one or more terrestrial or space radio communication services or radio astronomy services under specified conditions. In the context of the Defence Services, the *identification of DB itself may loosely be construed as Allocation* as WPC seeks clearance from Defence, i.e., JCES, HQ IDS, if any frequency spot within the DB, is sought by agencies other than Defence.

(b) **Allotment**. Allotment of a radio frequency or a radio frequency channel implies entry of a designated frequency channel in an agreed plan, adopted by a competent conference, for use by one or more administration for a terrestrial or space radio communication service in one or more identified countries or geographical areas under specified conditions. In the context of the Defence Band, it implies that if a frequency or frequency channel is allotted to a particular user, the user is free to develop/procure its equipment for that frequency or frequency channel. **Allotment of a radio frequency should be sought by the users before finalizing the GSQRs**.

(c) **Assignment**. Assignment of a radio frequency or radio frequency channel implies that authorization has been given by an administration for a radio station to use a radio frequency or radio frequency channel under specified conditions. In the context of the Defence Band, it implies that a specific user would be allowed to operate the equipment or system under specified conditions (linked to location, time or technical conditions like power output, type of antenna, etc). ***Assignment of a radio frequency should be sought by the users only after the supply order for the equipment has been placed.***

Owing to the fact that approximately 30 per cent of the spectrum up to 40 GHz has been identified as DB, it becomes imperative on the Defence Services that this available spectrum is used judiciously using various spectrum management/efficient ways. Defence Services applications for spectrum comprises the following categories:

(a) Strategic systems.

(b) Tactical mobile systems.

(c) Fixed systems.

Methodology for Frequency Assignment

This part covers procedural aspects pertaining to frequency assignments, which includes the role of the Dte of JCES, HQ IDS, the format of application for generating demand for frequency assignment, procedure of frequency assignments, timelines for processing of cases, arbitrators/appellant authority to resolve inter-service issues. The procedural aspects pertaining to frequency assignments, which includes the role of JCES, format of application for generating demand for frequency assignment, procedure of frequency assignments, timelines for processing of cases, arbitrators/appellant authority to resolve inter-service issues are proposed as below.

Procedure for Frequency Assignment for Cases Falling Within DB. All cases where frequency assignments fall within the ambit of DB are to be handled as per the following existing procedure:

(a) Five sets of applications as per the format would be forwarded to JCES, through respective SHQs, duly filled and signed.

(b) The applications would be vetted by JCES for completeness.

(c) The application would then be forwarded to the other Services for inter-Service coordination.

(d) Other Services would vet the application depending upon their future requirements for that frequency spot or channel.

(e) If the other Services have No Objection, then JCES would forward the application for allotment of that frequency spot or channel to that particular user under specified conditions, to the WPC.

(f) If the other Services fail to coordinate due to their own planned usage, JCES would make an endeavour to achieve coordination by conducting a tri-Services committee meeting under DACIDS JCES (now re-designated as Air Commodore/Brigadier/Commodore JCES), also referred to as Inter-Service Co-ordination meetings. During these meetings, the Dte of JCES will suggest an alternate plan or methodology to resolve the issue and attain coordination. However, if the effort of JCES does not materialise, the matter would be flagged by JCES to a tri-Service committee under ACIDS (ICT) , HQ IDS for resolution. The committee would comprise ADG Tac C from the Army, ACAS (Com) from the AF, ACNS (CSNCO) from the Navy and PD (Strat Comn) from HQ SFC. If no consensus is achieved, the matter would be referred to the Joint Operational

Committee (JOCOM) under DCIDS (Ops) and later to the Vice Chiefs Committee (VCC) under the CISC. All pending inter-service coordination cases would also be discussed during the JCEMCAB meetings.

(g) Once the coordination is received, JCES will forward the application for allotment of that frequency spot or channel to that particular user under specified conditions, to the WPC.

(h) WPC would allot the frequency spot or the frequency channel to the user along with the licence or **Decision Letter (DL)** and intimate the same to JCES.

Procedure for Frequency Assignment Cases outside DB. All cases where frequency assignment falls outside the ambit of the DB would follow the following procedure:

(a) Five sets of applications as per the format would be forwarded to JCES, duly filled and signed. Only exceptional cases, which cannot be located within the DB would be considered.

(b) The applications would be vetted by JCES for completeness. JCES would also ascertain whether the equipment can function within the DB.

(c) The application would then be forwarded to other Services for inter-Services coordination.

(d) The other Services would vet the application depending upon their future requirements for that frequency spot or channel.

(e) If the other Services have No Objection, then JCES would forward the application to WPC for further assignment.

(f) JCES would be responsible for further coordination with WPC Wing to ensure that the frequency assignment is achieved in a reasonable time frame.

Timelines. To ensure that all cases of frequency assignments are cleared within a reasonable time frame, the following time lines are normally adhered to by the Services and by JCES, assuming D-day to be the date on which the application was received by JCES:

(a) Vetting of application by D + 10.

(b) In case of observations/clarifications, application should be returned to respective users by D + 15.

(c) Users should provide clarification/rectify application by D + 30.

(d) Application forwarded by JCES for inter-Service coordination by D + 30.

(e) Inter-Service coordination to be achieved by D + 60 and latest by D + 90.

(f) Issue of frequency assignment letters/forwarding of cases to WPC for frequency assignments outside DB, by JCES by D + 100.

Appellate and Arbitration Authority. In case the users feel that their respective applications have been delayed beyond the stipulated time limits and is affecting the procurement/import of equipment, they may approach ACIDS (ICT)/ DCIDS (Ops), HQ IDS directly for an early resolution. The users may also approach DCIDS (Ops), in case they want to represent against the decision of JCES to deny the required spectrum. The final Appellate Authority for spectrum issues would be the VCC.

Coordination with other Government Users in DB

Till such time as licences within the DB are being issued by WPC, coordination with other Government users would be done by WPC by calling a joint meeting of JCES, WPC and the representatives of the affected government departments. Subsequently, if later, the MoD is

empowered to issue a licence within the DB, the task of coordinating with other Government departments could be considered to be carried out by JCES, wherein representatives of WPC and the concerned government department should be incorporated.

As per the terms and conditions of the DB, other users are required to relocate their applications outside the DB in the time frame of 5 to 6 years. JCES would ensure that minimum applications of other Government users are accommodated in the DB along with coordination with the Services. Extension for/exemption from migration could be taken up by JCES with WPC for exceptional cases, on account of operational emergency/exigencies of service/in overall national interest.

Maintenance of correct records is one the most importance facets of the Spectrum Management process. Authenticated and correlated data would ensure that data is readily available thereby speeding up the spectrum allocation, interference resolution and auditing of the spectrum process. The importance of this activity has increased manifold as the onus of managing the DB is now with the Defence Services. The records recommended to be maintained by JCES and by the Services are discussed in subsequent paragraphs.

Maintenance of Records

JCES being the nodal agency and apex body for spectrum management for the Defence Services would maintain the following documents:

(a) One copy of all applications in original.

(b) All documents pertaining to clarifications/rectifications and other correspondence in respect of different assignment cases.

(c) AIP issued by WPC.

(d) Wireless Operating Licence **(WOL)** issued by WPC.

(e) Copy of SACFA clearances.

(f) Copy of invoices and DPL (if applicable).

(g) Any other relevant document as required from time to time.

(h) Different Frequency Registers giving the entire details of allocations/assignments.

(i) In addition, an automated database containing all details should be maintained. The database should facilitate display of required details based on queries. The details to be mentioned in the database should be under the following heads:

  (i) Name of the project.

  (ii) Frequency assigned.

  (iii) AIP and WOL numbers.

  (iv) Date of assignment.

  (v) Bandwidth of application.

  (vi) User directorate/Service.

  (vii) Tx and Rx locations.

  (viii) Tx and Rx ant gains.

  (ix) Output power.

  (x) Type of assignment.

All records similar to those mentioned above, pertaining to their respective Service, should be maintained by the Services/other users, at all times.

Automation of Spectrum Records

JCES has developed an in-house JCES Spectrum Management System (**JSMS**) and is under the process of procuring and deploying

a "System for Management of Electro-Magnetic Battle Space" **(SMEMBS)** to automate the spectrum management and assignment issues to achieve EMC in the battlefield. The server of SMEMBS would be deployed within the complex of JCES/at a DCN Node and connectivity from this server would be extended to the concerned directorate of the Service HQs. The GSQRs of the hardware and software have already been formulated and the system once deployed will greatly facilitate and automate the Spectrum Management process. The project is planned to be implemented in two phases as under:

(a) **Phase I**. Hardware/Software procurement, installation and connecting the HQ IDS (JCES) with the three Service Headquarters.

(b) **Phase II**. Extension of the network up to all Command Headquarters of the three Services by procuring and installing hardware, software licences and upgrades by hosting the server over Defence Communication Node (DCN) .

Once deployed, the proposed system would manage and optimize frequency assignments for all electromagnetic emitters and receivers present in the complete geographical area on a near real time basis. The system is envisioned to have an Electro-Magnetic Battle Space **(EMBS)** visualization system based on a GIS package. The system would display individual emitters and receivers on a map. It would calculate electromagnetic influences associated with emitters and receivers and display the same for ease of decision by frequency assignment authorities.

Conclusion

The earmarking of an exclusive DB is a landmark achievement for the Defence Forces. It however increases our responsibilities manifold as we have to manage and restrict our systems within the available

band. It has to be ensured that the DB is utilized judiciously so that our operational needs are met and none of our projects are delayed due to non-availability of spectrum. This policy document on the management of DB is an endeavour to address all pertinent issues related to efficient Spectrum management. However, we would only be able to manage the DB efficiently if it is followed in true letter and spirit. The DB is scheduled to come up for review after five (05) years, i.e., in 2020. The **National Digital Communication Policy (NDCP)**–2018 has replaced the erstwhile National Telecom Policy (NTP) and the National Frequency Allocation Plan (NFAP)-2019 has also since been promulgated.

With the liberalization in the telecom policy, a number of service providers have entered the market because of which the requirement of spectrum has increased manifold. Due to this, the Defence forces were required to curtail their dominance on spectrum by coordinating certain spectrum with other users. In order to safeguard its own spectrum to have a non-interfering battlefield and to meet future requirements, it is essential that the Defence forces carry out proper planning and abide by it. It is thus essential that the Defence forces study certain aspects in detail, in order to plan the spectrum issues for the future to have a non-interference environment during war. Two key issues to be considered are:

(a) Identification of radar/communication frequencies for assignment including migration of working frequencies to the approved annexure.

(b) Updating of the records of WPC to reflect assignment of all frequencies being used by Defence, including those frequencies that were being used historically for a long time (since the time they had been major users), without proper authorization.

6

Impact of liberalised availability of spectrum on proliferation of social media and its effect on the armed forces

Introduction

The movement of our society and much of the world, from the industrial age to the information age, has been hastened largely by the liberalised availability of frequency spectrum (as was explained in Chapter 5), which has in turn led to the proliferation of social media. The reach of the social media wave has primarily been possible due to the liberalised availability of frequency spectrum and the drop in the charges of mobile data. The same has not only had an impact on the way news is handled in the country but has also had a profound impact on the Armed Forces, providing both opportunities and challenges to both friend and foe alike; hence, it is pertinent to discuss them in this study.

A few years ago, Social Media as a topic of discussion for a seminar for the Armed Forces had not been found acceptable and the presence of Armed Forces personnel on social media had been banned. These orders were however soon reviewed once the relevance of social media for the Armed Forces was appreciated by all concerned. The liberalised availability of frequency spectrum has not only helped in the proliferation of social media, but has had

an impact within the Armed Forces especially with regard to the manner and speed with which narratives are built. This chapter puts forth the condensed wisdom of deliberations carried out by various speakers during a seminar on the subject organized by CENJOWS on 04 and 05 September 2018.

Proliferation of and Exploiting Capabilities of Social Media

Social Media is all pervasive, all-encompassing and affects our personal and official lives. It has changed the way we think, spend, act, establish and maintain relationships; in fact, it has changed our way of life. Availability of high bandwidth and good connectivity, at even remote locations has transformed the manner of information flow and the way wars will be fought. The way we fight has also undergone a change and we need to factor in how social media affects a soldier's war-fighting abilities. On establishing contact with the adversary, immediate updates are provided on social media. *The videos and pictures of Wing Cdr Abhinandan, **unwittingly** uploaded by Pakistani civilians, gave undeniable proof of his being alive and in a healthy state when he had parachuted in Pakistan*. Within the first few minutes of the video having been uploaded on the Internet, the initiative had been snatched from the hands of Pakistan's ISI and *the narrative had totally changed*! The subsequent actions that followed were largely driven and assisted by the public opinion generated worldwide on various social media platforms. Social media drives public opinion which will drive decisions and it affects morale both in a positive and negative manner. Social media has also brought in major changes in the way the Armed Forces will function, lead and fight. The power of Social Media is both bad and good and the reach is unmatched. These days, a person is known by the number of followers he/she has on social media. As military leaders, we need to fully comprehend, harness and exploit this power and its reach.

New-age warfare is Multi-Domain Warfare and information and data are the drivers of power.

The proliferation of social media has exposed the limitations of policy and oversight which were present in the nation-state which had a regulatory framework. The younger generation connects through the social media as it does not merely give information, but interacts while giving information. The phenomenon of present-day "Breaking News" first explodes on WhatsApp or Twitter much before TV news channels. **Therefore, it is important for the Armed Forces to put across their version of the story first on the social media**. Social Media is a present-day reality which cannot be ignored by the Armed Forces and not responding to an adverse newspaper report is not an option in the present scenario. In fact, in today's digital-driven world, avoiding the social media may be counterproductive because rumours may begin to flow. And rumour is like butter; very easy to spread but difficult to un-spread. Perception is becoming more important than facts and it is very important that we in the Armed Forces connect on the social media. The fallout of social media is on equal measure on the Armed Forces also and there is a need to contain its negative fallout.

There are some inherent contradictions between the Military and the Media; while the former is secretive and centralized, the latter is open, flat, spontaneous and ubiquitous. These differences need to be resolved and there is a need in the Armed Forces to evolve and do these things timely. We need to engage over social media and there is a need to identify measures and guidelines for usage of social media. The low cost and high impact approach should be adopted for optimum results. ***Social media is gaining momentum at an exponential rate and the Armed Forces need to keep pace with these changes***, else we would be left behind. It has been acknowledged that information is a pillar of national power so it is logical that the Armed Forces be associated with it. A two-way communication between the

Armed Forces and society is imperative to project a correct image. We must convey to the people and, at the same time, we must be open to ideas. We must also leverage Social Media platforms to educate and empower the soldier. It is ***imperative to reach out to the soldier and to leverage the power of the social media***, without denying the use of Smartphones to our troops.

Perception Management and Social Media

William James had said "Thoughts become perceptions, Perceptions become reality; Alter your thoughts, alter your reality." Perception Management has been used in military operations under the ambit of Psy Ops in attempts to gain advantage over enemies. The goal is to alter the perception of the opposing party in a way that provides an advantage and can be used successfully to score a victory. This has now become an integral part of Info warfare. Militaries use social media increasingly and the UK has even raised a brigade (77 Brigade) specifically to deal with Social Media and Info warfare. Social media plays an important part in managing perceptions due to its extensive reach, speed and penetration. Exploitation of social media however needs to be handled with caution. Risks of social media-fuelled public relations disasters are very real. The ***risk of social media being used for unintended purposes such as brain washing, causing panic and unrest is real and needs to be guarded against***. It is of paramount importance for the state to monitor the social media and step in whenever anti-social elements attempt to twist or manage perceptions and the psychology of people. *If properly utilized, social media has been found to be highly effective especially in disaster management*.

The Government needs to actively use social media to correctly inform own population, gauge public sentiment, take feedback and initiate pre-emptive action. In today's fast-paced evolving scenario, social networking has become one of the foremost ways of

communication, both personal and official. ***Social media with its perils and boons is like a double-edged sword***. Since platforms like Twitter have enabled everyone to become a "citizen journalist", it is therefore being used in Psy Ops to spread rumours and misinformation. Issues particularly pertaining to the military are made viral on the social media to degrade morale and change public opinion. If the military does not tell its side of the story on the social media, people start believing whatever is being reported. Hence, military-public relations must have an active presence on the social media. *If we cannot even reach our countrymen through social media, then perception management through social media for warfare remains only a dream*. Social media is buzzing irrespective of our participation. By not participating, we are only favouring our enemies. It is time for the Armed Forces to do more in this field and act decisively and ride on top of this wave of Social Media, else we risk the threat of being swept aside or worse still, of being swamped by it!

Role of Social Media and Internet

The power hierarchy has changed due to easy availability, and democratization of information and social media has accelerated this change. There are over 200 million users of Facebook and WhatsApp in India itself. Amongst the presence of Global Defence Forces on Facebook, India takes the lead with the number of followers of the Army, Air Force and Navy being 11 million, 0.4 million and 1 million, respectively. The comparative figures for the US Army are 4.6 million, 2.7 million and 3 million, respectively. Fear may not be the answer to deal with technology and denying the Armed Forces access to social media may result in making them illiterate and unable to grasp AI, which will be a reality within the next 15 years. While fear is a defeating strategy, understanding and knowledge is a winning strategy. There is thus a need to optimally utilize this large presence of the Armed Forces on the social media platform.

5 G for Social Media and Armed Forces

5G or Fifth Generation mobile technology would provide a hyper-connected vision. 5G Network is envisaged to accommodate Apps and Services with different latency, reliability and bandwidth. 5G network can be used for multiple tasks like high speed fixed wireless access, industrial manufacturing, education and training, integrating public and private transport networks, public safety and disaster management and smart logistics management. The key differentiator will be greater connectivity, as an enabler for Machine-to-Machine **(M2M)** services and the Internet of Things **(IoT)** will be created. This vision may include a new radio technology to enable low power, low throughput field devices with long duty cycles of ten years or more. Next-generation Radio Access Technology sets specific targets that new radio interfaces must meet in terms of data rates (faster than 1Gbps downlink) and latency (less than 1ms delay). The Armed Forces thus need to be 5G network ready and there is a need to draw up an action plan for use of social media by them. Soldiers, leaders and children are all impacted by social media and hence it is our bounden duty to understand this platform and form a dedicated team to build expertise in 5G technology.

Social Media Strategy in the Armed Forces

The purpose of the presence of the Armed Forces on social media is to create a place for the organisation in cyberspace so as to create awareness among our countrymen and encourage connection with them. To ensure continued faith, the media content put out has to be credible, creative and interactive. World War III is likely to be a guerrilla information war with no division between military and civilian participation. While the mainstream media is defensive, high cost, low impact, with the user being subservient, in comparison, social media is offensive, low cost, high impact, inclusive, has instant reach, is user created and harvested and can be used as an effective

campaigning tool. Social media however has certain preconditions and intent which are generation of ideas leading to creation and sharing of content through networking and dissemination to influence Group Dynamics. The ecosystem involves a number of influencers, who could either be media houses, mainstream media, social media and veterans. The Indian Army is present on all social media platforms. Its largest audience is on Twitter which is the second fastest growing handle in the government category in India and is globally ranked ninth. On Facebook, it has the second-largest audience and is the fifth fastest-growing handle in the government category in India and is globally ranked third. On You Tube it is the fourth largest You Tube channel in the government category in India, while on Instagram, it is the top handle amongst all the militaries of the world.

Social media is a power which can be leveraged as it is the fastest means of passing messages, information and opinions; it contributes towards establishing a cohesive community and keeps a check on the internal health of an organization. It helps in curbing mis-information, in building goodwill and is an effective tool for internal communication. In order to shape initiatives, the Armed Forces need to establish truth, address aspirations, take few initiatives and course correction, reinforce linkages, create emotive and shareable content, which ultimately leads to *Image Projection*. The aim should be to keep the Armed Forces always relevant, propel institutions, honour our martyrs, curb misinformation, establish truth, give effective rebuttals, put forth human interest stories, build relations with journalists and editors, cultivate influencers and exploit alternate media like FM channels, regional media, AIR, Doordarshan and CRS.

Shaping of the Information Environment

Social media has taken major strides in this century and the security forces have equally benefited from its advantages and suffered from its ills. Social media has a wide landscape wherein large numbers of

media platforms are available today. The security forces need to adapt faster for getting the positives out of these platforms; hence, there is a need to work out a strategy and stay in tune with the latest technology advancement in social media platforms. The latest new holistic concept of perception management is the shaping of the information environment. It is a more elastic concept and most relevant in time and space keeping with technology update. If information voids are filled with a favourable narrative, then unfavourable information can also be changed into a favourable narrative for the security forces. To achieve this, the information fed has to be credible and timely to counter the unfavourable information narrative. The complete concept revolves around domination of the information space, which is where social media plays an important part.

The challenges of social media are that it can be exploited by inimical forces, groups and individuals who can enhance the scope of anti-Services sentiment. It is also very difficult to track and search for mischief-makers. At the same time, the security forces can also equally exploit the same social platform. To achieve this, the Armed Forces need to educate its troops to ***ensure awareness rather than make an attempt to control social media***. To counter misinformation, we need to work on an alternative explanation or narrative to prevent misinformation from being reinforced and ensure that the explanation given is simple and brief, and the language non-authoritative. The most important part is that ***time is very critical to react***. The way forward is to influence the media through own medium and narrative. Outreach needs to be carried out and linkages reinforced for image projection. The Armed Forces need to massively increase our presence in social media and leverage technology to synergise with subordinate formation HQ IW Cells. It thus entails a continuous cycle of shaping strategy, establishing linkages, increasing the reach of social media, leveraging technology and synergises to again shape strategy.

Effective Utilization of Twitter and Instagram by the Armed Forces

The use of Twitter is a revolutionary way of interacting on a social media platform. Twitter can be a resource for broadcasting important information, coordinating multi-agency efforts and getting help when crisis strikes. Twitter is live reporting, conversational in nature with a distributed framework, which can distribute the message at a very fast pace, connecting multiple agencies at a very big platform. It is being used for crisis management, voicing one's views, spreading ideas and create public opinion. The Armed Forces in India are on Twitter and they have a very large following. The images and short videos can be posted on Twitter which can then be shared very fast. It facilitates both passive exploitation, i.e., collection of information and active exploitation which entails engaging with the environment, conducting info operations and influencing them. Active exploitation could be done covertly or overtly as it allows engagement with key leaders, maintains contact with the target audience and helps contain adverse propaganda. However, it needs to be kept in mind that ***there is no control over the tweet once it has been sent and there is an inherent risk of conflicting versions*** being put out in the environment.

Instagram is however the medium of choice for the youth and upwardly mobile people, so it needs to be addressed. Mobiles have created a huge shift in the way people communicate and consume media. This shift can be broken down into three new consumer expectations; Immediate, Expressive and Immersive. Instagram has provided new features like comments, filters and controls whereby the user can manage and regulate the time spent on the Internet which facilitates control and monitoring and is of use to the Armed Forces.

Considerations for Deploying Social Media by the UK

In the UK, the Smartphone has overtaken the laptop as the device used by Internet users. Policymakers in MoD in the UK have begun

to understand the role of social media for the armed forces and their families. ***Access to social media influences the emotional and physical well-being of military staff.*** Enhanced contact with family can strengthen relationships and feelings of intimacy, but personnel may also be distracted by the concerns of family and loved ones. The British military's communications strategy has been modernised to better coordinate a full-spectrum approach. Amongst others, two key elements of this are Director of Defence Communications **(DDC)** (MoD) and 77 Brigade. The DDC provides leadership, coherence and governance to full spectrum communications across all Defence Board Standing Objectives, using all available internal and external channels. It oversees relations on behalf of the MoD, with communications organisations within NATO, UN, EU other international bodies and allies. Overseeing defence identity and brand policy including those of Single Services is done in association with the Directorate of Intellectual Property Rights. The British 77 Brigade **(Bde)** is however structured to execute operational outputs.

Social Media Exploitation. Social media should be exploited to support tactical actions. To maximise the utility of social media, it needs to be used socially. It should not be used as another delivery platform for traditional media products and press releases. ***Social Media exploitation*** can be divided into two categories—***Passive and Active***. Passive exploitation entails Intelligence preparation of the environment, monitoring and collecting intelligence or insight. Active exploitation, on the other hand, involves engaging with target audiences and conducting messaging and influence activities. Passive exploitation can be used for the collection of intelligence and insight. This is Open Source Intelligence collection activity and is not necessarily Information Activity. It can however give information about activities. Intelligence is provided in terms of near real-time situational awareness, Early warning indicators, Threat assessment, Collateral damage assessments and Battlefield damage assessments.

Target Audience Analysis serves as an input to inform about future Information Activities. These can be in the form of Content preferences, etc., Profiling of individuals/groups or organisations, Deeper understanding of adversaries ideology, Narratives, Key influencers and Demographics.

Active Exploitation. Active exploitation is the area that can offer the most noticeable outcome. This is where one can influence a target audience's attitudes and perceptions. It can be done overtly or covertly, and in support of one-off event-based activity, short term or persistent. This involves engaging with key Leaders and setting conditions prior to real-world engagement. We need to identify the levers of influence and maintain persistent contact with target audiences. Adversarial propaganda and narratives need to be countered.

It however needs to be considered that for Information Operations conducted online in support of tactical activity, there is no guarantee that they will remain at the tactical level. ***Once the content is out in the social media, no one has control over it any longer***. However, this should ***not be something to be worried about*** it, because it is just the Internet. Any activity conducted in support of a tactical activity must be approached holistically and must be consistent with messaging and with the activity conducted at the strategic and operational levels. Information Fratricide is a reality that needs to be guarded against.

Challenges for Deploying Social Media for Military Use

Bandwidth and IT Infrastructure. Besides ensuring availability of bandwidth, sufficient IT infrastructure and Internet bandwidth must be available at the tactical level to conduct the level of activity required to be effective. We need to be able to collect, create and disseminate content. This needs to be resourced sufficiently and the infrastructure needs to be protected and hardened from adversarial

action. In peace enforcement operations, infrastructure might be available at the tactical level due to permanent locations. However, in conventional conflict, it is extremely unlikely that there would be the infrastructure available at the tactical level.

Language and Culture. Language and culture other challenges. Despite sharing a common language, a lack of cultural understanding can result in unintended consequences and an inability to communicate messages properly. We thus need to find the individuals who have the correct language skills and cultural awareness to be able to convincingly and effectively engage in conversation with target audiences. Such individuals are likely to be found in the theatre and not at Service HQs. Thus, we need to decide whether we will make use of contractors or locally employed civilians.

Responsiveness. Responsiveness is the keyword in Info Operations. It was stated that the US WebOps based at CENTCOM believe *you only have around 15 minutes to engage with a story, before the initiative is lost* and you lose the opportunity to control the narrative. We need to empower units or organisations that are conducting Social Media exploitation to react when required. Formal boarding of every individual message will reduce effectiveness. They need mission command, but be given clear direction what their left and right of arcs of fire or bounds are, i.e., what can and cannot be said and done (including lines to take, narratives, etc). Like we give a soldier a loaded weapon and trust him to operate it within the Rules of Engagement, we must be able to trust our soldiers with a keyboard and Twitter account, after we provide our Armed Forces with the appropriate training and direction. The policies designed need to be robust enough to prevent the Armed Forces from breaching legislation, but flexible enough to be usable with evolving and emerging technologies. These also need to be updated regularly.

Options to Conduct Online Information Activities

Overt vs Covert. Online information activities can be conducted in an overt or covert manner or in a combination of both. Overt action provides you with authority, credibility and consistency, but only with certain audiences. It is a matter of conjecture how target audiences will react to overt messaging from a military organisation as people already have an established bias. Overt ops have less legal/policy constraints and there are lesser training requirements as there is a lesser need to obfuscate our digital footprint. Covert Ops provides the option of Grey or Black information activities and there are no established biases. These can be used to amplify white information activities. Messaging can be more irreverent, less formal and more attuned to what resonates with the target audience and can be more passionate and emotive. However, Covert Ops comes with a heavier training burden (tradecraft, etc.). Irrespective of the option we choose, we need to have things in place as it will take time to create credible profiles and place them within desired groups and therefore work must begin in that direction.

Policy Options for Exploiting Social Media in Indian Armed Forces

Fleet-Footedness and Nimbleness. The first principle in the use of social media is fleet-footedness and nimbleness. However, in the tradition-bound Army, change does not come easily to us. There is a need to leverage technology, social media and networks by the Indian defence forces. Social media and social networks use web based and mobile technologies which turns communication into an interactive dialogue with the aim to connect people with common shared interest. Social media usage in the Indian defence forces is in the form of perception management, open source intelligence, engagement with public and real-time situational awareness. Situational awareness is required during aid to civil authorities

and disaster management. Social networks can be utilized by the Forces for dissemination of information, engagement with service personnel, veterans and their families.

Security Aspects. Social networks can be utilized for dissemination of information which should be non-operational in nature, educative and for countering misinformation. While on social media, it is very important that the security aspects are taken care of by the organization as well as the users since these platforms are vulnerable and can be misused. No one is anonymous on the Internet and we must be careful while airing our grievances or defending our point of view on social media.

Big Data Analytics and Social Media Mining

Four V's of Internet. The four V's of Internet, .i.e., Volume, Variety, Velocity and Veracity are the key challenges for Data Analytics. There is 40 Zeta Bytes (One Zeta Bytes being equal to 10 to the power of 21 Bytes) of data which the analyst has to sift through. When a pattern is established, a lot of Intelligence can be found using Big Data Analytics. Big data analysis is both a challenge and an opportunity because of data explosion and diverse sets of data which need to be analysed to make any sense of it, i.e., in the cognitive domain. The process of big data analytics involves large data volumes, high data velocity, variety of data and proper data veracity. An additional challenge for the Armed Forces is that data needs to be collected by user agents, i.e., crawlers—which is a bandwidth, storage and time intensive proposition. The other option is to buy data from data aggregators. One of the most important facets of this analysis is predictive analysis which is extensively used for preventing crime and the same can be used for the Armed Forces requirements, like predicting areas susceptible to infiltration. Threat vectors are using non-traditional communications. Where an analyst should look is important as there are many alerts and hidden signals in the noise.

Lack of actionable Intelligence makes it difficult to translate technical findings to leadership and take action. Analytics thus aims at scale and speed in real time to persistently produce tactical insight. The solution should thus have Flexibility, while being stable, Support numerous integrations, be mission specific, Provide cognitive insight, Security and Anonymity.

Social Media Dynamics in the Extended Armed Forces Family

Training. In 2015, the Indian Army had contracted IBM to do Pro Bono work to find out what ails the Army. The sentiment analysis carried out provided deep insights and one fact emerged that everyone either has a grievance or contributes to it. The same or similar sentiment would most likely be there in the other two Services also. So there needs to be a mechanism to address the anguish integral to the organization. We need to have a group of experts/specialists/sociologists to work out specific campaigns, for example, to justify AFSPA, etc. The manpower for this could either be from inherent resources or hired on an ad hoc basis, to enable projection of issues in a proper manner. Training on use of Social Media needs to go down to the grassroots level.

Safe Use of Social Media. Threat to data security and privacy is real and data mining needs to be done. The content is available online to friends and enemies. Social Media at times provides a false sense of connection. The reach of social media is dependent on carriers and at times, the target audience is not fully addressed. Mistakes, when they happen, will go viral and hacking of accounts for misuse is a threat to be guarded against. There are few limitations of existing policies in the Army besides being restrictive. There is no legal mandate of monitoring/blocking anti SF content. There is a need for integration in agencies managing cyber issues and structures and policy to exploit and monitor social media is lacking. The Armed

Forces could consider following the US model and encourage safe use of social media by our soldiers with clearly laid down restrictions.

Recommendations

At a time when the liberalised availability of frequency spectrum has led to the proliferation of social media, which in turn is changing rapidly and having a huge impact on all aspects of functioning of the Indian Armed forces, the key recommendations on optimally utilizing this platform are appended below:

(a) **Organization and Structure**. Due to the vast scope of social media, there is a requirement to assess the organizational structure for effectively leveraging all aspects of social media.

(b) **Dissemination of Policy Guidelines**. The policy guidelines on usage of social media should be simple and easily implementable by defence personnel, with the aim being 'education and regulation'.

(c) **Hiring Social Media Professionals**. As in-depth technical knowledge of using and leveraging various platforms is required, the IW core group should remain with the defence personnel, but specialized tasks should be carried out by hiring information warfare experts from the industry.

(d) **Creation of Core Groups for Media Campaigns**. Running of successful campaigns needs content generation by experts and specialists. A core group of such experts, with continuity, needs to be created for campaign management. The core group should have full knowledge of the requirement of apex leadership, which will accordingly be manifested in the campaigns.

(e) **Policies, Procedures & Regulatory Framework.** The use of social media is one of threats and opportunities; however,

there is a need to effectively operate in this space. There is thus a requirement of detailed policy guidelines on the usage of social media by members of the Indian Armed forces personnel with effective oversight mechanisms in place. These should not be restrictive but enabling in nature.

(f) **Leveraging the Veteran Community**. The Indian Armed Forces have a huge veteran community who should be an intrinsic part of our social media warriors. We need to reach out to the veterans so that their aspirations are understood, solutions provided and a correct message is spread among the masses.

(g) **Training.** Meaningful and effective training needs to be carried out for educating all ranks and the families of Armed Forces personnel to make them aware of the risks and opportunities of social media.

(h) **Specialized Training & Longer Tenures**. Social media brings a host of vulnerabilities, especially for persons holding sensitive appointments. Specialized training needs to be organized for such personnel on a regular basis. Personnel holding such appointments also need continuity.

(i) **Hosting Armed Forces Unit Pages on Facebook**. Hosting of unit pages on the Facebook could go a long way in bringing to the fore the rich history, traditions and accomplishments of our defence forces and raise the morale of defence personnel.

(j) **Coherent Social Media Campaigns**. For running successful social media campaigns, the campaigns have to be run at all levels of our hierarchy in not only all the three Armed Forces, but also in related departments in the GoI. The complete organization including the veterans has to be incorporated in the campaign to achieve victory in this space.

(k) **Mobile Applications for Veterans**. Though the Armed Forces have launched a few apps for use by serving personnel, the veteran community feels left out. The Armed Forces could consider launching mobile apps to engage with the retired fraternity also. These apps would be an easy way to spread the right message and dispel any false propaganda by anti-national elements.

(l) **Big Data Analytics and Artificial Intelligence**. Social Media platforms are a rich source of information which can be used by the defence forces in furtherance of their operational objectives. Important information can be mined using big data analytics and prediction analysis carried out using artificial intelligence. When a pattern is established, a lot of intelligence can be found using Big Data Analytics. Data Analytics aims at scale and speed in real time; persistently produce tactical insight. The Armed Forces need to train defence personnel on priority in these two domains to fully exploit the power of social media.

(m) **Use of Roman Hindi & Regional Languages.** Like the print media, social media is active at a large number of regional forums in various languages. Hence, exploitation of all regional forums is essential in the Indian context.

(n) **Speedy Response; Delegation to Units**. Centralized structure for responding on social media cedes space to anti-national elements to spread false propaganda. Speed of social media is too fast to be handled by our structures. Our structures and procedures for according approvals for social media need a relook and delegation at the functional level is required.

(o) **Strategy for Social Media**. The Armed Forces need to work out a detailed strategy for leveraging the social

media domain encompassing all aspects of organizational structure, training, human resource, oversight mechanism and its integration with the operational domain.

(p) **Conceptualizing Social Media Campaigns**. Conceptualizing and running a successful social media campaign requires detailed planning and content generation. This requires the assistance of experts who have in depth knowledge of the subject of the content that is being generated. Personnel following up such campaigns need continuity in their appointments.

(q) **Specialization Training for Social Media.** The rapid changes and advancements in technology has huge spin-offs in the Defence domain. There is a need to undertake specialized training for social media to examine all the means by which it can be leveraged as an important domain of information warfare.

(r) **Industry Collaboration to Leverage Social Media for the Armed Forces**. Some of the aspects in which the industry can help out are:

(i) ***Glorifying our heroes*** using social media platforms such as Facebook, Twitter to run positive social media campaigns in support of the defence forces. Making 'Follow our Heroes Campaigns' is an example of one campaign. More such initiatives must be supported like comics, apparel, etc.

(ii) ***Highlighting the Good Samaritan work*** by the defence forces in support of the common man as part of 'Winning the Hearts and Minds of the People'. Initiatives such as 'Op Sadbhavna' being implemented by the Indian Army in J&K, need to be brought to the knowledge of the entire world.

(iii) ***Launching Recruitment Campaigns*** on all social media platforms to help in recruitment of suitable candidates. Such campaigns should thus focus on the benefits that the prospective candidate is likely to get rather than focusing only on adventure and hardship.

(iv) ***Employment of Veterans*** by the industry for running social media campaigns for the Indian Defence Forces will also increase collaboration with our veteran community towards common goals and give them employment. The veterans have in-depth knowledge of the functioning and requirement of the Armed Forces which can be leveraged by both the industry and the defence establishment.

Conclusion

Social media has revolutionised global communication and professional discourse. One of the most potent impacts of the latent influence of social media was the ushering in of the people's revolution or the Arab Spring and the number of regime changes that this led to. The reach and unstoppable power of social media has forced the world to acknowledge it as a powerful weapon in shaping and influencing opinions. It has demonstrated a capacity for penetration that is historically unprecedented, especially compared to other means of communication.

Existentially, the Armed Forces and social media are at the opposite ends of the spectrum when it comes to access to information openness and freedom of expression. Security of information, which is paramount, marks most of the actions of the Armed Forces, while free access is the central theme of social media. However, this historic and fundamental divide must be bridged effectively if the Armed Forces were to remain contemporary in this information age. How the Armed Forces would walk the middle path between the need

to keep things secure, vis-à-vis maintaining information dominance would be crucial.

Everyone is enjoying a direct connect with the entire spectrum of society, organisation, and administration and everyone seems accessible. This has however led to citizens bypassing existing structures and hierarchy. It is a new exciting phenomenon in a nation like India built around classes, hierarchy, and barriers in official or personal interactions. By virtue of their operational philosophy, the Armed Forces need to be more rigid and compartmentalized in their functionality. In this regard, social media, on the down side, has now opened avenues for all the rank and file to air their opinions, views, cribs, criticism, and target individuals and organisations jumping the hierarchical ladder. Successful conduct of operations and safety of our personnel is non-negotiable. Therefore, we need certain policies for optimum exploitation of the social media. It is also important that government policies must be able to adapt with every changing social media environment.

Future conflicts will occur in increasingly connected and networked environments, which will be characterised using new communication and information technologies, including social media. The utilisation of social media during a conflict adds and enhances the conventional tools of mass media for propaganda, influence and deception activities. Thus, control and acquisition of data has become as vital as gaining new territory or dominance over a region. Some of the key issues for leveraging Social Media to boost the Armed Forces, specific to our demography and operational philosophy, would be bringing about a change in the mindset, re-evaluate existing organisational structures, set up social media monitoring centres, provide specialised training for sensitive appointments, educate military families, leverage the veteran community, Big Data Analytics and create seamless policy guidelines factoring for an oversight mechanism. Social Media is a potent tool

of the new age Multi-Domain Warfare and information and data are the drivers of power. *As military leaders, we need to fully comprehend, harness and exploit the power and reach of this Genie which has been unleashed; it definitely cannot be put back inside the lamp so we might as well learn to tame it and use it for our benefit.*

7

Defence spectrum requirement—analysis of responses

Introduction

In order to ascertain the views of the concerned communities, a questionnaire was formulated to carry out an appraisal of the present and futuristic frequency spectrum requirements of the three Armed Forces to facilitate optimal utilization of the Defence Band. The same is placed at **Appendix 'A'.** It was circulated and the respondents (of diverse rank and file) were requested to provide free and frank responses to the questions listed in the questionnaire and also to provide any additional input/views not covered in it.

The aim of the questionnaire was to obtain views/counter-views of the relevant community on the subject, to facilitate a viable research outcome. The personal views of the respondents to the questions were sought instead of organizational views; however, consolidated single responses were also received from a few organizations/directorates. Responses were sought from a total of 270 respondents out of which 136 responded. The details of the organizations/Service HQs/Category A Establishments to which the questionnaire had been circulated and the summary of responses received from various organizations are tabulated at **Appendix 'B'**. Subsequently, a slightly

differently worded questionnaire was formulated to seek inputs on the subject from Subject Matter Experts **(SMEs)** and from officers who had earlier served in the JCES Dte or had domain knowledge in the field of frequency management. The same is placed at **Appendix 'C'**. During the course of this study, a large number of seminars and conferences were also attended and the details of the same are placed at **Appendix 'D'**. The responses to questionnaires and interaction during various seminars provided considerable inputs on various issues and the question-wise analysis of the responses received is presented in subsequent paragraphs.

QUESTION-WISE ANALYSIS OF RESPONSES

Question 1: Shaping Nature Of Wars

On the attribute which is most likely to shape the nature of wars in times to come, the majority of the respondents said that Hybrid Warfare (to include Information Communication Technology (ICT), Space and Cyber Warfare), is the attribute which is most likely to shape the nature of wars in times to come as human resources in developing countries are becoming scarce. Hybrid warfare uses coordinated military, political, economic, civilian and informational instruments of power that extend far beyond the military realm and is thus the universal favourite. A few respondents listed more than one attribute (according equal importance to them) while others listed other attributes like Leadership and Water and stated that each attribute has varying significance during different phases of war. The summarized responses are tabulated in Table 7.1. It can thus be reasonably concluded that *in addition to* ICT, Space and Cyber, the other attributes that are also likely to shape the nature of wars are:

(a) Initial Phase—Hybrid Warfare to include ICT, Space and Cyber Warfare.

(b) Contact Phase—Conventional arms superiority including Aerospace and Naval power.

(c) Culmination Phase—Nuclear Deterrence.

	Conventional arms superiority	**Nuclear deterrence**	**Aerospace power**	**Naval power**	**Hybrid warfare**	**Any other**
ADGMO(IW)	(a)	(b)	(c)	(d)	(e)	(f)
ADGMO(IW)	1	1			3	
DG Sigs					1@(Consolidated response)	
DG Air Ops		1	1		6	1
ACNS(CSNCO)		1		2	4	
Sig Int, HQ IDS	1	3			14	1
Tech Int , HQ IDS					1@(Consolidated response)	
DSSC	2	1	1	1	9	3
CDM	1				7	
AWC	7	2	3	2	20	3
MCTE	3	1	3	2	38	2

Table 7.1: Summarized Responses for Question 1

Question 2: Attribute With Maximum Bearing

On being asked which of the attributes listed in Question 1 had the maximum bearing on all other attributes of force projection, though the majority voted for Hybrid Warfare to include ICT, Space and Cyber Warfare, yet there were other interesting responses. A couple of officers stated that force projection by a nation state is governed by the Naval Power and Conventional Arms Superiority possessed by the nation. Below the red line of the nuclear war threshold and minor skirmishes for dominance, there is a wide gap available for manoeuvres. It is in this gap that conventional forces would have the maximum impact and are thus an important attribute of force projection. The irony is that due to the proliferation of technology

and ICT into all weapon platforms, the efficacy of Conventional Arms Superiority is actually dictated by:

(a) Possessing the said weapon platforms.

(b) The standard of training and expertise in handling the same (a case in point was the outcome of the recent aerial dog fight between Pakistan's technologically superior F-16 and India's Mig-21, piloted by Wg Cdr Abhinandan).

(c) The ability to effectively leverage Social Media platforms to create favourable narratives and change perceptions (i.e., winning wars without actually waging them).

(d) The freedom to be able to use these weapon platforms in a battlefield subjected to intense Hybrid Warfare.

While the first two factors listed at paras 4(a) and (b) above are a measure of a nation's economic ability and training threshold, they can be undone by the third and fourth factors. It will thus not be incorrect to state that ***in future high tech wars, the efficacy of Conventional Arms Superiority will actually be dictated by its expertise in leveraging Hybrid Warfare to include ICT, Space and Cyber Warfare.*** Hybrid Warfare has the maximum bearing on all other attributes of force projection because in today's military scenario, military force projection cannot be viewed independently and should be analysed considering foreign policies, economic growth and technological hold as a world power. So by dominating ICT, Space and Cyber domains, a nation would gain control over the economy and functioning of a nation, which by default gives supremacy over military force in terms of Arms and Weapons. The efficacy of all these realms of Hybrid Warfare is dependent upon the frequency spectrum available.

Info gathering, processing, analysis, filtering and dissemination will form the basis for any future conflict. ***Communication network integration with all the three Services, as also with the government,***

***especially in spheres of ISR, will thus be a critical operational impediment**, which will in no small measure be dictated by the **availability of frequency spectrum.** Acting first on information gained, duly processed and shortening the commanders' OODA loop has to be the aimed manifestation.*

Question 3: Global Power Projection

Respondents were given an array of options and were asked to identify the main reason why developed nations like the USA, Russia and the UK are able to effectively project their power globally. This generated interesting and wide-ranging views on the subject. The effective global power projection capability is a result of strategic culture fostered by the nation as a whole and political will. The same is however helped in no small measure by effectively leveraging ICT to augment all facets of warfare. The respondents found that the factors listed were complementary to each other and no single aspect could be singled out as of higher precedence. The reasons were attributed to various tangible and intangible factors as explained below:

(a) **Tangibles**

- (i) Ad hoc/semi permanent/permanent alliances.
- (ii) Bases across the globe giving extended reach.
- (iii) Availability of carrier-based battle groups.
- (iv) Effective projection of aerospace power.
- (v) Effectively leveraging ICT to augment all facets of warfare.

(b) **Intangibles**

- (i) Political will.
- (ii) Foreign policy.

A few of the respondents felt that the reason why developed nations like the USA, Russia and the UK are able to project power

globally is because of their ability to integrate naval and air forces with land armies as part of joint warfare. Their airlift and sealift capabilities facilitate the deployment of soldiers and weapons to a distant theatre of war. The aircraft carrier strike group, strategic bomber, ballistic missile submarine, and strategic airlifter are all examples of power projection platforms. ***Light and Mobile military units*** such as airborne forces (paratroopers and air assault forces) and amphibious assault forces, are utilized in power projection. ***Forward Basing*** is another method of power projection, which, by pre-positioning military units or stockpiles of arms at strategically located military bases outside a country's territory, reduces the time and distance needed to mobilize them. Both these capabilities, however, require command and control to be exercised through robust, reliable and resilient means of ICT, which in turn requires adequacy of frequency spectrum.

It will be safe to state that the question is complex and demands a nuanced response. Real Politik, Geo-political/Geo-strategic aspects and the economy too need to be considered. A single reason cannot be attributed for any nation to be able to project power globally and it is a combination of all the attributes listed. *Technology is however important as else nations will always be playing 'catch up' with the developed nations. There is a need to invest in technology and in learning new techniques. Network is an enabler and needs to be synergised with all resources of national power.*

Question 4: Net-Centric Warfare

On being asked whether Net-Centric Warfare has been correctly leveraged by developed nations like the USA, Russia, China, France and the UK and its relevance in the Indian context, affirmative responses were received. Developed nations have adequately leveraged NCW to best suit their requirements. NCW is very much relevant in the Indian context and already steps towards the same

have begun at strategic level where the Government has approved the creation of three new formations, i.e., Defence (**Def**) Cyber Agency, Def Space Agency and a Special Operations Division, under the aegis of HQ IDS. However, there is a need to flesh out these organisations to maximise the potential of the system.

In militaries of advanced countries, roadmaps for NCW have progressed in two dimensions simultaneously to enhance the overall war fighting capability. One is the network dimension, referring to the physical systems providing connectivity between sensors, commanders and those involved in engaging the adversary, and the second dimension is the human dimension road map. Developed countries such as the USA, Russia, France and the UK have adequately established their dominance in the NCW domain in the recent wars in Iraq, Afghanistan and Syria.

Employment of NCW by the USA in Iraq and by Russia in Syria. During the US campaign in Iraq, which was possibly the first war to be telecast live into the living rooms of the common people back home, the results of effective use of NCW by the USA was seen by the world. Later on, in Syria, within two-weeks of Russia's Aerospace Forces starting their operations, Moscow-based military-diplomatic sources were explaining to media that the use of Su-34 jets to strike targets was an important feature, which also highlighted the network-centric dimension of some air operations. These platforms were network-enabled and were operating on a single information network. The Su-34 had been fitted with the TKS-2M communications and information management system, which allows data targeting coordination with automated output on electronic maps without depending on ground command posts.

Relevance of Net-Centricity in the Indian Context. Future conflicts are expected to be short, fast paced and intense. In both pro-active and reactive roles, early prediction of information would be the key to success. Information has become time sensitive

and continuous and thus all respondents felt that NCW *or Net-Centricity was relevant* in the Indian context to meet future security requirements. Nearly 11 per cent of the respondents said that with aspirations of becoming a regional power in the near future, India should pitch its NCW resources and efforts at the *Global Level* in an escalatory manner. Another 58 per cent of the people surveyed however said that NCW is relevant at the Regional Level in India's context while 26 per cent supported the relevance at the National Level. The remaining 5 per cent were unable to comment on the subject. It would be right to state that for India, NCW needs to be coordinated at the Global Level, controlled at the National Level and executed at the Regional Level. ***All however agreed on the fact that acquiring this NCW capability entails availability and judicious management of scarce frequency spectrum.***

Question 5: Preferred , Responsive And Resilient Communication Medium

On this point, the majority of the respondents, irrespective of the colour of their uniform or their affiliation to any particular arm/ branch of Service, said that the wireless medium, using frequency spectrum, was the preferred medium to effectively utilize mobility, speed and next generation technology, i.e., 5G and IoT. Though fixed wire communication cables (preferably OFC) has been and will always remain the most secure means of transmission medium, yet hostile terrains and oceans and ***fluid battle fields require wireless connectivity***, for which highly directional transmission/reception antennas are envisaged to minimize the effect of adverse interception and analysis.

Based on an analysis of the responses received, It can be safely stated with conviction that a network-centric approach to warfare links all military assets to each other and to decision-makers via computer, radio, and data networks, enhancing the way military

objectives are accomplished because of information superiority. In addition to communication systems, there is a requirement of having a dedicated frequency spectrum for surveillance grid, weapon system (missiles) and mil satellites and UAVs. Here again we see an **increased *requirement of dedicated frequency spectrum.***

Information sharing and collaboration enhances the quality of information and shared situational awareness. Shared situational awareness enables self-synchronization. These, in turn, dramatically increase mission effectiveness. Doing so requires a true military-grade wireless network that must provide continuous communication to stations in motion and stationary personnel, vehicles, and equipment, keeping commanders and troops always-connected, secure access to applications and information and improving situational awareness and mission effectiveness. ***There is an inescapable requirement to have a dedicated frequency spectrum to meet the genuine technological needs of the Armed Forces.***

One medium of communication cannot be relied upon completely as each has its inherent advantages and disadvantages. Though wired media carries a large bandwidth and is resistant to jamming, yet it is crippled due to cable laying time and down time during failure/ outage. The wireless media, on the other hand, is quickly deployable but has limitations of BW besides being susceptible to EW. Hence, backbone connectivity up to own borders should be on wired media and thereafter wireless media should extend into the TBA. Redundancy of each wired and wireless link needs to however be planned with overall BW requirements of the end user/formations.

To conclude, wireless medium using frequency spectrum is the most preferred in TBA. It will be the order of the future warfare where a plethora of sys will require the necessary bandwidth to connect to a cloud, especially mobile communication systems with high bandwidth that will enhance the effectiveness of combat elements in TBA with a healthy mix of CNR in the form of SDRs or

cognitive radio along with high bandwidth backbone networks. This could be backed by robust and secure fixed wire communication infrastructure to cater for contingencies.

Question 6: Areas other than Comn Sys Requiring Dedicated Frequency Spectrum

With the advent of technology, the majority of the arms/Services have upgraded to wireless forms of communication, weapon delivery platforms, and surveillance, reconnaissance and navigation systems. A few active subscribers of the frequency spectrum are listed below:

(a) **Infantry**. Surveillance Radars, Remote Explosive Devices, Hand-held UAVs.

(b) **Armoured/Mech Infantry**. Communications, Target Acquisition, Reconnaissance and Navigation systems.

(c) **Signals**. Communications, Electronic Warfare, Cyber Warfare, Signal Intelligence, Electronic Intelligence, Data Processing and NCW grid.

(d) **Artillery**. Target designation, Remotely delivered munitions, Missile delivery, UAV and its payloads, Surveillance, Target Acquisition and Weapon-locating Radars.

(e) **Engineers**. Remote Bomb/Mine/ Explosive Detection and Detonation Devices.

(f) **Army Air Defence**. Radars, Guided Munitions, Identification of Friend or Foe (IFF).

(g) **Army Aviation**. UAV and its payload.

(h) **Intelligence**. Satellite Imagery and Counter Intelligence.

In addition to communication systems, there is a requirement of having a dedicated frequency spectrum for surveillance grid, weapon system (missiles) and military satellites and UAVs. The

requirement of frequency spectrum for military purposes may be broadly categorised into the following:

(a) **Communication.** These requirements are generally well understood and comprise all systems which enable communication between the various entities of an organization.

(b) **Non-Communication**. The Non-Communication requirements of frequency encompasses a wide range of activities and platforms which include but are not limited to the following:

(i) Air Defence Radars.

(ii) Aerostats.

(iii) BFSRs.

(iv) Weapon-Locating Radars.

(v) RF fuses of precision munitions.

(vi) Navigation Systems.

(vii) IR-seeking Missiles.

(viii) Identification of Friend or Foe transponder systems.

(ix) Radio control systems (UAVs, RPVs, etc.).

Question 7: Efficacy of Promulgation of the Defence Band for the Armed Forces

About 32 per cent of the respondents were unable to respond to this question, due to inadequate knowledge. The remaining 68 per cent however gave considered responses. Of these 68 per cent, a few respondents felt that the promulgation of the Defence Band and the resultant delineation of the spectrum for defence and commercial purposes provides immense benefits to defence in formulation of policies and GSQRs for procurement of various

EM-related equipment. The balance of the respondents however opined that the promulgation of the Defence Band has not been able to meet the requirements of the Defence Forces in a holistic manner. A few respondents also felt that the promulgation of the Defence Band was primarily driven by commercial considerations rather than a genuine assessment of defence needs and equipment profile of the present and the future. A minority of the respondents also felt that DB has neither been able to impart the due impetus in procurement of eqpt for in-force development nor has it been able to meet the requirements of the Armed Forces, due to the reasons given below:

(a) **Erstwhile Major User Status**. Prior to 2008, prime importance was given to national security and, accordingly, the Armed Forces enjoyed the status of major user of spectrum. Based on this philosophy, procurement of eqpt was carried out and the Armed Forces have inducted a variety of in-service eqpt over the years, including Radio Sets, Radio Relays, EW sys, UAVs, Tactical Communication Networks Systems, Tropo Systems, Surveillance **(Svl)** Sys, Radars, etc., which use spectrum for gainful utilization. Post promulgation of def band, in-service eqpt has been found to be using spectrum outside Def Band, as enumerated by the Def Band policy letter. Def Band promulgation does not address the issues pertaining to usage feasibility of such in-service eqpt. *(Though defence was given a certain period of time to migrate its systems to the delineated portion of the defence band, yet wherever the same was not feasible due to the constraints of eqpt profile/legacy equipment, JCES HQ IDS has approached WPC for a waiver to be accorded and in many case permission has been given by WPC to continue operating in the earlier frequency band which now falls outside the Def Band)*.

(b) **Equipment Under Procurement**. Def band promulgation was done on March 15. A number of capital procurement **(proc)** schemes involving proc of eqpt using spectrum were initiated much before its promulgation and were under various stages of procurement at the time of promulgation of the Def Band. WPC has not allocated freq spots for such eqpt when applied for, at the trial/induction stage post promulgation. Delay in allocation of freq spots for such schemes not falling under def band impedes force modernisation. *(This aspect is partially true as though a blanket allocation has not been given, yet on a case-to-case basis, WPC has allotted freq spots for such projects.)*

It was also opined that due to the DB, there is the limitation of constraining the GSQR's of the equipment to within the DB. The optimal operational capability of the equipment may be constrained/ compromised due to the limitation of working within the DB.

Once the provisions of the Union War Book are invoked, the Armed Forces are not required to operate solely in the DB. However, the equipment which is procured during peace time does not factor in the same, which needs to be reconciled. Also, in mountainous terrain and High Altitude Areas (HAA) there is a requirement of several frequency spots in the sub GHz range and the same needs to be catered for.

However, a majority of the respondents agreed that the advantages which accrued due to the Def Band are:

(a) Import of eqpt working in the def band, for use by only the Armed Forces.

(b) Exclusivity in development of eqpt in def band is now feasible.

(c) Resolution of spectrum conflicts with civilian users has been streamlined through harmonization, i.e., civilian

users have been shifted out of def band and def users have been shifted into the def band.

(d) Usage by def users outside the def band is also possible now with suitable justification.

Question 8: Change in Procedure for Freq Allocation for Def Post Promulgation of DB

About 63 per cent of the respondents were unable to respond to this question, due to inadequate knowledge and having had no experience in this niche field. The remaining 37 per cent of the respondents however gave considered responses. Of these 37 per cent, a few respondents felt that no significant improvement had been observed in the procedure of frequency allocation to the Armed Forces post promulgation of def band as it still remains the same. They also felt that the filing of applications is still being undertaken at WPC wing of MoC and WPC continues to be the single-point authority for allocation of freq spots (within def band) to defence forces, even after promulgation of the def band.

However, the majority of these 37 per cent respondents felt that as exclusive frequency bands are now available for defence, hence the demand and allotment of freq spectrum would be based on them. The procedure for frequency allocation has also improved due to the resolution of conflicts pertaining to spectrum within the defence users being resolved at JCES level itself and with those pertaining to civilian users being resolved at WPC level. However, WPC continues to be the single-point authority for allocation of freq spots even within def band.

Question 9: Adequacy of Spectrum Earmarked in DB for Armed Forces and Instances of Conflict

In this question, inputs had been sought on two aspects, each of which is elaborated below.

Adequacy of Allocated Frequency Band.

Firstly, in response to whether the frequency spectrum earmarked for the Armed Forces, as promulgated in the Def Band, was adequate to meet the present and future requirements of the Armed Forces, the views were divided. A few respondents felt that the promulgation of Def Band had been done keeping in mind only the present requirement of frequencies considering the family of radio equipment. It is however likely that an increasing shift of future warfare into network-centric and net-centricity domains would demand more allocation of frequency spectrum. The majority however opined that post promulgation of def band, though 32 per cent of overall spectrum had been earmarked for the Armed Forces, yet the allocated bands are not contiguous and not sufficient especially in HF/VHF/UHF bands. The concentration of the usage of EM of various equipment to a narrow frequency spectrum results in offering a vulnerable target for enemy ECM, which needs to be addressed. Thus, frequency allocation for defence needs to be dispersed more widely in various bands.

The frequency allocation for defence may seem adequate for the present but is inadequate to meet future communication requirements of the Armed Forces. The IAF Satcom projects would need additional band with (BW) and spectrum as the number of airborne assets of the IAF have increased considerably due to the induction of AWACS, Aerostats and Drones. The Army's use of UAVs is also likely to increase. There is a shortfall in the frequency spectrum available for LTE and the same will be grossly inadequate for future expansion. There will also be a requirement in the future to use frequency spectrum above 40 GHz bands, especially by the IAF.

Instances of Conflict. Post promulgation of the Defence Band, the major disagreement between DoT and MoD was over the extent of spectrum to be vacated in the highly valued 1700-2000MHz band

that is currently shared with telecom companies for their 2G services. This has since been resolved due to the harmonization carried out. A few Government public services are utilizing freq spots in the portion of def band, in certain locations, based on coordination carried out by all the three Services and vetted by JCES, HQ IDS. However, such occurrences are rare. The parts of Defence Band which have been allotted for commercial purposes for 3G proliferation would possibly need a re-look in the future. In addition, India has not adopted the "NATO Band" for their defence spectrum requirements. This has resulted in a situation where the cost-effective commercial equipment bought by India from these countries, falls in a non-NATO spectrum band, of which a significant part of this overlaps with the Indian Defence spectrum bands. This is therefore a crucial reason leading to serious conflict of commercial public telecom services with the defence spectrum bands.

Question 10: Maint of Judicious Balance Between Development and Defence Preparedness

The majority of the respondents who were able to reply to this question opined affirmatively that due to spectrum swap and earmarking of exclusive Defence Band and DIZ, a judicious balance of spectrum distribution has been maintained between a nation's development and its safety security and defence preparedness. This will happen in the next 4-5 years. The DIZ rules give a clear-cut advantage for defence to use the frequency up to 50 km from the border in case of hostilities. *The promulgation of Def Band has paved the way for the use of the spectrum for the nation's growth*. Enormous growth in the wireless services have fuelled a corresponding demand on the spectrum; thus the periodic audit and review of the Defence Band is likely to be a continuous process. It is therefore of paramount importance to maintain a judicious balance between a nation's development and its safety, security and defence preparedness.

Question 11: System of Mutual Accommodation

About 23 per cent of the respondents were unable to respond to this question, due to inadequate knowledge and having had limited exposure to this subject. However, 8 per cent of the respondents who replied did not feel that such a system of mutual accommodation is beneficial to the Armed Forces and they felt that the Def and Non-Def requirements of Frequency spots should be consigned to their respective parts of the spectrum. In their view, the element of surprise through unprecedented swiftness in action marks the success of any Armed Force. In their opinion, the system of mutual accommodation will and has been hampering this element of an expeditious allotment of frequency during times of need.

However. the majority of the respondents who had replied felt that mutual accommodation was beneficial in the overall national interest as it ensured that requirements of Defence and Non-Defence Spectrum are met amicably. Freq spectrum mgt is a complex and difficult activity. To cater for technological advancement, judicious use of spectrum has to be carried out and spectrum has to be controlled and allotted judiciously. The system of mutual accommodation is beneficial in the overall interest of the nation. However, ***in view of national security, the defence requirement should be given a higher precedence, viz., commercial requirements.***

Question 12: Improving System of Frequency Allocation and Equipment Procurement

All respondents universally agreed that while the equipment procurement cycles of the Armed Forces are rather deliberate and long, the pace of technology change is very rapid. The Defence Procurement Procedure and the rapidly changing/ evolving technologies as viewed above are contradictory to each other and require foresightedness/deliberate futuristic approach at the planning stage. However, a deep and deliberate study of the evolving

global technological trends in civil as well as military would give us an estimate of the future requirement while planning for equipment procurement. While the procurement cycles need to be reduced, the local manufacturing of communication equipment that meets the criteria should be encouraged. The only solution to overcome this lies with the indigenous research and development of the state-of-the-art equipment, with provision to accommodate future technologies. The venture into the same may initially prove costly and sometimes run into failure, but in the long run, the only way to achieve military superiority is through indigenisation. For the induction of any equipment (especially through imports), the frequency of use for the same needs to be allocated before it can be brought to India. However, there have been instances where the technology has undergone a change, while the equipment/weapon system is under development.

Certain other suggestions received in this regard are listed as under:

(a) In order to reduce the procurement cycle, timelines and accountability to be enforced. Development of a system by DRDO/Private vendor should be conjoint with the development of technology available. In order to speed up the process, private vendor should be co-opted for development of the prototype. There should be coordination between equipment procurement and frequency allocation.

(b) An MoU should be made with the production agency not to change the frequency band outside the acceptable limits/range decided, even while carrying out technology updating of equipment.

(c) The RFP should give out the intended frequency and the user must process the application for allocation of the frequency to JCES, HQ IDS.

(d) There should be a long-term plan and vision for procurement/ development of equipment using the frequency spectrum. There should be synergy between various users of Defence and MoC regarding the same.

(e) Domain specialists in this niche field should be identified and their employment within the Armed Forces and WPC be managed accordingly to optimally leverage their expertise for the benefit of the organisation.

(f) Keeping in mind the long procurement cycles of the Armed Forces, during the AON stage itself, there should be a policy of temporary allocation of frequency spots to an SHQ for a period of two years. Frequency should be allotted as per technical and operational considerations only, as per the merits of the case. In case procurement of the equipment is done, the frequency spots are allotted permanently to the SHQ, else it gets released back into the general pool of frequencies available.

(g) It is important to understand that due to change/upgrade in technology, the equipment profile (GSQR) of the project is affected but the basic provisioning remains the same. It should be feasible to accept change in technology of the project at the RFP stage, CNC stage and even before signing the contract to enable carrying out a change in the GSQRs. However, all such changes should be progressed through the DAC for approval.

(h) JCES, HQ IDS must be consulted at the project inception stage itself by all the procurement agencies of respective SHQs. The TPCR must include futuristic frequency spectrum use.

(i) Frequency allocation issues should be resolved prior to the development of the prototype. Frequency allotment should

be reviewed every three (03) years keeping in view the technological changes.

(j) There should be a process for technology upgrade to be undertaken within six (06) years of procurement of the project and for firm allotment of the fresh frequency slot required (if any).

(k) **Proposed Model**. If we consider the frequency requirement for in-service equipment to be (x) and that of equipment being inducted over a 5-year, 10-year and more than 10 year period is (y),(z) and (w), respectively, then the overall requirement of spectrum for the Armed Forces is R = (x) + (y) + (z) + (w). Whenever the overall requirement exceeds the availability of spectrum, then the case for timely advance allocation of spectrum for the Armed Forces should be taken up by JCES, HQ IDS. The SHQs however need to plan in advance for the same for this model to be effective.

It was also brought out that the prior allocation of frequency through Decision Letters, issued by WPC is a mandatory requirement in all cases of procurement, especially for induction of ex-import eqpt into the Armed Forces. However, the changes in technology have made the systems more efficient in spectrum usage, unless there is disruptive technology which changes the user requirement itself, e.g., GPS/Laser-based range finders have made Distance Measuring Eqpts (DMEs) obsolete. The ITU rules and regulations and the NFAP take care of the mapping of a type of system to a freq band, thus taking care of the above issue. However, some of the suggestions to improve the system of freq allocation and equipment procurement, which were received from the respondents, are enumerated below:

(a) The freq within Def Band should be allocated at the level of JCES.

(b) The Decision Letters (DLs) be issued for a min validity of 5 years.

(d) The spectrum requirements of the Defence Forces be reviewed every 10 years.

Question 13: Major Drivers for Def Spectrum Requirements

The mandate of the Armed Forces in the future is likely to undergo a paradigm shift with advancements in technology and evolution of future warfare concepts. The future of warfare is no longer likely to be about bullets and bombs or dominating land, sea and air. Instead, ***tomorrow's victors will dominate the ether***. Though the mandate of the Armed Forces is the basic requirement for use of spectrum, yet cutting across the colours of the uniform or the affinities to respective branches/lanyards, all respondents universally agreed that existing/futuristic ***communication technologies were the major drivers for Defence spectrum requirements*** with Electronic Warfare and Mandate of the Armed Forces coming up as a close second and third, respectively. Though a few of the respondents listed inter-se priority, yet most of the respondents voted for more than one reason being most important/second most important factor, possibly on account of according equal importance to them. The summary of responses (in percentage preference and as per inter-se priority), as received from various organizations are as tabulated below:

	Mandate of the Armed Forces	Existing/ Futuristic Commu-nica-tion Tech	Electronic Warfare	Future Warfare Concepts	Early Warning/ Surveil-lance Systems	AI and Robotics	Any other reason
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
ADG-MO(IW)	60%	80%	100%	60%	20%	20%	-

	Mandate of the Armed Forces	Existing/ Futuristic Commu-nica-tion Tech	Electronic Warfare	Future Warfare Concepts	Early Warning/ Surveil-lance Systems	AI and Robotics	Any other reason
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
DG Sigs	P1-Being the basic require-ment	P2-For continu-ation in service, i.e., con-flict-free environ, Plg/Devp/ Proc in Def Band	P3- For control of the spectrum	P3- For continu-ation in service, i.e., con-flict-free environ, Plg/Devp/ Proc in Def Band	P3- For Plg/Devp// Proc in DB	P3- For Plg/Devp/ Proc in DB	-
DG Air Ops	28.5%	57.1%	57.1%	14.2%	28.5%	28.5%	-
ACNS (CSNCO)	P5	P2	P4	P3	P1	P6	-
Sig Int, HQ IDS	P2	P1	P3	P4	P3	P5	-
Tech Int, HQ IDS	P1- Man-date has to be clear	P2-Im-portant for Armed Forces to communi-cate	P4- used in tactical war	P4- Allows planning strategy	P3- Gives edge in warfare	P5-in-fluences everything in future	Cognitive Radio & Cognitive EW
DSSC	52%	48%	42%	40%	30%	10%	-
CDM	28.5%	100%	100%	14.2%	57.10%	42.8%	-
AWC	35.7%	71.4%	60.7%	60.7%	46.4%	28.5%	-
MCTE	53%	72%	51%	50.5%	49.5%	40%	-

Table 7.2: Major Drivers for Defence Spectrum Requirements

The inter-se priority of major drivers for defence spectrum requirements can thus be summed up as under:

Ser No	**Drivers For Defence Spectrum**	**Percentage Votes Received**
(a)	Existing/Futuristic Communication Technologies	76.4 %
(b)	Electronic Warfare	69.4 %
(c)	Mandate of the Armed Forces	56.1 %
(d)	Early Warning/Surveillance Systems	51.9%
(e)	Future Warfare Concepts	46.3 %
(f)	AI and Robotics	31.3%

Question 14: Likely Utilisation of all Types of Frequency Bands for Use by Defence

S/No	Type of Systems (Weapons/Svl/ Comn/EW/AI)	Frequency Band	Approx Band width Reqd	Envisaged area of utilization, i.e., pan India/ along borders
	Maritime Radio, Navigation	3KHz – 30KHz	VLF	Maritime use & Navigation pan India
	Maritime Radio, Navigation	30KHz – 300KHz	LF	-do-
	AM Radio Aviation, Radio, Nav	MF	300KHz – 3 MHz	Pan India
	Radio Communication incl SDR	HF	3 MHz- 30 MHz	Restd Area Usage
	Early warning Radars (OTH)	HF, VHF	3-300 MHz	Pan India
	Communication equipment	HF, VHF	3-300 MHz	Pan India
	VHF Radio, FM Radio	VHF	30 MHz-300 MHz	Restd Area Usage
	Ballistic Missile Tracking Rdrs	UHF	300 MHz - 1 GHz	Pan India
	Radars for detection and tracking of satellites.	UHF	300 MHz - 1 GHz	Pan India
	UHF television, mobile phones, GPS, Wi-Fi,	UHF	300 MHz- 3 GHz	Pan India
	Mob Cellular Comn Sys (MCCS)	UHF & C Band	800 MHz/ 2-4 GHz	Along Borders
	Long Range Svl Radars	L Band	1 to 2 GHz	Pan India
	Med Range, all-weather 3D Svl Radars	C Band	2 to 4 GHz	Pan India(for detection and iden of aerial targets)
	EW	C and S Band	2 to 8 GHz	Along Borders

S/No	Type of Systems (Weapons/Svl/ Comn/EW/AI)	Frequency Band	Approx Band width Reqd	Envisaged area of utilization, i.e., pan India/ along borders
	High Capacity Radio Relay (HCRR)	S Band	5 to 5 GHz	Pan India
	BFSRs. Missile Control and ground svl Radars	C Band	4 to 8 GHz	Pan India
	AF Satcom	C & Extended Ku Band	4 to 8 GHz (based on services)	Pan India
	Fire Control AD Radars	X &Ka Band	8 to 12 GHz 26 to 40 GHz	Pan India
	Satellite Communication, WiFi	SHF	3 GHz- 30 GHz	Pan India
	Satellite Communication, UAV	E HF	30 GHz- 300 GHz	Restd area usage
	5G Systems (Surveillance, EW and Communication)	EHF	26-28 GHz	As per project—Pan India or Along Borders

Table 7.3: Likely Utilisation of Various Frequency Bands for Use by Armed Forces. The NFAP lists the types of systems and their frequency band of operations. The bandwidth requirements and locations have security implications, hence, the exact requirements are not being listed. However, a generic requirement for various branches of the Armed Forces are tabulated in Table 7. 3. The list is purely representative and by no means exhaustive. We are passing through very challenging times and the pace of change of technology which was earlier seven years, was reduced to five years and now changes every three years. Also with AI, 5G and IoT just round the corner, the applications can be limited only by imagination. Thus, it may be assumed with a reasonable amount of certainty that the

above list is likely to increase in future and at that time, the flight of the modernisation/technological upgrade of the Armed Forces must not be hampered due to lack of spectrum availability.

Question 15: Challenges in Field of Spectrum Mgt for Def and Suggested Improvements

There are numerous challenges which are faced by the Armed Forces in the field of spectrum allocation and spectrum management and listed below are few of the important aspects which were projected by the majority of the respondents, along with possible mitigation measures:

(a) There is lack of awareness in the environment about the importance of frequency spectrum. This needs to be addressed by conducting courses/awareness capsules at all Category A Establishments.

(b) High mobility, quick reaction and speedy and timely information mandate a large number of various kinds of communication equipment. Such equipment works in different bands including several frequencies at the same time and the same needs to be reconciled.

(c) The technology advancement has necessitated a variety of user services, which has naturally caused an increase in the needs for frequencies from the commercial and military sectors. This has resulted in the civil administration having a tendency to increase the amount of spectrum for commercial purposes, which at times may not be in the interest of the Armed Forces. JCES, HQ IDS and SHQs need to guard against this tendency.

(d) Defence needs to be actively engaged for a clear and sole objective of the spectrum in the internal and international contexts and in according priority treatment in the discussions for spectrum allotment/definition.

(e) Orientation towards national and international policies, agencies and procedures and standards need to be kept in mind while carrying out procurements for Defence.

(f) Frequency management with inter-operability between communication and information systems needs to be carried out as a matter of routine.

(g) Planning, allocation and spectrum usage should be planned in accordance with systems characteristics currently available and those of the future. Moreover, the levels of command and control of the spectrum in the defence bands need to be clearly delineated within the Armed Forces.

(h) Time-to-time evaluation of current and future needs for spectrum, aiming at more clear definitions of spectrum resources and more effective ways of spectrum utilization must be the norm.

(i) Mobility of combat elements in TBA is a reality during active hostilities. The same does not however seem to be evident during peace time but it must never be lost sight of and planning for it needs to be a continuous process.

(j) There is a plethora of equipment in the battle space that would be used only during active hostilities, which requires dedicated spectrum allocation. The same needs to be catered for at all times.

(k) The rapid pace of change of technology and the exponential growth of non-defence wireless users has put a strain on the spectrum. There is a school of thought which advocates re-distribution of spectrum "apparently lying vacant", without realizing that it would be a critical requirement during active hostilities. It needs to be explained to the policy makers to disregard such views of people who inadvertently advocate commercial growth at the cost of national defence.

(l) Delay in procurement of eqpt due to lengthy procurement procedures is a major challenge due to the rapid speed of change of the technologies and consequently of the frequency of operation of the said equipment intended to be procured. The licensing of spectrum takes anywhere between 2-4 months, from the date of submission of corrected application to the JCES, HQ IDS. There is thus a need to speed up the procurement process.

(m) Lack of understanding in the environment to identify optimal spectrum required for proposed allocation is a major challenge and so is the tendency to unnecessarily hoard spectrum for projects which have not yet been formally conceived.

(n) Technological constraints like usage of Software Defined Radios **(SDRs)** with wide capability in spectrum waveforms, aggregation of spectrum in single BTSs and enhanced Frequency Hopping (FH) capability, also pose a challenge in the management of spectrum.

(o) The ever-increasing need of bandwidth on account of technological advancement has necessitated a variety of user services, which has naturally caused an increase in the needs for frequencies both in the commercial and defence sectors. While the commercial requirements are very visible, effort must be made to project and explain the defence requirements, especially those that would be used only during active hostilities.

(p) Orientation towards national and international policies, agencies and standards along with periodic evaluation of current and future needs for spectrum mgt with an aim of effective spectrum utilization must be ensured.

(q) Coordinated procurement of similar types of equipment (requiring frequency spectrum), by the Armed Forces is a major challenge. If the same can be coordinated, it will not only bring down costs by leveraging economies of scale, but will also make the aspect of frequency spectrum management more efficient.

Additional Suggested Improvements. In addition to the measures listed above, additional ones are that suitable amendments must be carried out in Defence Band to accommodate the in-service equipment with a residual life of three years or more and operating in the frequencies which were earlier being used by the Defence but now fall out of the delineated Def Band. Also in case of such equipment, safeguards must be provided that the frequencies which were earlier historically being used by the Defence, but for which no formal Decision Letter for frequency allocation exists, should continue to remain with Defence, subject to a consolidated list of the same being provided to WPC by JCEs in a mutually acceptable time frame.

Question 16: Chances of an Unauthorized Entity Using Def Spectrum in an Unauthorized Manner

A certain section of the respondents felt that it may not be possible for any unauthorised entity to use the defence spectrum without allocation of frequencies by civil administration/DoT/MoC, because they felt no one could do so and get away with it as they assumed (incorrectly) that there existed some organization that was able to monitor, report and prevent such an incursion. However, the majority of the respondents felt that there was a high likelihood of the defence spectrum being utilised in an unauthorised manner by certain entities, if monitoring and policing of the spectrum by the authorised agencies is not carried out. Frequencies promulgated under the Defence Band are confidential information. Hence,

unauthorised use of def spectrum by other users intentionally or inadvertently cannot be ruled out. The use of various types of ECM is also a type of unauthorised use of defence spectrum.

A few of the respondents were more familiar with the phenomenon and with the name associated with it, i.e., ***"Spectrum Squatting",*** which they reaffirmed to be a definite possibility. It was agreed that technology makes it feasible to operate equipment in a wide freq range with software defined controls. Thus, unauthorised usage especially with low power radio sets cannot be ruled out. The Def Band is of 2015 vintage and as such unauthorised usage has not come to light as yet.

Question 17: Organization within Armed Forces/Govt to Monitor Frequency Spectrum

In response to whether there was any organization within the Armed Forces or within the Government, mandated to monitor or police the frequency spectrum to detect and prevent such instances of "spectrum squatting", a mixed bag of responses was received. The common unifying thread across all these responses (barring a few) was the near complete lack of awareness regarding the responsibility to do the same. Almost all the respondents assumed that being such an important task, there would be some organisation tasked to look after it; however, they invariably homed on to or suggested an organisation not mandated to do so. The summary of the responses received is given in the subsequent paragraphs.

All respondents opined that ***prevention of interference by an unauthorised entity is a must*** and Defence, through their corresponding organizational structures, must take care of monitoring the frequency bands defined/allotted for them. It was felt that there were structures in place in the Defence Forces authorised to carry out spectrum management and monitoring and most of the respondents assumed that it was being done by SI/EW

units or by Formation Signal units (***which is not the actual position on the ground***). A few respondents even stated that ACE, Mhow or DIPAC could be tasked to do the task with proper argumentation of resources.

However, it was felt that a lot needs to be done in this regard and ***a national level organisation was recommended to be created under the HQ IDS***, Ministry of Defence, with reps from Ministry of Communication, Ministry of I&B and MHA, for coordinating and streamlining the execution of the mandate. Exchanging such data with government/non-government agencies was one such suggested method of addressing the issue of spectrum squatting.

A few respondents felt that the erstwhile Radio Monitoring Company **(RMC)**, affiliated to Central Monitoring Org **(CMO)** was the mandated agency. The RMCs were in fact responsible for monitoring and reporting breaches in wireless communication and deviation from proper Radio Telephony (RT) procedures. The CMO and RMCs have however since been disbanded. Post disbandment of these RMCs, there exists no other organization within the Armed Forces at present, which can monitor or police the defence frequency spectrum. Spectrum monitoring requires expensive equipment and qualified personnel and a large number of respondents suggested that for monitoring the Defence Band, ***units like the erstwhile RMCs should be revived under HQ IDS.*** The PE of such units should be sufficiently augmented and enhanced to enable them to carry out this task.

Question 18: Suggested Organization within Armed Forces to Monitor Frequency Spectrum

Most of the respondents were unable to comment on the subject citing inadequate knowledge as the reason. The majority of those who did respond stated that the Army had RMC in the Corps of Signals that were doing the task of monitoring the spectrum (*this*

is a common incorrect understanding because RMCs were in fact responsible for monitoring and reporting on breaches in wireless communication/proper Radio Telephony (RT) procedure). However as these units have been disbanded under force downsizing, it was recommended that ***these RMCs should be reinstated with a new mandate of freq spectrum policing and monitoring to prevent violation of 'spectrum squatting'.***

Wireless monitoring is an integral part of Spectrum Mgmt. At the national level, the Wireless Monitoring Organisation (WMOs) and its detachments are the field units of the WPC wing. They carry out wireless monitoring through a network of strategically loc units in the country. There is a dire requirement of replicating such an organization within the Armed Forces.

Question 19: Validity of Decision Letters (DLs) Issued by WPC and Suggested Improvements

Very few inputs were received in response to this question, possibly it being a niche subject. However, all those who responded said that the validity of DL is for a specific duration—possibly for a year, which appeared to be less, given the time-penalty in the current procurement process. It was also stated that the time period to pay the licence fee after issue of DL is 30 days. In case payment is not completed, the application is treated as cancelled. All the respondents said that this period needed review considering the time lag in payment procedures. It was recommended that the payment period of DL should be increased to min 90 days and the validity of DL be increased to at least 5 years.

Question 20: Measures to Improve Process of Issue of Decision Letters (DLs)

All the respondents who provided inputs to this question said that the validity of DL is for a specific duration—possibly for an year,

which appeared to be inadequate, given the time-penalty in the current procurement process. All suggested that the validity of DLs be increased to a minimum of five (05) years and preferably to ten years or till End of Life **(EOL)** of the equipment. It was also universally felt that the ***issue of DLs for the Armed Forces, within the Defence Band be decentralized to the JCES , HQ IDS.***

Question 21: Common Repository of Freq Spots Allocated for the Armed Forces

Despite being a niche subject, valuable inputs in response to this question were received from a large number of respondents. All agreed that there is a requirement to have a common repository of the frequency spots allocated to various projects of the Armed Forces. It was opined that repositories of frequency spots allocated to Defence by the WPC are available with respective Service HQs. The coordination to resolve conflicts on use of frequency spectrum within the Defence is done at JCES level and with non-Defence users at the level of WPC. It was not recommended to maintain a separate repository of frequency spots allocated to various projects of the Armed Forces at any level other than JCES, HQ IDs, due to security reasons.

Question 22: Requirement for Freq Spectrum for Defence in India to be Aligned with Global Trends

Nearly 96 per cent of the respondents felt that there is a requirement for frequency spectrum for Defence in India to be aligned with global/international trends. On analysis of the responses, it can be safely concluded that the global ecosystem for weapon and communication systems using spectrum for commercial utilization, as also for induction into the Armed Forces, can be exploited on a wider platform by the Armed Forces, only if there exists a commonality in alignment of frequency for Defence in India in

consonance with the global trends in requirement. Hence, the same is very much required.

Worldwide utilization and development of frequency spectrum usage is compliant to rules and regulations as specified by the International Telecommunication Union. The National Freq Allocation Plan **(NFAP)**of the country also complies with the ITU. The Wireless Planning Commission of the India is responsible for spectrum mgmt in the country and it takes the NFAP into cognisance while giving spectrum licences. The requirement for frequency spectrum for Defence in India is thus fully aligned with the global trends to the extent feasible in utilization and development of the Defence wireless ecosystem.

Question 23: Exposure Provided within Defence in Field of Frequency Spectrum Management

The majority of the respondents felt that the opportunity and exposure provided within the Armed Forces to carry out training in the niche field of frequency spectrum management is not at all adequate. It requires more exposure and training. The spectrum managers at all levels within the Armed Forces should be encouraged to participate in World Radio Conferences and in the APG to remain aware of developments taking place in the Radio Regulations at the global and regional forums. They should also be made to undergo the ITU-run *Spectrum Management Training Programme* **(SMTP)** to undertake the task of spectrum management more efficiently and in consonance with the global practices being adopted by developed nations.

Suggested measures in this regard are listed below:

(a) Training on the subject should be conducted under the aegis of WPC for all stakeholders. Defence, being a major stakeholder, should have zonal centres for training under the concept of 'Train the Trainer'.

(b) Academia like IITs/IISc should be co-opted to include courses in the field of Spectrum Management in their curriculum, in addition to the normal course curriculum. These courses should be subscribed by various stakeholders from the Armed Forces.

(c) Sharing of knowledge with global entities and defence organisations.

(d) Institution of new course curriculum and introduction of institutionalized training within the training institutions of the three Services, i.e., Army, Navy and Air Force.

(e) WPC to be asked to conduct training for all stakeholders to ensure effective and continuous training of frequency administrators. Defence being a major stakeholder, should take the lead and get it implemented.

Question 24: Representation of Defence in Formulation and Implementation of Telecom Policy

All the respondents agreed that this was a very important field and the majority of the respondents who had domain knowledge on the subject felt that the representation of the Armed Forces as regards formulation of telecom policy was though earlier present, had reduced over the years and is presently very limited. Though the views of the Armed Forces had been sought while formulating the NFAP, yet the same could not be commented upon as regards formulation of the National Telecom Policy. At times, certain inputs are obtained from JCES, HQ IDS, for which views are sought from the Armed Forces and deliberated upon at HQ IDS prior to forwarding the same, yet the inclusion/incorporation of the same is not mandatory/binding upon the WPC/ MoC. There should be a provision that the views of the Armed Forces, forwarded by JCES, HQ IDS, should be included/incorporated by the WPC/MoC. If it does not seem to be possible, then detailed reasons for such non-inclusion must be communicated back to JCES, HQ IDS.

The civil authorities that manage frequency spectrum are often unable to understand the typical Defence requirements and do not harmonize the spectrum as per the requirements of the Defence. The Armed Forces should be actively engaged for the clear definition and articulation of the needs of the spectrum for Defence in various forums of not only WPC but at the national, regional and international levels. There should be major priority treatment accorded to Defence in the discussions held for frequency spectrum by WPC.

Question 25: Other Measures to Improve System of Allocation of Frequency Spots for Defence

Very good constructive suggestions were received in response to this question and they are listed below:

(a) NCW is likely to become the basis of conflict in the future and if networks are to become critical enablers of future operations, India must develop capability for defeating these networks. As implications of NCW are not restricted to Strategic/Operational/Tactical levels, so capability can be structured right from Tactical level upwards based on potency, applicability and implications.

(b) The spectrum regulators in all the Armed Forces should be the centralised authorities for spectrum allocation and usage decisions, including procurement and deployment of equipment, which utilizes frequency spectrum.

(c) ***Importance of spectrum as a scarce mission critical resource*** needs to be recognized by the Armed Forces and due priority be accorded to the same.

(d) Short and long-range frequency allocations should be designed and Spectrum swapping and frequency re-use within the Armed Forces could be considered.

(e) Introduction of newer wireless technologies that are more efficient and consume lesser spectrum needs to be explored.

(f) Requirement of upgrading present systems of communications, surveillance, decision support, sensor-to-shooter integration, etc., to higher bandwidth, due to requirement of higher resolution video feeds would need additional spectrum which needs to be factored.

(g) For the future integrated NCW battlefield, there would be a requirement of Inter Services Radio Integration, which would again need additional spectrum.

(h) There is a need to have a long-term acquisition and associated technology integration plan. This would generate a frequency band which should be earmarked for utilization by Defence. It is likely to be dynamic with a progressive increase in dimensions as per the modernization plans of the Armed Forces.

(i) There should be a synthesis of communication and information to speedily address the alteration in the concept of operations, doctrine, organization, logistics, education and training, with concurrent action being taken in all these fields.

(j) The Defence Band was promulgated on March 15 and there are challenges in usage feasibility of in-service equipment. Post promulgation of the DB, WPC is also reluctant to allot spot frequencies for trials/induction stage, for the capital procurements which are already under process and the same needs to be resolved.

Conclusion

With the proliferation of technology in the Armed Forces, in addition to communication systems, it has emerged that there are a

number of other areas/fields, where there is a requirement of having a dedicated frequency spectrum (i.e., weapon system/platform/smart ammunition/surveillance grid/navigational systems/Identification Friend or Foe **(IFF)** Systems, etc). Though the evolution of digital communication has drastically reduced the band width requirement, the proliferation of the diverse systems and platforms which need spectrum have made the battle field a very challenging space. In order to enhance the overall war fighting capability, there is a pressing requirement to accord due importance to the critical aspect of Frequency Spectrum Management within the Armed Forces.

8

Spectrum management challenges for defence and recommendations

Introduction

In militaries of advanced countries, roadmaps for NCW are progressed in two dimensions simultaneously to enhance the overall war-fighting capability. One is in the network dimension, referring to the physical systems providing connectivity between sensors, commanders and those involved in engaging the adversary, and the second dimension is the human dimension roadmap. However, the driving fuel to propel all these activities in the network dimension of NCW is the availability of Frequency Spectrum and it is against this backdrop that various challenges being faced by the Armed Forces pertaining to spectrum management will be examined along with likely recommendations.

Improving System of Frequency Allocation and Equipment Procurement

The normal frequency management in Defence is based on existing policies, guidelines and procedures/manual. The preparation, harmonization with international, regional and national regulations and keeping pace with technological developments is a continuous and on-going process. Computer software application ensures

optimal administration and coordination of frequencies. These applications should be capable of centralized and decentralized management of frequencies. Equipment procurement should be adaptable and take into consideration the technical capabilities and equipment's limitations and should be ready to adjust to newer tech as and when inducted. Listed below are certain measures to improve the system of frequency allocation:

(a) Speeding up of procurement process is the primary requirement to avoid such dichotomy at the first instance. If this is achieved half the problems being encountered will be resolved.

(b) Correct appreciation and prediction of likely technological advancements having influence on frequency allocation needs to be carried out. The correct frequency specifications including the bandwidth required need to be correctly worked out and included at the GSQR stage itself.

(c) Flexibility to carry out changes in allotment of frequency, because of technological changes, needs to be retained by the Armed Forces while framing the terms and conditions of business.

(d) Indigenisation will go a long way in resolving the spectrum conundrum, as in that case we would not be dependent upon the frequency band used in a different nation.

(e) Pursue innovative approaches for the efficient, flexible and adaptable use of spectrum. In order to effectively adopt them, the concerned officers must be exposed to the latest trends being followed internationally, by sending them to attend seminars/discussions at national/ international forums.

(f) To ensure that the present and future needs of Defence are fully comprehended and taken into account, the Defence

spectrum needs and constraints need to be strongly communicated in a deliberate and structured manner to the national policy makers. This would result in catering for unforeseen spectrum requirements during procurement.

The primary aspect is that prior allocation of frequency through Decision Letter/Letter of Intent (DL/Lol) issued by WPC is a mandatory requirement in all cases of procurement, especially for induction of ex- import equipment into the Armed Forces. WPC promulgates the philosophy that spectrum is agnostic to rapid changes in technology. Based on the aforementioned, the following is suggested to improve the system of freq allocation and equipment procurement:

(a) JCES under IDS should be consulted at the project inception stage by all procurement agencies and spectrum coordinators of respective SHQs to discuss and ascertain the optimal spectrum requirement for the proposed procurement.

(b) The spectrum availability/supportability and identification of the best suited spectrum within the def band for the proposed technology should be obtained on file from the spectrum coordinators of respective SHQs before initiation/finalization of GSQR. The spectrum coordinators of respective SHQs should, in turn, ascertain the same from JCES, HQ IDS.

Validity of Decision Letters (DLs) Issued by WPC

The validity of the Decision letters (DLs) is for one year, extendable thereupon. Since the renewal of DLs is not perceived as critical by the users, as the licences are in Def Band, the users at times miss this crucial aspect. There is a requirement of educating the users on the necessity of keeping the licences current at WPC. A repository with tracking feature at the Service HQ levels and at JCES, to keep track of

renewals of DLs is recommended. The DLs should have a minimum validity of 5 years, keeping in mind the usable life of equipment.

Certain other measures that could be considered to be taken at WPC are improving the service standards and the putting in place a grievance redress mechanism to ensure timely processing of DLs. The system needs to be automated at each service HQ level and advance reminders for payment/expiry of DL should be generated. The procedures at WPC should be made simpler and standardized and subordinate organizations be empowered to act as responsibility centres

Miscellaneous Challenges in Spectrum Mgt and Recommendations

Based on the inputs received from various respondents, the major challenges faced in the field of spectrum allocation and spectrum management for Defence have been deliberated upon at Para 33 of Chapter 7. However some other aspects which could be considered are listed as under along with the suggested mitigation methods for them:

(a) There is limited awareness in the environment about promulgation of def band as also about the need to carry out spectrum management. This needs to be addressed by conducting awareness capsules during various courses at all Category A Establishments.

(b) Most of the users in the environment are unable to identify optimal spectrum required for the proposed application and project an incorrect requirement, i.e., end up either asking for less frequency spectrum or else there is a tendency of users to ask for excess spectrum, at times, even for projects not yet conceived. Adequate training needs to be imparted at various levels for the same.

(c) There is a lack of awareness about correct application procedures, resulting in avoidable delay in allotment of DLs. Adequate training needs to be imparted at various levels for the same.

(d) Aspects of ***spectrum availability, spectrum re-usability and spectrum supportability*** are being taken for granted and are not being accorded any priority in operational preparedness. The same needs to be addressed at the appropriate level. It needs to be understood that the latest high technology equipment/weapon platform will be a useless piece of ordnance if the Armed Forces do not have the frequency spectrum allotted to operate it.

(e) Import of equipment from a wide variety of sources, viz., from both NATO countries and from erstwhile Soviet Bloc countries, both operating in widely separated frequency bands, places additional challenges for the spectrum manager. The same need dexterous handling by JCES and WPC to ensure that Defence interests are looked after.

(f) Fast paced technological advancements demanding a wide range of frequency spectrum have led to a situation where the growing requirements of civil/commercial sectors are at times found competing for the same frequency spectrum with Defence. As such, the Defence interest needs to be properly articulated and projected at the appropriate forum. In order to do this, each SHQ needs to evolve its Long/Mid-Term Perspective Plans, keeping in mind the futuristic developments like AI, 5G and IoT.

(g) Another major concern is that there is a high likelihood of encroachment of civil/commercial sectors in the Defence spectrum, because there is no agency within the Armed Forces, which is carrying out monitoring

and policing of the Defence Band. The same needs to be addressed on priority.

(h) There is at times reluctance on the part of various stakeholders to seek inputs on frequency spectrum, at an early/inception stage of a project, from the concerned spectrum manager of the SHQ or from the integrated frequency spectrum management cells of the three Services. Such an input from the specialist must be made mandatory to enable proper guidance to be provided in the matters of Defence equipment procurement or production.

(i) There is a large number of legacy equipment which is being used by the Armed Forces and some of them operate in frequencies which now fall out of the def band. Since they were being historically used by the Defence since the time they were major users of frequency spectrum, so at places no formal application may have been filed with JCES, HQ IDS or with WPC for the same. Suitable amendments must be carried out in the Defence Band to accommodate the in-service eqpt with a residual life of three years or more and operating in frequencies which now fall out of the Def Band. Suitable suggestions for incorporation in the Def Band must be sent as and when it is reviewed.

(j) There is a need to articulate and promulgate the Defence frequency spectrum management policy at the level of SHQs and at JCES, HQ IDS to guide various procurement and production aspects. In order to facilitate a smoother functioning between WPC and Defence, it is recommended that Defence representation, in terms of one officer, a JCO and two NCOs, be allowed on deputation to MoC with instructions to work in the security section of WPC itself.

Relevance of Frequency Spectrum in NCW

The Indian military perhaps has yet to fully realise the essential requirement of viewing information from the strategic viewpoint and recognise it as a mission critical resource. Had we realised this, we would have adopted a top-down NCW approach. To adopt this, we need a synthesis of communications and information and also speedily addressed alterations in our concept of operations, doctrine, organisation, force structure, psyche, leadership and associated changes in logistics, education and training. All these need to be concurrently addressed in order to acquire, build and enhance NCW capabilities within the constraints of development and implementation time; piece-meal solutions are not the panacea. However, all these attributes of NCW are merely vehicles and the driving fuel to propel all these vehicles is the Frequency Spectrum, whose availability we must ensure.

The integration of Intelligence (SIGINT and HUMINT) into Operational Orders and Cognitive Hierarchy is required to be fed directly through Net-Centricity for achieving precise targeting and the upper hand during military operations. Presently the mechanism of Cognitive Hierarchy is piecemeal in nature and is different for all the components. This mechanism precludes the speed of delivery and execution of orders to the battle field. The same needs to be negated through Joint Operational Centres and Theatre Commands (as and when they are established), with a more profound understanding of the intra-Services' modus operandi. Geographic Information System (GIS) is a powerful tool to combine various spatial, spectral and other sources of data to generate key insights for security stakeholders. With the ever-increasing computational power alongside the increase in the number of sensors available, utilisation and integration of GIS into specific scenarios and actual traditional battlefield systems (such as UAVs, submarines, aircraft, etc.) will provide an edge over adversaries. As all future battles/wars are likely to be fluid in nature

and fought over mobile platforms, hence the criticality of wireless networks and of the frequency spectrum.

Preferred and Resilient Means of Communication

Fixed wire communication cables (preferably OFC) have been and will always remain the most secure means of transmission medium. However the Routing protocols presently being used (for example, MPLS, OSPF, etc.) are generic technologies that are easily prone to tampering for breach in integrity. Therefore, the need of the hour is to evolve proprietary Routing protocols in conjunction with DRDO and CDAC. Hostile terrains and oceans require wireless connectivity for which the following are highly envisaged:

(a) Highly Directional transmission/reception antennas to minimize the effect of adverse interception and analysis.

(b) Development of laser/quantum technology in lieu of SHF/UHF in the field of SATCOM to minimize the risk of interception/jamming.

(c) Vehicle-mounted Mobile Telemetry/Receiving stations as a redundant measure to control operations of satellite communications in case of destruction of Telemetry and Satellite Hubs as these facilities remain the prime and priority targets during times of war.

A network-centric approach to warfare links all military assets to each other and to decision-makers via computer, radio, and data networks, enhancing the way military objectives are accomplished because of information superiority. Information sharing and collaboration enhances the quality of information and shared situational awareness. Shared situational awareness enables self-synchronization. These, in turn, dramatically increase mission effectiveness. Doing so requires a true military-grade wireless network that must provide continuous communication to stations

in motion and stationary personnel, vehicles, and equipment, keeping commanders and troops always-connected, secure access to applications and information and improving situational awareness and mission effectiveness. *These reinforce the requirement of* ***a dedicated frequency spectrum to meet the genuine technological needs of the Armed Forces.***

Areas Requiring Dedicated Frequency Spectrum

With the proliferation of technology in the Armed Forces, in addition to communication systems, it has emerged that there are a number of other areas/fields, where there is a requirement of having a dedicated frequency spectrum (i.e., weapon system/platform/smart ammunition/surveillance grid/navigational systems/Identification Friend-or-Foe Systems, etc). Though the evolution of digital communication has drastically reduced the band width requirement, yet the proliferation of the diverse systems and platforms which need spectrum have made the battle field a very challenging space. Various weapons and sensors including IFF systems will require dedicated frequency spectrum. In addition, the operation of UAVs will also have to be catered for, in which the signal coding requirement shall have to indigenous and robust. The fact that China has evolved technology to jam and interfere with telemetry signals of UAVs and China having imported the same UAVs from Israel as India possesses in its arsenal, the prime thrust area therefore remains for secure data transmission with preservation of integrity.

Efficacy of Promulgation of the Defence Band for the Armed Forces

Ending a long eight-year dispute over spectrum-sharing with Defence, exclusive bands were earmarked for use of security establishments. Nine exclusive bands have been earmarked between 3 GHz to 40 GHz for use by the Armed Forces. Procurement of eqpt

having this exclusive freq band will definitely help in improving comn infra for future developments. By and large, the freq reqmts of Defence could be met by the proposed spectrum swap and DIZ rule. However, the following aspects merit consideration in order to be able to carry out better management of the frequency spectrum for the Armed Forces:

(i) Procurement of major EM-related defence equipment to be carried out either from NATO or erstwhile Soviet bloc countries, in order to utilize the globally accepted bands of frequency earmarked for military use.

(ii) All indigenous production of EM usage equipment both in communication and non-communication fields to be aligned with the band allocation constraints to the extent feasible and without hampering operational preparedness.

(iii) Inter-operability of the frequency bands for military and commercial purposes based on case-to-case requirement should be worked out between DoT and MoD, as is being done.

(iv) Fragmented and inflexible rules need to be reformed for better inter-operability between military and commercial players.

The announcement of the Defence Band is a positive step towards efficient spectrum management for both Defence as well as civil purposes. However, various aspects of disagreement need to be resolved at the earliest.

Maintenance of Judicious Balance Between Development and Def Preparedness

Def Band specifies the freq bands/spots available to the def spectrum users, pan- India. However, the changing technology continuously leads to change in equipment profile operating in a different

frequency. In such a scenario, at times it may not be feasible to restrict def usage within the Defence Band. Also, due to the heavily congested and contested non-def spectrum requirements, especially in the metros, mutual accommodation is thus unavoidable and in the national interest.

The quality of spectrum is an issue because certain bands are reserved for specific applications. The commercial and private sectors have the incorrect apprehension that too much spectrum is occupied by the Defence Ministry and is therefore underutilised, and that this limits private sector access to these resources. When Government agencies seemingly sit on unused spectrum, it creates an artificial scarcity for companies that wish to innovate and reduces the spectrum that is available for consumer and commercial applications.

Frequency spectrum is a national resource. This aspect has been recognized worldwide and the Indian Government, by auctioning spectrum, has generated significant revenue for the nation's growth and development. The Indian Defence Ministry is a big player in the spectrum space because of the country's legitimate security worries. Going back decades, the Ministry had got large blocks of contiguous spectrum and due to operational reasons, it was not required to relinquish any of it. The common misconception is that even though a lot of it is unused or under-utilised, it is still not available for commercial development. This keeps prices high for the remaining spectrum. Promulgation of the Defence Band is a right step not only in maintaining a judicious balance between the nation's development and its safety/security but also in streamlining the usage of spectrum by the Defence forces while aligning all its future procurements in consonance with the promulgated Defence Band, to the extent feasible.

The Government should take into account the legitimate concerns of the Armed Forces before arriving at any decision to free

up ***"seemingly available"*** spectrum for commercial development. Certain frequency bands held by Defence should not be vacated and made available for auctioning, even if they have reasonable reserve prices, if the same is required for Defence for any of their projects in the pipeline or even at the conceptual stage. However, a commonly heard rejoinder to the above logic is that unless there is sufficient licensed spectrum, it will be hard for India to achieve its goals of higher economic growth and greater social inclusion.

Thus, in order to maintain a judicious balance between development and defence preparedness, the Government thus needs to create dialogues across the Ministries of Telecom, Defence and Finance to resolve this problem. Fragmented and inflexible rules need to be reformed to enable businesses to have more spectrum available for commercial use, keeping in mind that the safety and security preparedness of the nation is not jeopardized. That will help India gain the benefits of new mobile solutions in education, health care, transportation, urban planning, energy and at the same time be in a position to modernize its Armed Forces. Policy should be designed to make usage of the scarce and valuable spectrum more efficient. Policies should also be adopted to allow trading and swapping of spectrum between Defence and commercial players for mutual benefit. Such policies would enable freeing of unused spectrum that might be trapped in either of the fields. However, the aspects of time of lease and ***aspect of defence priority requirements*** should be suitably dovetailed into formulation of such policies. More importantly, ***JCES, HQ IDS*** should be ***incorporated while formulating*** such policies and it must have a ***veto vote in according approval*** for the same.

Major Drivers for Def Spectrum Requirements

The faster pace of future warfare demands greater integration of sensors to weapon systems through a robust and secure communication

links. The success would also depend on the extent to which own forces deny the effective use of spectrum by adversaries by employing ECM. Robotics is still in a nascent stage of employment in the battlefield but with the advent of autonomous unmanned vehicles, it is the future in the field of warfare and electronic surveillance. Further, with the inclusion of AI into the same, real-time cognition in the field of warfare is just a step ahead. Towards its successful implementation a robust database of the enemy ORBAT, human behaviour of the adversary force, physiological differences of the soldiers of the enemy and own forces and detection of psychological process through facial/body gestures is required to be developed and subsequently gleaned to these machines. ***Towards this end, the frequency spectrum requirement for the same in the future is likely to be considerable and remains the prime priority.***

Likely Utilisation of Frequency Bands

The likely utilisation of all types of frequency bands for use by Defence have been deliberated upon in Table 7.3 and at para 32 of Chapter 7. The said list is by no means exhaustive. Due to rapid technological changes and with the likely advent of AI, 5G and IoT, some other applications which could be considered are listed as under:

S.No	Type of Systems (Weapons/Svl/Comn/ EW/AI)	Frequency Band	Approximate Bandwidth Required	Envisaged Area Of Use. i.e., Pan India / along borders
	Weapon Control	I - Band J - Band K - Band	8-10 Ghz 10-20 Ghz 20-40 Ghz	Pan India
	Surveillance	D - Band, E – Band, L & Ka band	1-2 GHz 2-4 GHz	Along borders
	Satellite	L, S, C, X, K & KU Bands	3 –30 GHz	Pan India
	Smart Weapons	A, B, C, D, E/F, G/H, J, & KU Bands	3 KHz-300 GHz	Along borders

S.No	Type of Systems (Weapons/Svl/Comn/ EW/AI)	Frequency Band	Approximate Bandwidth Required	Envisaged Area Of Use. i.e., Pan India / along borders
	UAVs (Drones)	VUF, UHF, D, E/F, G/H, J & KU Bands	30 MHz-30 GHz	Along borders
	Artificial Intelligence/ Robotics	A, B, C, D, E/F, G/H, J, & KU Bands	3 KHz-300GHz	Pan India
	AAD/Arty/ATC Radars	3-5 GHHz	75-100 MHz	Pan India
	Communications	HF, VHF & UHF	28, 60 & 2700 MHz for HF,VHF & UHF	Pan India
	Communication Satellite Uplink	27-40 GHz		
	LTE/4G/5G Communication	1800-2100 MHz	10-15 MHz	
	C3 I (Command Control Communication Intelligence)	VLF Band LF Band ELF Band	10 KHz-30 KHz 30 KHz-300 KHz 3 Hz- 30 Hz	Pan India
	Communication [High capacity short haul Point-to-Point (P2P) Microwave (MW) radios]	21.2 to 23.6 GHz	28 MHz	Pan India

Table 8.1: Futuristic Utilisation of Various Frequency Bands by the Armed Forces

In the light of the above, Defence must keep adequate spectrum readily available to be utilized for futuristic use in order to remain relevant and contemporary.

Requirement of Dedicated Frequency Spectrum

Indications are that the Armed Forces will experience increased usage of EM spectrum for numerous systems in the future; wireless networks that contribute to the realization of Network-Centric Warfare. These networks will provide increased situational awareness,

dissemination of timely intelligence, and direct high-bandwidth communications to all battlefield users. For terrestrial mobile operations using spectrum above 3 GHz, data link requirements for battlefield systems are projected to grow significantly. Two areas/ fields in the Armed Forces, in addition to communications, where there is a requirement of having dedicated frequency spectrum are:

(a) Downloading images from remote sensing satellites in satellite frequency bands.

(b) Dedicated communication with Geo-Communication satellites in satellite frequency bands.

This growth is driven by the need to support the increased use of battlefield sensors and high data rate transfers associated with airborne high-resolution, hyper-spectral sensor data. Moreover, new requirements are surfacing for Secure Wireless LANs in the 5 GHz band and UAV Command & Control links along with Future Combat System (**FCS)** Data Networks in the 30 GHz to 40 GHz frequency band. With respect to the MoD's need for spectrum in bands allocated for satellite communications (SATCOM), both Government and non-government spectrum bands may be considered.

To satisfy the increased demand for SATCOM associated with transformational war-fighting and MoD's need for information, MoD is planning to field several new satellite constellations that will require access to satellite spectrum. As these systems are expected to operate in the current bands identified for satellite utilization, ***the increase in the number of constellations utilizing the same frequency bands will put pressure on the frequency spectrum*** to satisfy this demand while providing necessary assurance of interference-free operations. Since all currently used SATCOM frequency spectrum is projected for continued or expanded use, there is growing competition for SATCOM spectrum. This competition will increase as new commercial satellite constellations and MoD transformational SATCOM constellations are fielded.

Future systems will use all the existing SATCOM frequency bands and the associated orbital slot assignments unless, or until, other bands or services can better meet their requirements. Consequently, sufficient nationally and internationally allocated frequency spectrum and orbital slots must be retained/obtained as an essential enabler of military-unique systems and capabilities.

Common Repository of Freq Spots Allocated for the Armed Forces

There is a requirement of creating and populating a common repository of the frequency spots allocated to various projects of the Armed Forces. Such a repository of frequency spots allocated to Defence by the WPC should be available with respective Service HQs also for the allocations made for their respective Service HQ. The coordination to resolve conflicts on use of frequency spectrum within Defence is done at the JCES level and with non-defence users at the WPC level. It is not recommended to maintain a separate ***consolidated*** repository of the frequency spots allocated to various projects of the Armed Forces at any level other than JCES, HQ IDS, due to security reasons. Along with this repository, a spectrum geo-location data base (similar to that in countries such as the UK) could also be considered so that vacant spectrum across space and time dimensions can be easily identified for better use. The same would also be useful to manage the Electromagnetic (EM) environment and could be shared with the SHQs of the three Armed Forces over a secure network. However, respective SHQs must also have a separate repository of the frequency spots allocated to various projects of their respective Service. Sharing of data between the SHQs and JCES/HQ IDS over a secure network could be considered.

Unauthorized Entity Using Defence Spectrum in an Unauthorized Manner

Post the rollout and conceptualization of 5G and IoT, the likelihood of non-government/unauthorized entities using the defence spectrum

cannot be negated, given the fact that the main challenge for executing IoT shall be the bandwidth requirement. The population and ever-increasing demand in the Indian market may therefore force some non-state players for executing the same in total privacy, which shall come to light only when the same interferes with military operations.

Wireless Monitoring Organisation (WMO). The WMO of the Department of Telecommunications is an integral part of the spectrum management. It is a field unit of the WPC Wing and carries out wireless monitoring through a network with its Monitoring HQ (MHQ) at Delhi, four Regional HQs (i.e., NRHQ, SRHQ, ERHQ AND WRHQ at Delhi, Chennai, Kolkata and Mumbai, respectively), one International Satellite Monitoring Earth Station **(ISMES)** at Jalna, five International Monitoring Stations **(IMSs)** and 23 Wireless Monitoring Stations **(WMSs)**, strategically located all over India. WMO is also equipped with five Radio Noise Survey Units **(RNSUs)**, which undertake detailed and complicated measurements to aid in spectrum management activity. In addition, WMO, with its 10 Inspection Units, carries out physical inspection of wireless installations. There is a pressing need to ensure prevention of interference by unauthorised entities within the Armed Forces. Thus Defence, through their corresponding organizational structures, must take care of monitoring the frequency bands defined/allotted to them. Such an organization could be called the Central Spectrum Monitoring Org **(CSMO)**. Its suggested function and organizational structure is deliberated upon in subsequent paragraphs.

CSMO and Spectrum Monitoring Company (SMC). The erstwhile Radio Monitoring Company (**RMC**), affiliated to the Central Monitoring Org **(CMO)** was in fact responsible for monitoring and reporting on breaches in wireless communication and proper Radio Telephony (RT) procedure. The CMO and RMCs have however since been disbanded. Post disbandment of these RMCs, there exists no other organization within the Armed Forces at present, which

can monitor or police the Defence frequency spectrum. Spectrum monitoring requires expensive equipment and qualified personnel for monitoring the Defence Band. A tri-Service organisation like the erstwhile RMCs should be created under HQ IDS, to meet the requirements of the above mandate. Additionally, inputs from WMOs should be made available to the Defence Forces on a regular basis. The PE of such units should be sufficiently augmented and enhanced to enable them to carry out this task. The manpower for them could be obtained through accretion from the three Services in the ratio of 5:3:2 from the Army, Air Force and Navy. These units could be designated as Spectrum Monitoring Company **(SMC)** and could be affiliated to Central Spectrum Monitoring Org **(CSMO)**, which ***could function under JCES Dte of ICT Div of Ops Branch, HQ IDS***. These additional specialised units can be entrusted with this responsibility after due deliberation.

Suggested Functions: Central Spectrum Monitoring Org (CSMO). As under:

(a) Resolution of harmful interference in Defence Band.

(b) Monitoring for prevention of use of Defence Spectrum by a non-entitled entity, in an unauthorized manner.

(c) Monitoring for spectrum recovery-unused/under-used frequency authorizations.

(d) Monitoring for ensuring adherence to licensing conditions.

(e) Monitoring/measurement for sharing studies. Monitoring for identification of frequency sub-bands for introduction of new services/for trials/new equipment.

(f) Assistance to WPC/other government organizations/ domestic commercial users.

(g) Participation in special monitoring campaigns at the national level.

(h) Measurement of radio emissions (intentional and non-intentional) for the possible introduction of new radio communication standards and for studying the EMC compatibility of proposed new installations in the field.

(i) Monitoring of space emissions to protect unauthorized satellite transmissions.

(j) Work in close coordination with the CMO of WPC and JCES Dte, HQ IDS.

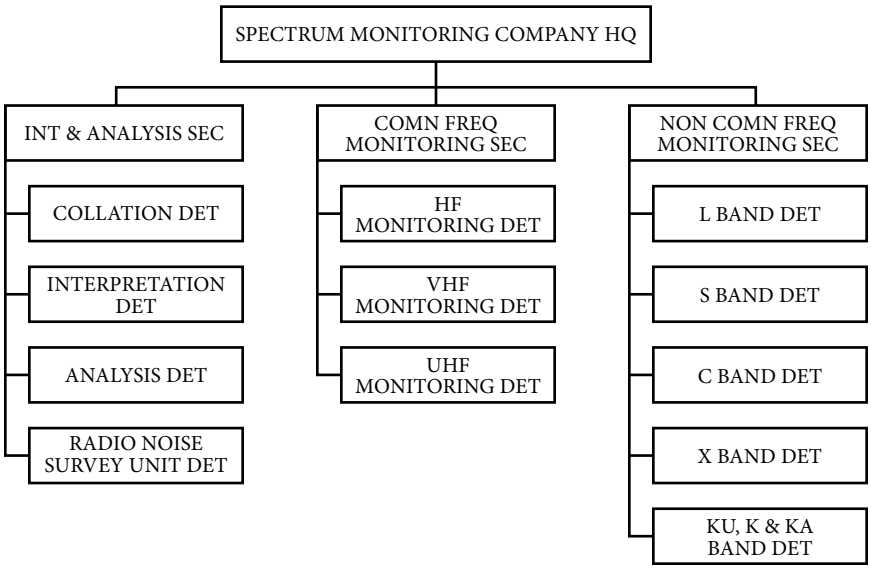
(k) Measure SNR & noise floor at field locations, using Radio Noise Survey Unit Dets.

Suggested Organisation: Central Spectrum Monitoring Org (CSMO). Akin to the organizational set-up of WMO, the following is suggested for CSMO:

Ser No	Organisation	No	Remarks
	HQ Central Spectrum Monitoring Org (CSMO)	01	To function under JCES Dte, ICT Div, Ops Branch, HQ IDS and be based at Delhi .
	HQ Spectrum Monitoring Company (SMC)	10	To function under CSMO and be located at Delhi and at each of the six operational commands of the Army, .i.e., Udhampur, Kolkata, Lucknow, Pune, Jaipur and Chandi mandir. And also at HQ SAC (Thiruvananthapuram), HQ ENC (Vishakapatnam) and at HQ ANC (Port Blair).
	Communication Freq Monitoring Sec	10	One each per HQ Spectrum Monitoring Company (SMC). Each comprising a HF, VHF & UHF Monitoring Dets and Radio Noise Survey Unit Dets.
	Non Comn Freq Monitoring Sec	10	One each per HQ Spectrum Monitoring Company (SMC). Each comprising 05 Dets for monitoring various bands (L,S,C,X and Ku, K & Ka bands)
	Intelligence & Analysis Section	10	One each per HQ Spectrum Monitoring Company (SMC), Each comprising 03 Dets (Collation, Interpretation & Analysis Dets)
	International Satellite Monitoring Earth Station (ISMES)	01	To function under CSMO and be located at DSSC Bhopal.

Suggested Equipment Profile and Manning Norms: (SMC). There would be a requirement of high sensitivity receivers of different frequency ranges, of spectrum analysers and of digital recording equipment. Likewise there would be a requirement of manpower (Officers, JCOs and ORs), as per the manning norms for such detachments required to work round the clock. Broadly, there would be a requirement of two officers for the CSMO and for each of the seven SMC's and for the ISMES. Each of the 21 sections would be required to be led by a JCO (equivalent). All the detachments would be led by an NCO each. Half of the detachments could be considered to be 08-men Dets and the balance would be 04-men Dets. The corresponding administrative staff required at the CSMO and SMCs can be accordingly worked out as per the template and staff tables available. The detailed PE and PET can be subsequently worked out once the broad proposal as given in para 30 above and as diagrammatically explained in para 32 below is agreed to. The same is essential for safeguarding the defence spectrum.

Suggested Organisation: Spectrum Monitoring Company (SMC). A suggested organization of SMC could be as depicted:



Freq Spectrum for Defence in India to be Aligned with Global Trends

The International Telecommunication Union (ITU) is part of the United Nations (UN) that manages the use of both the RF Spectrum and space satellites among nation-states. The Indian Defence Ministry is a big player in the spectrum space because of the country's legitimate security worries. Spectrum is a scarce natural resource, since allocated spectrum cannot simultaneously be used for other purposes. In other parts of the world, for example, NATO countries and several NATO allies have adopted the "NATO-Band" of the spectrum for their defence requirements, while the non-NATO Band accommodates most of the commercial telecom in these countries. Some countries, including India, have not adopted the "NATO Band" for their defence spectrum requirements as the import of defence equipment could be from nations other than those in the NATO. This has resulted in a situation where the cost-effective commercial equipment bought by commercial telcos in India from these countries falls in a non-NATO spectrum band, of which a significant part of this overlaps with the Indian Defence spectrum bands. Likewise, some of the equipment imported by Defence (especially the ones which were under procurement process prior to the promulgation of the Defence Band in 2015), falls out of the Defence Band. This is therefore a crucial reason leading to serious conflict of commercial public telecom services with the defence spectrum bands, which is reconciled by periodic dialogue between the JCEs and WPC.

The global ecosystem for weapon and communication systems using spectrum for commercial utilization, as also for induction into Armed Forces, can be exploited in a wider platform by the Armed Forces, only if there exists a commonality in alignment of frequency for Defence in India in consonance with the global trends in requirement. This is required, yet it has its advantages and disadvantages, analysed as under:

(a) **Advantages of Alignment with Global Standards**

(i) Equipment procurement processes simplified.

(ii) Facilitates Transfer of Technology (ToT) of military equipment being procured.

(iii) Interoperability and compatibility.

(iv) Reduced interference.

(v) Easy and efficient spectrum management.

(b) **Disadvantages of Alignment with Global Standards**

(i) Security.

(ii) Secrecy.

(iii) Surprise.

Development of Expertise Within Defence in Field of Frequency Spectrum Mgt

Frequency Spectrum Management. It is the gamut of requesting, recording, de-confliction of and issuance of authorisation to use frequencies (to operate electromagnetic spectrum dependent systems), coupled with monitoring and interference resolution processes. Frequency Spectrum management is, though a niche field requiring specialization and continuity, an opportunity and exposure within the Armed Forces to work in this field despite limited number of appointments and the organizational constraints of limited duration of tenures is essential. The Defence Band and DIZ too are of 2015 vintage. Personnel dealing with procurement of spectrum-dependent equipment need to be exposed to the importance of spectrum. Suggestions for providing opportunities to more officers in the environment with exposure to Spectrum-related issues, includes qualification in online courses on spectrum mgt being conducted by ITU by a select group of officers. The qualified officers can then conduct capsules as part of longer courses in MCTE, Mhow. The

challenges faced in this regard in both the Communication field and the Non-Communication Field are explained below:

(a) **Communication Field.** Though the formulation of Signal Instructions is formally taught in certain courses in MCTE, Mhow, a limited amount of formal training on the complex subject of frequency spectrum management is carried out. The same needs to be addressed.

(b) **Non-Communication Field.** No formal training of frequency spectrum management in this domain is carried out. The allocation of frequencies for a particular equipment is based on the design of the equipment and the user does not have any role in altering it. The band of operation of the equipment is based on its role and is inflexible at the user end. The training for user is only limited to selection of a frequency within the frequency band of operation of the equipment. The training frequencies and operational frequencies are pre-laid and thus there is little scope of altering them.

Recommendations. At present, there is only one Frequency Spectrum Management Course which is conducted once an year under the aegis of HQ IDS, in rotation by the three Services. There is a pressing need to not only increase the frequency of this course, but also to impart basic training within the Services on this subject. Thus, the aspect of frequency management in the non-communication and communication fields should be carried out at the national level (tri-Services effort). MCTE, Mhow, could be considered to be nominated as the Centre of Excellence for frequency spectrum management and the training should be imparted there for all ranks of the three Services. Air Force Station Sohna Road, Gurugram, and Naval School, Kochi, could also conduct courses on this subject for their respective Service.

Representation of Defence in Formulation and Implementation of Telecom Policy

Though the representation of the Armed Forces as regards telecom policy and formulation is present, it is extremely limited. The Armed Forces need to be not only adequately represented but also integrated in formulation of national telecom policy and subsequently in its implementation. At the national level, defence representation is recommended in all the policy-making bodies dealing with telecom/ spectrum policy issues to convey the correct perspective of the Armed Forces on frequency spectrum issues.

The national policy makers and planners also need to be explained that decreasing the military force does not mean that their available spectrum should be decreased as well. The converse is in fact true as reduction in manpower comes at the cost of enhanced automation and consequent requirement of frequency spectrum. The variety of operations (combat, non-combat and peace support) of military forces has increased and they usually use the RF frequencies based on activities and not on the number of the force.

Miscellaneous Measures for Improvement

Policy Formulation. Integrated Frequency Spectrum Management for Defence should be carried out by JCES, HQ IDS as done in the past. A Joint Defence Frequency Spectrum Management policy (as also similar policies for the three individual Services) could be considered to be formulated in line with national and international policies. Defence representation must be essential at WPC in all forums of policy formulation. There should be a permanent representation of DG Signals, ACAS (Comn) and ACNS (CSNO), at JCES to resolve matters of frequency spectrum management policies. WPC needs to be approached for formally waiving off the spectrum charges in respect of the spectrum allotted to the Armed Forces and to also consider delegating freq allocation within the Defence Band to JCES, HQ IDs.

DLs should be issued for a minimum period of five years. Automation of complete wireless equipment profile with technical characteristics and area of deployment on a GIS platform, up to the command level, could be considered as a possible way forward. Certain other suggestions/measures are as listed in subsequent paragraphs.

Training. MCTE, Mhow, may consider conducting frequency spectrum management courses in the communication and non-communication frequencies domain for imparting training for all ranks of the three Services. Brainstorming sessions and conferences on the subject matter to be held quarterly, alternatively at MCTE, Mhow, Air Force Station Sohna Road, Gurugram and at School of Naval Signals, Kochi, with domain experts from various fields including civilian scientists and academia.

Conclusion

National security is not restricted to securing the land, air and maritime boundaries and pursuing strategic interests but encompasses all aspects that have a bearing on the nation's well-being. Outer space and cyber space have emerged as the new enablers for nations, enhancing the speed and efficiency of national security and socio-economic efforts and also in providing novel applications for the same. In an information-dominated world, they are instrumental in providing the competitive edge among the global community, strategic and tactical superiority in conflict situations, and projection of national power and influence. In addition to capability enhancement towards national aspirations, investments are also necessary for securing these facilities against deliberate or unintentional intrusions or attacks and in ensuring safe and sustainable operations. Wireless medium using frequency spectrum will be the preferred highway of choice where all these battles will be waged using the latest high–tech weapons. ***This precious resource of frequency spectrum thus needs to be guarded zealously and optimally utilised.***

9
Conclusion

Nature of Wars and Frequency Spectrum

Hybrid Warfare. It has been universally acknowledged that in future wars, Hybrid Warfare will have a major role to play and it becomes even more potent and volatile with an information war. It creates the perception of success, decides the scale of victory, and acts as a potent tool for a misinformation campaign. ***India*** should not become a victim of hybrid war or casualty, because of its own neglect. There is a need to introspect, analyse and formulate doctrine and strategies to have an effective mechanism to deal with it. Hybrid warfare will be a defining feature of the future security environment and thus a fragmented approach will be detrimental to the national interests. The debate of ethics and rules does not apply to hybrid war; what is important is the impact of own response to a borderless war. As Frank Hoffman states, 'Tomorrow's conflicts will not be easily categorised into conventional or irregular, the emerging character of conflict is more complicated than what it appears. A binary choice of big and conventional versus small or irregular is too simplistic.' India needs to develop an understanding of hybrid war and the contours of conflict suggest that future wars will not be completely conventional, nor should it be assumed that

state-based conflict has passed into the dustbin of history. Many have made that mistake before.

National security encompasses all aspects that have a bearing on a nation's well-being. Outer space and cyber space have emerged as the new enablers for nations, enhancing the speed and efficiency of national security and socio-economic efforts and in providing novel applications for the same. Space-enabled services enhance existing technological capabilities or create novel applications to support national security objectives—both military and non-military. They have maintained their pivotal role towards strategic warfare. However ***all the instruments listed above,*** viz., securing the land, air and maritime boundaries, outer space, cyber space and information warfare ***are merely vehicles and like the classical motor vehicles they need fuel to function properly.*** In this information age, ***the fuel for these instruments is the availability of requisite frequency spectrum.*** Thus, if India is not to become a victim of hybrid war, there is a need to introspect, analyse and formulate doctrine and strategies, to include but not limited to ensuring availability of requisite frequency spectrum for Defence, to have an effective mechanism to deal with it.

Emerging Regional Superpower

A 'superpower' is a country that wields enough military, political and economic might to convince nations in all parts of the world to do things they otherwise would not. Political pundits across the world including many ordinary Americans have rushed to label China as the next superpower, but the rumours of America's decline have been greatly exaggerated. In the key categories of power, the USA will remain dominant for the near future. **Military** America's military superiority remains unrivalled. The USA dominates across land, sea, air and space, which is possible in no small measure because of its effective use of NCW, which in turn is ***made possible on account of availability of requisite frequency spectrum for its***

armed forces. America's wars in Iraq and Afghanistan speak more about the changing nature of warfare than declining U.S. military superiority. China has also made rapid strides in modernising its armed forces to fight the "Future Next Generation" war and the same has been made feasible in no small measure by optimal use of ICT, ***facilitated to a large extent by the ready availability of requisite frequency spectrum for its armed forces.*** If India aspires to play the role of a global/regional superpower then it too needs to address these issues and accord a very high priority for making available to Defence the requisite frequency spectrum

Net-Centric Warfare and Increasing Spectrum Requirements

Net-centric warfare has been correctly leveraged by developed nations like the USA, Russia, China, France and the UK. Net-Centric Warfare or Net Centricity is also relevant in the Indian context at the national level and the same could be extended to the regional level also. With the beginning of the space age, during the so-called "cold" war, intensive development of technical means of Intelligence, primarily of space satellites with optical, infrared, radio, and electronic intelligence, allows continuous and all-weather surveillance of enemy territory, passing on information to Intelligence centres in almost real time. Different kinds of radars, including air and ground station Airborne Early Warning (AWACS) missile defence systems and air defence, have the ability to detect the enemy's weaponry at great distances, including over the horizon.

Success in future battles will not be due to one type of weapon: victory will only be achieved by the harmonious interaction of all species and genera of troops—fleet, aircraft, missiles, intermediate-range, artillery, tanks and infantry. Thus, from the action of various combat platforms on the battlefield, a kind of synergy effect will have to be achieved, *which is possible only due to the networks in place,*

which will be a combination of a limited percentage of fixed-wire networks (primarily used for backhaul) and the predominantly wireless networks in the Tactical Battle Area (TBA). Point-to-point connections between individual systems are fragile and certainly do not meet the requirement for dynamic data integration between multiple systems. The correct approach is to provide real-time connectivity to all systems within the battlefield framework, and to move the limited intelligence and data away from the individual system and onto the network as a whole. Once the data, such as position, radar signals, and ground intelligence, is abstracted from the individual system and made available across the network, numerous applications can be written to analyse and act on it, providing a significantly higher-level view and a faster response time. In all this, ***ready availability of requisite frequency spectrum for the Armed Forces and its effective management will be the deciding factor.***

Denying the war fighters' the use of any portion of the spectrum would reduce flexibility and jeopardize mission accomplishment. The current Armed Forces radar spectrum requirements are extensive and are likely to grow in the future; the trend in military radar is towards wider bandwidths, in improve discrimination of targets and provide additional signal processing for anti-jam techniques. New developments in radar systems are planned for the upper frequency bands (above 10 GHz), but these developments are generally intended to enhance capabilities rather than supplant the existing systems in the lower bands. Training and Test And Evaluation **(T&E)** missions have different, independent objectives. However, they most often share common radio frequency (RF) equipment and common resources and are often conducted in parallel to ensure realistic operational testing while maximizing training opportunities for military units. The demand for spectrum to support training and T&E events has increased over the last decade and will continue to increase as the design, development, testing, fielding, and employment of systems

in support of force transformation is matched more closely with the war-fighting needs of the Armed Forces.

As with many other armed forces systems and services, the spectrum requirements of unmanned systems will continue in all of the same frequency bands utilized today but will grow in selected bands. In these selected bands, there will be a steady rise in the number of frequencies required to support the growing use of unmanned systems, an increase in the bandwidth for frequencies to support increased data transfer, and an increase in the time of operation due to longer on-station requirements. *Meeting the increased requirement for spectrum dedicated to support unmanned systems* ***will require increased attention to spectrum management schemes and scheduling*** *to promote sharing of frequencies.*

Additionally, technologies that increase on-board processing and compression of sensor data will assist in reducing the amount of contiguous bandwidth needed to support airborne data links. Without significant spectrum reuse and fielding of spectrum efficient technologies, unmanned systems will be constrained in their use of spectrum to achieve overall mission needs and may require highly refined scheduling plans to ensure that operations are executed within the limits of available spectrum.

Adequacy of Spectrum Earmarked in DB for Armed Forces and Instances of Conflict

The frequency spectrum earmarked for the Armed Forces, as promulgated in the Defence Band, is not adequate to meet both their present and futuristic requirements. Due to the advent of 5G and Internet of Things (IoT), potential increase in demand for wireless data and Internet services is likely to *put a strain on wireless networks*, both in developed and emerging countries. *Spectrum, an essential national resource for commercial mobile services, needs to be allocated, assigned, and managed appropriately* within the extant

institutional framework in respective countries. Spectrum has varied uses apart from commercial mobile services, especially in Defence and national security.

There have been instances when the spectrum earmarked in the Defence Band been sought for commercial purposes and, considering the larger goals of national development, Defence has been periodically coordinating certain portions of spectrum allocated to it, keeping in mind the security requirements. The growth in the cellular communication sector is sufficient proof of the cooperation provided by Defence in this regard. Most of the spectrum used by the cellular operators belonged to the Defence Services earlier and a major effort has gone into readjusting Defence usage and making way for commercial services. Further coordination may not be possible unless we have major changes in our equipment and systems. This will take a long time due to the constraints of procurement from other countries, limitations of indigenous development and international restrictions on transfer of technology. The Network for Spectrum (NFS) project is such example where defence spectrum has been surrendered for a pan India network, which is being implemented by the state-run BSNL.

Judicious Balance Between Development and Defence Preparedness

Spectrum is an essential input in the provision of mobile/wireless services. The potential increase in the demand for wireless data and Internet services within the Armed Forces is likely to put a strain on wireless networks. The value of spectrum has also been shown to be immense. Hence, *there is a need for optimizing spectrum management practices.* Any mode of spectrum management has to address the issue of the management of the government spectrum. *Government spectrum is put to sensitive use in defence and communications, hence posing thorny questions that may not entirely be addressed*

by considerations of efficiency. Moreover, most spectrum bands are presently under the control of the Government/private telcos, complicating an already vexed issue with the inertia of incumbency.

The objective realities facing a nation, including perceived security threats, the prevailing norms underpinning social choices, and the governance structures in place, determine the outcomes that emerge in the release of spectrum. *The legacy of certain departments like Defence having had control of spectrum for a long time also plays an important role and the concerns of national security need to be adequately addressed and should not be sacrificed at the altar of commercial progress.*

Unauthorized Use of Defence Spectrum

Real-estate borders, if left unguarded/not kept under surveillance, are likely to be encroached upon; the same analogy is true for frequency spectrum. This encroachment could be either deliberate or unintentional; it could be driven by commercial concerns or as a result of covert action by our military adversaries. Whatever be the cause, in either situation, secure communications could be interrupted by mobile telephone services that distort messages in operational areas and can even affect the functioning/accuracy of surveillance and reconnaissance equipment. Interference puts the Forces at risk as encrypted communication, while not being cracked, could distort messages. There is thus a pressing need to have in place an organisation which can effectively monitor the Defence Band, to prevent such situations. The same has been explained at length in the preceding chapter.

Conclusion

Technological advances such as cognitive radio and spread spectrum techniques appear to have mitigated the risk of interference to the point that the shared use of spectrum is becoming a real possibility. The

idea of "pluralistic licensing" allows shared use of spectrum among spectrum holders in the context of 5G network deployment. Future spectrum management within the Armed Forces could consider using the latest techniques if feasible. The **Armed Forces need to recognize the tremendous role that wireless communication, and thus, spectrum, can play in Defence**. At the national level, there is always the **classic guns versus butter paradigm**, but security concerns must be addressed. The Armed Forces could ensure that the equipment procurement cycle and frequency allocation process for the said equipment should go together and procurement time be minimised to the extent possible to leverage the advantage of the latest technology. Strategic alliances may be made with vendors or supplier nations for supplying the desired item for long duration with latest technology and scalability.

Not only is an armed conflict now of a "hybrid nature" but the Army, Navy and the Air Force are also adapting to "Network-Centric Warfare" for mobile operations. Therefore, the demand for spectrum within the military has increased. The presence and use of unregulated mobile operations in this environment may create "Electro Magnetic Interference", (EMI) and it needs to be avoided at all cost. Spectrum is a critical resource which needs to be managed in an efficient manner.

Civil/commercial requirements are bound to grow at a faster pace, which may result in more demand for the surrender of Defence Band frequencies. In order to obviate such a situation from arising, the three Services will have to diversify along the full spectrum, with suitable gaps for their own future expansions. Any future civil/commercial requirement must be resolved with a jump in technology and not by any further surrender of frequency spectrum in the defence band.

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Appendix 'A'

Questionnaire: Appraisal of the spectrum requirements of the armed forces for optimal utilisation of the defence band

Guidelines to Respondents

The questionnaire is being circulated as part of a ***classified*** Research Fellowship Study being undertaken at CENJOWs, to carry out an appraisal of the present and futuristic frequency spectrum requirements of the three armed forces to facilitate optimal utilization of the Defence Band.

Respondents are requested to kindly fill in their particulars and provide free and frank responses to the questions listed in the questionnaire. Any additional input/ views not covered in the questionnaire are also welcome. The response to the questionnaire may please be forwarded by attaching additional sheets and the questionnaire returned alongwith.

The response to the questionnaire should be the personal views of the respondents. Organizational views are **NOT** being sought.

The aim of the questionnaire is to obtain views/ counter views of the environment on the subject, to facilitate a viable research outcome. Respondents are assured of the confidentiality of their views expressed as response to this questionnaire. The inputs may please be forwarded by 15 Oct 18, at the following address:-

Centre For Joint Warfare Studies
(CENJOWS)
HQ IDS, MoD
R. No 66 West Hutments, Kashmir House,
Rajaji Marg, New Delhi-110011

Details of Respondent			
Organisation/ Service		Name	
Unit/ HQ/ Department		Appointment/ Nature of Job	
Rank/ Designation		Service (in yrs)	

Questionnaire

What in your view is the attribute which is most likely to shape the nature of wars in times to come?

(a) Conventional arms superiority

(b) Nuclear Deterrence.

(c) Aerospace power

(d) Naval Power

(e) Hybrid Warfare to include Information Communication Technology (**ICT**), Space and Cyber Warfare.

(f) Any other (please specify)

Which of the attributes listed in ques 1 above has the maximum bearing on all other attributes of force projection ?

What is the main reason why developed nations like USA and UK are able to effectively project their power globally ?

(a) Superiority of Conventional armed forces.

(b) Nuclear Deterrence.

(c) Cohesive theatre commands.

(d) Real time Intelligence & Precision targeting.

(e) Effectively leveraging ICT to augment all facets of warfare.

(f) Exploiting Cyber Warfare as a specialized arm of combat.

(g) Effective projection of aerospace power.

(h) Availability of Carrier based battle groups.

(i) Any other (please specify)

Do you feel Net Centric Warfare has been correctly leveraged by developed nations like USA , Russia, China, France and UK ? In view of the envisaged enhanced role of India in the near future, is Net Centric Warfare or Net Centricity relevant in the Indian context ? If so at what level ie at the National /Regional/ Global level ?

In the era of Net Centricity ,Automation, Artificial Intelligence **(AI)** and Robotics, there will be a requirement of speedy passage of instructions to a host of entities in a fluid environment. In such a scenario requiring quick response, what would be the preferred and more responsive and resilient communication medium for passage of instructions ie fixed wired communication cables or wireless medium using frequency spectrum?

In earlier times, frequency spectrum and bandwidth was required primarily for communication systems. However with the proliferation of technology, in addition to communication systems, which are the other areas/ fields in the armed forces, where there is a requirement of having dedicated frequency spectrum (ie weapon systems/ platforms / smart ammunition / surveillance grid/ navigational systems/ Identification Friend or Foe systems etc) ?

Seized with the genuine requirements of the armed forces, the GoI had promulgated the Defence Band in 2015, wherein a portion

of the frequency spectrum was earmarked for use by Defence. Has the promulgation of the Defence Band assisted the armed forces in procurement of equipment , in force development and has it been able to meet the frequency requirements of the armed forces? Please give a brief justification in support of your answer.

Post promulgation of the Defence Band, has the procedure for frequency allocation for armed forces improved ? Please give reasons in support of your answer.

Is the frequency spectrum earmarked for the armed forces, as promulgated in the Defence Band, adequate to meet the present and futuristic requirements of the armed forces ? Have their been instances when the spectrum earmarked in the Defence band been sought for commercial purposes ? Please elaborate indicating how the matter was resolved.

Frequency spectrum is a national resource and is also required for a nation's growth and development. In your view, with the promulgation of the Defence Band in India, is a judicious balance being maintained between a nations development and its safety/ security and defence preparedness ? Kindly elaborate.

There are at times few instances when frequency assignments to non defence users are made within the defence band and the Armed Forces are at times constrained to seek allocation of frequency spectrum in Out of Defence Band. Is such a system of mutual accommodation beneficial in the overall national interest or should the Defence and Non Defence requirements of Frequency spots be consigned to their respective parts of the spectrum ?

The equipment procurement cycles of the armed forces are rather deliberate and long and the pace at which technology changes (especially in the field of ICT) is very rapid. For the induction of any equipment (especially ex import), the frequency of use for the same needs to be allocated before it can be brought to India. However

there have been instances where the technology has undergone a change, while the equipment / weapon system is under development. In light of these two dichotomous situations, please give suggestions to improve the system of frequency allocation and equipment procurement.

Which of the under mentioned factors in your view are the major drivers for Defence spectrum requirements.; Please list them in the inter-se order of priority (ie most important to least important) and give reasons in support of your answer:-

(a) Mandate of the Armed Forces.

(b) Existing/ Futuristic Communication Technologies.

(c) Electronic Warfare.

(d) Future Warfare Concepts.

(e) Early Warning/ Surveillance Systems.

(f) Artificial Intelligence & Robotics.

(g) Any other reason

With the rapid proliferation of technology, especially in the field of ICT, do you feel that there is a need to explore the utilization and optimal exploitation of certain higher frequency bands also for Defence ? If yes, please give suggested likely utilization of all types of frequency bands (from 3KHz to 40 GHz), fpr use by various systems (ie Weapons/ EW/ Communication/ Surveilance/UAV/Radars/AI etc). The approximate bandwidth that these systems would require would use, may also be mentioned. Views may also be offered on whether such systems would be needed pan India or only along border areas. A suggested tabulated format for giving inputs is as under:-

S.No	Types of systems (ie Weapons/ Surveilance/ Communication/ EW/AI etc)	Frequency band of operation (ie xx KHz/ MHz/GHz to xx KHz/ MHz/GHz	Approximate bandwidth required by the systems	Envisaged area of utilization ie Pan India or only along borders

Please list out the challenges faced in the field of spectrum allocation and spectrum management for Defence and suggest improvements that could be incorporated in the same? Also additional amendments that could be suggested for being incorporated in the Defence Band may please be listed.

With spectrum being such a scarce, quantified yet intangible resource, is there any likelihood of a non defence/ non govt/ unauthorized entity using the defence spectrum, in an unauthorized manner ? Please elaborate with reasons.

If the answer to Ques 16 above is "yes' then is there any organization within the armed forces or within the government mandated to monitor or police the frequency spectrum to detect and prevent such instances of "spectrum squatting " ? Please suggest recommendations

Please suggest an organization within the armed forces, specifically mandated to monitor or police the defence frequency spectrum to prevent violations of "spectrum squatting ?

What is the validity of the Decision Letters (DLs) by which allocation of frequency spots for the Armed Forces is done by the Wireless Planning & coordination (WPC) Wing of MoC? Does the same meet the users requirements ? If not please suggest measures to improve the same.

Please list certain measures in which the process of issue of Decision Letters (DLs) by WPC can be improved upon to enhance efficiency.

The WPC maintains a record of the frequency spots allocated to various users pan India. Is there a need to have a similar common repository of the frequency spots allocated for the Armed Forces, as also to manage the Electromagnetic (EM) environment? If so measures that have been taken in this direction may please be intimated.

Is the requirement for frequency spectrum for defence in India aligned with the global trends in requirement, utilization and development of an ecosystem to support the same world wide?

Is there adequate opportunity and exposure provided within the armed forces to carry out training in the niche field of frequency spectrum management ? Please elaborate and suggest measures for improving the same.

Do you feel that as regards telecom policy formulation and implementation, the Armed Forces are represented adequately, both at the national and international level? Please elaborate with reasons and suggest measures for improvement, in the same, if any.

Please suggest certain other measures which can improve the system of allocation of frequency spots for the Armed Forces and.

SUMMARY OF RESPONSES TO QUESTIONNAIRE

	Responses Sought						Responses Provided					
	Lt Gen	**Maj Gen**	**Brig**	**Col**	**Lt Col/ Maj**	**Total**	**Lt Gen**	**Maj Gen**	**Brig**	**Col**	**Lt Col/Maj**	**Total**
ADGMO (IW)	-	1	2	3	2	8	-	-	2	1	2	5
DG Sigs	1	2	3	4	4	14	-	-	1	-	Dte Response	01
DDG ICT	-	-	1	1	2	4	-	-	-	-	-	-
DG Air Ops	1	2	3	4	4	14	-	-	-	4	3	7
ACNS (CSN-CO)	1	2	3	4	4	14	-	-	-	1	5	6
Sig Int, HQ IDS	-	-	2	4	6	12	-	1	-	4	8	13
Tech Int , HQ IDS	-	-	2	4	6	12			1		Dte Response	01
DSSC	1	3	4	10	20	38	-	1	3	8	8	20
CDM	-	1	4	8	30	43	-	-	-	7	-	7
AWC	1	2	4	10	20	37	-	1	5	10	12	28
MCTE	1	1	4	8	20	34	-	-	2	2	44	48
NDC	1	3	4	10	20	38	-	-	-	-	-	-
HQ SFC	-	-	1	1	2	4	-	-	-	-	-	-
Total (136/272)	**7**	**17**	**37**	**71**	**140**	**272**	**-**	**3**	**14**	**37**	**82**	**136**

Appendix 'B'

	Responses Provided					
	Lt Gen	**Maj Gen**	**Brig**	**Col**	**Lt Col/ Maj**	**Total**
ADGMO (IW)	-	-	2	1	2	5
DG Sigs	-	-	1	-	Dte Response	01
DG Air Ops	-	-	-	4	3	7
ACNS (CSNCO)	-	-	-	1	5	6
Sig Int, HQ IDS	-	1	-	4	8	13
Tech Int , HQ IDS			1		Dte Response	01
DSSC	-	1	3	8	8	20
CDM	-	-	-	7	-	7
AWC	-	1	5	10	12	28
MCTE	-	-	2	2	44	48
Total (136/272)	**-**	**3**	**14**	**37**	**82**	**136**

Appendix 'C'

Questionnaire: appraisal of spectrum requirements of the armed forces

Guidelines to Respondents

The questionnaire is being circulated as part of a Study being undertaken to carry out an appraisal of present and futuristic frequency spectrum requirements of the Armed Forces.

Respondents are requested to kindly fill in their particulars and provide free and frank responses, i.e., personal views to the questions listed in the questionnaire. Any additional input/views not covered in the questionnaire are also welcome.

The aim of the questionnaire is to obtain views/counter-views of the environment on the subject, to facilitate a viable research outcome. Respondents are assured of the confidentiality of their views expressed in response to this questionnaire. The inputs may please be forwarded by 15 Mar 19, by return email at **bedins1@gmail.com**.

Details of Respondent	
Name	
Designation/ Appointment/ Nature of Job	
Domain Experience(in yrs)	

Questionnaire

In earlier times, frequency spectrum was required primarily for communication systems. However, with proliferation of technology, in addition to communication systems, **which are the other fields,** where there is a requirement of having dedicated frequency spectrum (i.e., weapon systems/smart ammunition/surveillance grid/navigational systems/Identification Friend or Foe systems, etc.).

Seized with the genuine requirements of the Armed Forces, the GoI had promulgated the Defence Band in 2015, wherein a portion of the frequency spectrum was earmarked for use by Defence. Has the promulgation of the Defence Band assisted the Armed Forces in procurement of equipment, in-Force development and has it been able to meet the frequency requirements of the Armed Forces? Please give a brief justification in support of your answer.

The equipment procurement cycles of the Armed Forces are rather deliberate and long and the pace at which technology changes (especially in the field of ICT) is very rapid. For the induction of any equipment (especially ex import), the frequency of use for the same needs to be allocated before it can be brought to India. However, there have been instances where technology has undergone a change while the equipment/weapon system is under development. In the light of these two dichotomous situations, please give suggestions to improve the system of frequency allocation and equipment procurement.

Based on the trends being followed by other nations globally and on inputs available in **open domain,** do you feel that there is a need to explore the utilization and optimal exploitation of certain higher frequency bands (other than VHF, HF & UHF) also for Defence? If yes, please give suggestions on the likely utilization of all types of frequency bands (from 3KHz to 40 GHz), for use by various systems (i.e., Weapons/EW/Communication/Surveillance/UAV/

Radars/AI, etc.). The approximate bandwidth that these systems would require (as per trends being followed globally), may also be mentioned. Views may also be offered on whether such systems would be needed pan India or only along border areas. A suggested tabulated format for giving inputs is as under:

S.No.	Types of systems (i.e., Weapons/ Surveillance/ Communication/ EW/AI, etc.)	Frequency band of operation (i.e., xx KHz/MHz/GHz to xx KHz/MHz/GHz	Approximate bandwidth required by the systems	Envisaged area of utilization, i.e., Pan India or only along borders

With spectrum being such a scarce, quantified yet intangible resource, is there any likelihood of a non defence/non-govt/-unauthorized entity using the defence spectrum in an unauthorized manner? If 'yes' then is there any organization within the Armed Forces or within the Government mandated to monitor or police the frequency spectrum to detect and prevent such instances of spectrum squatting ?

In case no specific organization exists within the Armed Forces specifically mandated to monitor the defence frequency spectrum to prevent instances of "spectrum squatting, please suggest an organization within the Armed Forces, specifically mandated to undertake this task.

Please list measures in which the process of issue of Decision Letters (DLs) by WPC for allocation of frequency spots for the Armed Forces can be improved upon to enhance efficiency. Please list the other challenges faced in the field of spectrum allocation and spectrum management for Defence and suggest improvements that could be incorporated in the same.

The WPC maintains a record of the frequency spots allocated to various users pan India. Is there a need to have a similar common

repository of the frequency spots allocated for the Armed Forces, as also to manage the Electromagnetic (EM) environment? If so, measures that have been taken in this direction may please be intimated.

Is there adequate opportunity and exposure provided within the Armed Forces to carry out training in the niche field of frequency spectrum management? Please elaborate and suggest measures for improving the same.

Do you feel that as regards telecom policy formulation and implementation, the Armed Forces are represented adequately, both at the national and international levels? Please elaborate with reasons and suggest measures for improvement, if any.

Appendix 'D'

LIST OF SEMINARS/CONFERENCES ATTENDED

S.No	Date	Name of Seminar/ Conference	Organised By	Venue
1	17 May 18	World Telecom & Info Society Day	ITU-APT Foundation of India	Imperial, New Delhi
2	27-28 Jun 18	Cyber Tech India 2018	CENJOWS & South Asia Defence Review	DRDO Auditorium, Delhi
3	26-27 Jul 18	Air Defence India 2018	CENJOWS & IMR	DRDO Auditorium, Delhi
4	04 Sep 18	Social Media & the Armed Forces	CENJOWS, COAI & South Asia Defence Review	DRDO Auditorium, Delhi
5	05 Sep 18	RTD on Social Media & the Armed Forces	CENJOWS, COAI & South Asia Defence Review	Purple Bay, Jodhpur Hostel, Delhi
6	06 Sep 18	UAV 2018 Seminar	CENJOWS & IMR	Manekshaw Auditorium, Delhi
7	07 Sep 18	Mandatory Testing and Certification of Telecom equipment-Interactive Discussions and Live Demo	ITU-APT foundation of India & TEMA/ CMAI	Vigyan Bhawan Annexe, New Delhi
8	26 Sep 18	India 5G Evolution-Empowering Business Customers	COAI & 5G India Forum	Lalit, New Delhi
9	26 Sep 18	28 GHz India 5G Initiative Workshop	ITU-APT Foundation of India	Imperial, New Delhi
10	27 Sep 18	26-28 GHz India 5G Technical Session	ITU-APT Foundation of India	Park, New Delhi
11	28 Sep 18	26-28 GHz India 5G Spectrum Workshop	ITU-APT Foundation of India	Imperial, New Delhi

S.No	Date	Name of Seminar/ Conference	Organised By	Venue
12	25-27 Sep 18	India Mobile Congress	COAI & MoC	Aerocity, Delhi
13	26 Sep 18	Workshop on 5G Technology and Standards	TSDSI & IEEE	Aloft, Aerocity, Delhi
14	04 Oct 18	5th Data Centre India 2018 International Conference	Bharat Exhibitions	Shangri-La, New Delhi
15	14 Dec 18	1stAI & IOT India 2018 International Conference	Bharat Exhibitions	Shangri-La, New Delhi
16	14-16 Nov 18	International Conference on Cyber law, Cybercrime & Cyber security	Cyberlaws. Net and Pavan Duggal Associates	Scope Complex New Delhi
17	06-07 Dec 18	Indian Defence Conclave 2018	Ms TraiCon Ltd	Taj Vivanta, New Delhi
18	15 Dec 18	3rd National Workshop on WRC-19 Preparations	ITU-APT Foundation of India	Le Meridian , New Delhi
19	08-10 Jan 19	Raisina Dialogue 2019	MEA & ORF	Taj, New Delhi
20	06 Feb 19	2nd WiFi India Summit 2019	Bharat Exhibitions	Shangri-La,
21	21 Feb 19	2nd Open Source Summit	Bharat Exhibitions	Shangri-La,
22	22 Feb 19	Meeting-WMO	WPC, MoC	New Delhi
23	14-15 Mar 19	Workshop on Cyber War & Technologies	CENJOWS,HQ IDS	Purple Bay, Jodhpur Hostel, Delhi
24	19 Mar 19	Indian Mobile Conclave	Economic Times	Hyatt Regency, New Delhi
25	27 Mar 19	National Workshop on "Advances in Satellite Technologies"	ITU-APT Foundation of India	Le Meridian , New Delhi
26	16 May 19	RTD: 5G, IoT and Its Implications for the Armed Forces	CENJOWS, COAI & ITU-APT Foundation of India	Purple Bay, Jodhpur Hostel, New Delhi