Ministry of Information Technology & Telecommunication

DIGITAL PAKISTAN

ROLLING SPECTRUM STRATEGY

2020-2023

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1 Introduction

The telecommunications industry is constantly evolving with new technologies being developed to address market demand or to open up new markets. With the growing demand for wireless communications and spectrum, it is necessary for spectrum management organisations to put in place a framework to coordinate spectrum management activities in a structured and transparent manner. This is the main goal of the Spectrum Master Plan and this report is developed by incorporating international best practices that are applicable to Pakistan.

The Spectrum Master Plan provides a future roadmap for spectrum allocation as well as spectrum-related policy reviews that are anticipated to take place between2020 and 2023. This report will assist Ministry of Information Technology and Telecommunication (MoIT&T), Pakistan Telecommunication Authority (PTA) and Frequency Allocation Board (FAB) in formulating the 3-year rolling Spectrum Strategy – which is a key area highlighted in the Telecommunications Policy 2015.

Section 2 of this report discusses global trends around wireless communications and highlights the challenges faced by spectrum managers. Chapter 3 provides approaches that are now being adopted/investigated by various countries to overcome some of the challenges.

Section 4 to 10 look at different radio services, the current utilisation in Pakistan and the future outlook for various spectrum bands. Some spectrum bands will need to be refarmed before they can be allocated and these issues are being detailed in the report.

The publication of the spectrum roadmap helps commercial operators with their network planning investments. It is crucial to recognise that the pace of change of industry is rapid and whilst the aim is to provide transparency and certainty to the industry, there is a need to review the plan (every 3 years) to ensure that the plan continues to be relevant.

2 Global Trends for Wireless Communications

Globally, the wireless communications industry has witnessed several major shifts that is resulting in the convergence of services and technologies. The last decade saw tremendous growth of demand for mobile services whilst some services such as paging ceased to exist. Today, there are over 9.4 billion[1] mobile connections globally exceeding the total world population. This means that the adoption of mobile services is not just happening in the affluent markets but also penetrating into the developing world. In Pakistan, the number of subscribers had grown at a Compound Annual Growth Rate (CAGR) of 32% from 2003 to 2019. There is still room for growth as the current mobile penetration at around 77.2 % is still low compared to many countries. Based on ITU's statistics for mobile-cellular subscriptions, more than 50% of the countries have already surpassed 100% mobile penetration.

[1] Source: GSMA Intelligence (https://www.gsmaintelligence.com/)

There are a few key factors that helped to accelerate the growth of the mobile services and they fundamentally point to an expanding ecosystem that enables faster innovation both in terms of technologies as well as the usage of these technologies.

2.1 Network – Faster Speeds Moving into 5G

At the beginning of the millennium, the mobile industry was looking at developing mobile broadband capabilities through the IMT2000 vision. It took a decade for IMT2000 (or 3G including HSPA) to take off and to demonstrate the viability for the mobile network to also deliver Internet access. With the appetite for faster connection, the industry has since evolved the network to IMT-Advanced (i.e., 4G / LTE-Advanced) and this is spreading rapidly across the world right now. Zong, the first operator in Pakistan to launch 4G/LTE in 2015, is seeing strong growth in its data revenue. In other markets, operators are looking at aggregating spectrum to achieve higher speeds. For example Zain Kuwait, Namibia's MTC and Australia's Optus have announced trials with Huawei that pushed the download speeds to 1Gbps and above. This is the result of applying techniques such as MIMO, carrier aggregation, higher-order modulation which drive spectral efficiency as well network speeds.

Research and development (R&D) continues to push the envelope as equipment manufacturers prepare for the next phase – IMT 2020 or 5G.Trials are already underway with several mobile network operators working with manufacturers to test IMT2020 capabilities. ITU WRC 2015 paved the way for IMT2020 with the deliberation of the spectrum requirements and allocation of spectrum to support the technology. In IMT-2020, a total, 17.25 GHz spectrum has been identified for IMT, in comparison with 1.9 GHz of bandwidth available before WRC-19.

Generation		Period	Speed
2G	Pre-IMT	1990s	64kbps
3G	IMT2000	2000s	2Mbps
4G	IMT-Advanced	NOW	Above 100Mbps
5G	IMT2020	2020	Above 1Gbps

Figure 1: IMT Evolution

Moreover, with economies of scale, the LTE technology has formed the basis for many other applications such as voice-over-LTE (VoLTE), LTE-broadcast (eMBMS) and machine-to-machine (LTE-M). There are also increasing interests to deploy private LTE networks for specialised requirements (a remote mine site).

2.3 Devices–Affordability and Functionality

The network evolution has to go hand in hand with the availability of handsets that can take advantage of the network speeds. The development of handset has also been making progress by leaps and bounds focusing on improving functionality and affordability.

The ecosystem is now fairly mature and device manufacturers often work closely with network equipment manufacturers to adopt standards for faster speed-to-market. Device manufacturers are also cognizant that mobile operators have to operate in multiple frequency bands and in multiple modes (FDD and TDD) so the devices have to support these requirements. For example, mobile operator Three in Hong Kong (3HK) partnered with Huawei to demonstrate multi-mode (FDD-TDD LTE-A) with carrier aggregation to deliver a faster network. 3HK is looking at moving from 2 Component Carrier (2CC) to 5CC in the future. Device manufacturers (Huawei is also one of them) will need to ensure that they keep pace with the requirements from operators and introduce devices that can support multi-mode, multi-band in a timely manner.

New devices introduced to the market by leading global manufactures such as Apple and Samsung are often positioned as premium products and distributed first in the affluent markets. Once there is economies of scale, the prices of these products will fall rapidly and become more affordable for consumers in other parts of the world. Increasingly, there are also low-cost manufacturers, often local companies developing products for domestic market initially before distributing into international markets. Some of the Chinese device makers such as Oppo, Xiaomi and Gionee have already expanded overseas and penetrating well into emerging markets.

Country	Brand(s)	Price Range
Pakistan	QMobile	US$50 – US$440
Indonesia	ADVAN EVERCOSS	US$30 – US$180
Bangladesh	WALTON	US$37 – US$390
Thailand	i-mobile WellcoM	US$72 – US$340

Figure 2: Low-cost Handset from Domestic Manufacturers

Going forward, the devices connected to the network will not only be mobile phones. Increasingly media tablets, 2-in-1s and ultrabook convertibles are mobile-enabled, which allow consumers and workers to access information and content with multiple devices. The next wave is the emergence of wearables. The industry is developing wearables such as smart watches, fitness bands and smart glasses that are mobile enabled.

2.4 Smart Cities, Connected Homes and IoT

Wireless communications will also play a key part in smart city implementation. Some smart city initiatives involve installing sensors on street lamps, garbage bins, parking meters, surveillance cameras, etc. that transmit information via a wireless connection. Smart cities are gaining interests from governments in the Asia-Pacific region driven by the desire to leverage technologies to develop sustainable cities. Many counties in the region are facing the issue of overcrowding, especially in mega cities that have seen rapid urbanizations. China and India in particular have gained a lot of attention due to their commitments in smart city projects in multiple cities. Developed countries such as Australia, South Korea and Singapore are also showing strong support for smart city development.

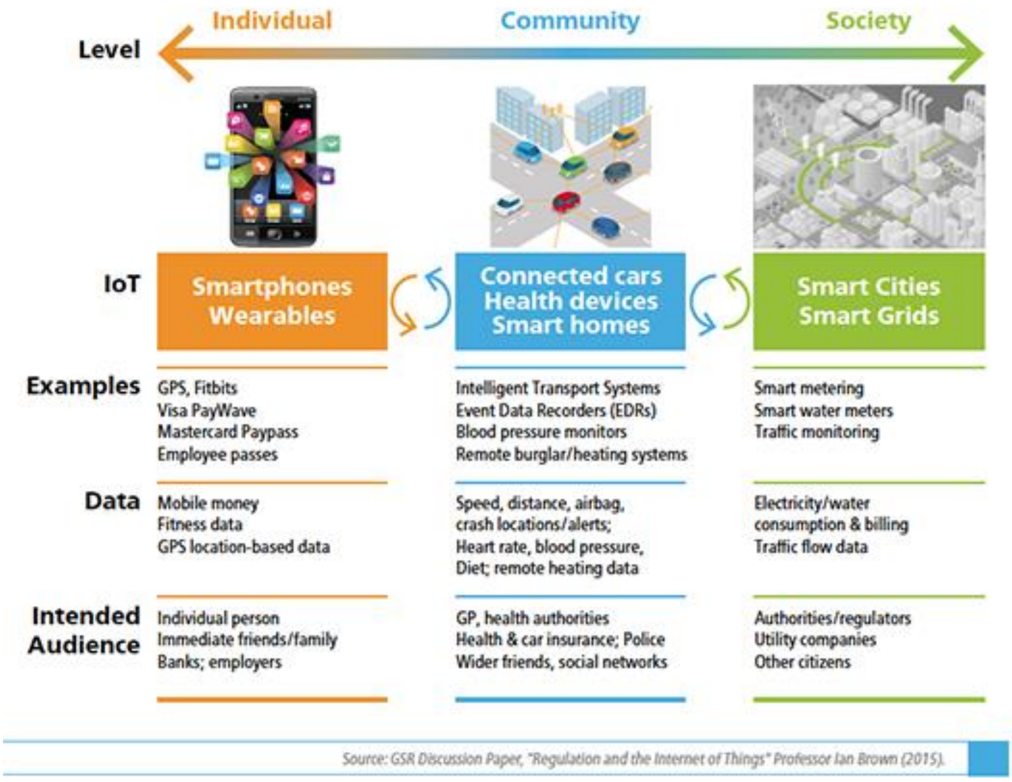


Figure 3: Connected Devices – from Personal Wearables to Smart Cities

From connected homes to industrialised IoT (Internet-of-Things), the industry is also developing solutions that will see objects being connected to the network. Different industries today from agriculture, manufacturing to transport & logistics are starting to deploy machine-to-machine (M2M)/IoT solutions to improve productivity, operational efficiency and develop new business models. Even in case of Agriculture and Livestock, farmers have started to use smart sensors/devices for improving productivity. All of these solutions require the sensors to be connected to the network via wireless means. Different standards have emerged to support different applications and they deliver the connectivity using either the mobile networks or using unlicensed bands.

Short Range	Long Range with Battery	Long Range NB-IOT
Wi Fi	SIGFOX One network A billion dreams; LoRa	3GPP A GLOBAL INITIATIVE

Figure 4: IoT Standards

The smart cities and IoT solutions are no more at the nascent stage and they have wide implication on telecommunications' networks including the amount of traffic these connectivity will generate. Popular projections are pointing to the number of things/machines connected to reach tens of billions by end 2020. There are positive signs that different pieces are coming together and the ecosystem starting to form.

These IoT solutions are generating significant amount of network traffic as they scale up. Therefore appropriate amount of Spectrum should be assigned by PTA/FAB as the unlicensed band/s, as per international practices. The application in NB-IoT in the bands licensed to mobile operators, are also required to be encouraged.

2.5 Applications & Content Ecosystem – Convergence

Smartphones and tablets are sometime collectively known as smart devices. However, they are only 'smart' because of the large number of applications available to consumers that can help them to perform many tasks from chatting, navigation and payment to information access and entertainment. With the growing ecosystem and the availability of open sourced platforms, there are now myriads of software developers creating applications and content trying to solve different problems for consumers and businesses.

The availability of applications resulted in a growing demand for mobile data services giving mobile service providers an additional source of revenue. In response to the growing demand for data services, mobile operators' strategy is to implement voice-over-LTE (VoLTE) and Rich Communications Services (RCS).These services will enable operators to eventually shutdown their circuit switched 2G/3G networks, and refarm spectrum for 4G/LTE and beyond.

2.6 Competition & Consolidation

The liberalisation of the telecommunications market has brought about competition which resulted in better quality of service and improvement in pricing. In a competitive environment, mobile operators have to maintain cost efficiency and stay innovative to win customers and minimise churn. Often with the introduction of a new player, there is a tendency for the new entrant to offer attractive pricing to build up their subscriber base. This may result in a price war but will accelerate the rise in mobile penetration. In many markets, regulators have also introduced rules and regulations to enable the growth of MVNOs to create more competition. MVNOs can be very effective in targeting underserved market segments such as youth, budget customers and migrant workers. In markets with favourable regulatory environment, MVNOs have flourished. Whilst not all MVNOs can be successful depending on their business model and ability to promote their products, these players can take a healthy slice of the mobile market.

In many markets where there had been too many players, market consolidation became inevitable. In Pakistan, there were six operators up until 2008 when Instaphone's licence was terminated by the PTA due to unpaid licence fees. More recently, Mobilink and Warid merged. The merger resulted in a larger player not only in terms of subscriber base but also in spectrum holding. By merging two networks, there is a gain in efficiency and the operator will have more capacity.

One main consideration for the regulators in assessing the merger approval is the spectrum they hold as the combined entity. The general view is that each player should not hold more than a certain threshold to ensure effective market competition. Some countries have imposed a spectrum cap to limit the amount of spectrum an operator can hold. However, with the changes in technology (higher speed mobile broadband requires more spectrum using carrier aggregation techniques) it means that there is a need to constantly increase the spectrum cap (in MHz). This being the case, regulators are adjusting the spectrum cap requirements to ensure greater flexibility.

Country	Spectrum Cap	Notes
Spain	185MHz across all bands; with 135MHz limit for the higher bands (1.8GHz, 2.1GHz, 2.6GHz and 3.5GHz)	Vodafone and ONO merger and the tie-up of Orange Espana and Jazztel required the return of spectrum to the regulator; CNMC now proposes to increase the cap.
USA	The FCC eliminated the limit on the aggregation of Commercial Mobile Radio Services (CMRS) spectrum in 2003. Instead, the FCC now analyses the competitive effects of transactions involving mobile telephony service providers on a case-by-case basis.	30MHz of at least 70MHz in the 600MHz band auction is set aside for participants with sparse holding below 1GHz (i.e., excluding AT&T and Verizon).
UK	Ofcom applies general policy to ensure effective market competition, without strict spectrum caps. The UK regulator applies band-specific spectrum caps that provide greater flexibility.	Ofcom proposed to introduce a spectrum cap for the 2.3GHz and 3.4GHz spectrum auction planned for 2017. The proposal is to limit bidders from processing more than 255MHz (39%) of any spectrum band thus preventing BT/EE (holds the largest share of spectrum at 45%) from bidding on the 2.3GHz band. After the auction, BT/EE's share will drop to 35%.

India	TRAI imposes a cap of 25% of the total spectrum assigned (all bands including 700, 800, 900, 1800, 2100, 2300, 2500 MHz); and 50% within a given band in each of the access area.	Mobile operators have been lobbying for a raise of the overall spectrum cap from 25% to 33% or 40%. For instance, Bharti Airtel which has over 35% market share is not able to increase its share of spectrum to enhance its network. TRAI and Telecom Commission agreed after a review that the spectrum cap should stay. The major spectrum auction in October 2016 significantly increased the total spectrum available therefore giving all mobile operators the opportunity to acquire more spectrum.

Table 1: Spectrum Cap in other Countries

Recommended Actions: It is not recommended for PTA/FAB to put in place a fixed spectrum cap defined in MHz. PTA/FAB can consider using a percentage share of overall mobile spectrum as a guide to decide if further evaluation needs to be performed. Since there are four mobile operators in Pakistan, it is recommended that PTA/FAB consider 35% or 40% a reference point. PTA/FAB should in conjunction with the Competition Commission of Pakistan (CCP) ascertain if an operator acquiring spectrum (whether through merger or through an upcoming auction) will have unfair advantage over small competitors. The evaluation will take into account the operator's share of subscriber as well as the opportunity for other operators to acquire spectrum through an upcoming auction. MoIT&T/PTA/FAB may take a stance that the operator with a higher than 35% / 40% of all mobile spectrum to be barred from an impending auction.

3 Spectrum Management Needs to Cope with these Trends

The rapid evolution of wireless technology and services makes it imperative for spectrum management practices to be sufficiently flexible to meet the changing demand. At the same time, the enhancement of wireless technology is also making it more feasible for spectrum to be shared, resulting in improved spectrum efficiency. Several approaches have been adopted or are being considered by regulators to introduce greater flexibility in spectrum management. Regulators need to look at these options and formulate their stance on these issues.

3.1 Technology Neutrality Regulation

Flexibility in spectrum management and access to spectrum can be increased through technology- and service-neutral authorisations to let spectrum users choose the best technologies and services to apply in a frequency band. This is becoming common, and administrative determination of technologies and services should become the exception and should be clearly justified. In some countries, technology neutrality is often applied to spectrum bands that are auctioned (or under spectrum rights framework) to commercial operators. The regulator specifies the emission criteria instead of the technologies that can operate in the spectrum bands. In addition, mobile spectrum assigned administratively was re-assigned through an auction or converted to spectrum rights that are aligned to spectrum awarded via auctions.

The technology-neutral approach incentivises network operators to adopt the most spectrally efficient technology. Pakistan has already adopted technology neutrality for spectrum that was auctioned. The mobile licenses for Jazz, Zong and Telenor which are under renewal process, also include provisions for technology neutrality.

3.2 Spectrum Sharing and Trading

There are emerging technologies that are enabling more efficient use of spectrum, either limiting the power to avoid interference to primary users; or tapping into spectrum that are unused at a given time and location. Different levels of coordination may be required for the introduction of spectrum sharing. Ultra-wideband (UWB), software-defined radio (SDR) and cognitive radio are technologies that will enable greater spectrum sharing amongst different users thereby promoting spectrum efficiency.

SDR are radio systems implemented on general purpose hardware where specific operational characteristics are implemented in software. Different radio systems and standards are essentially loaded as software programmes (e.g. a GSM program or a Wi-Fi program). A radio increases its flexibility as more of its functionality is software based. Cognitive radios on the other hand can be programmed to detect and use the frequency channel in its vicinity that is not in use.

Ultra-Wide Band Technology (UWB) is an active underlay technology, transmitting signals that spread over a large bandwidth (>500MHz). Operating at very low signal levels, UWB emissions appear as noise floor to narrowband radio systems, allowing UWB devices to operate underneath existing services. UWB technology is typically used to transmit large amount of data over a short distance (<15m). UWB devices have not seen widespread adoption and it is losing relevance since WiFi standards (802.11n/ac/ad) now offer longer range and faster speed. However, UWB has found its place in specific applications, in areas such as automotive sensing, wall or ground penetrating radars, and automotive radar. Some companies are also looking at UWB for indoor positioning systems.

A key concern for spectrum managers is the potential rise in the overall noise floor as a result of a large number of UWB devices operating in an area. The rise in noise level will reduce their S/N margins and affecting the performance of existing systems. The concerns expressed by operators of existing radiocommunications services led to significant work in the ITU-R to update the protection requirements for existing services and to develop a framework for the introduction of UWB technologies that would protect existing services. To address UWB issues, ITU-R created a Task Group (TG1/8) which completed its work without endorsing a common emission mask. TG1/8 developed key recommendations for administrations to consider when developing their framework for introducing UWB technology. Key documents produced include:

1. Report SM. 2057 presenting UWB compatibility studies

2. ITU-R SM.1754 [9] recommends measurement techniques for generating UWB signals with various modulation and randomisation schemes. This document includes both frequency domain and time domain measurement techniques of the PSD of UWB transmissions for all UWB signal types
3. ITU-R SM.1755 [10] recommends the general characteristics of UWB technology;
4. ITU-R SM.1756 [11] recommends the framework and provides guidance to administrations considering the introduction of devices using UWB technology
5. ITU-R SM.1757 [12] recommends methodologies which assess the impact of UWB devices on systems operating in the spectrum band concerned. It includes a summary of both theoretical analyses and measurement studies carried out in the laboratory and in the field.

The setting of emission standards remains largely as a national issue. It is noted that several administrations have allowed UWB devices and introduced emission standards by referencing the US FCC or Europe ECC standards. In the Asia-Pacific region, countries such as Australia, Japan, Korea, New Zealand and Singapore have introduced UWB technology.

Light licensing is a way to minimise regulatory intervention and it removes the need for the regulator to coordinate frequency assignment. Instead, an automated notification and frequency assignment process is set up to allow users to register for a frequency via an online system. The system will perform an interference assessment and inform the user whether the registration is successful or not.

Light licensing is different from licence-exempt since the users still need to go through the registration process and pay a fee. The spectrum band under this approach is still controlled and there is a limit to the number of users within an area. An example of this is the Managed Spectrum Park introduced in New Zealand[2] for the 2.5 GHz band (2575 – 2620 MHz). The registration is to be performed by an Approved Radio Engineer and there is a requirement for the user to implement services within two years of allocation to ensure efficient use of spectrum. Another example is the use of 5.8GHz band in the UK[3] for fixed wireless access (FWA) services which are operating at higher power than other licence-exempt applications. Similarly, a minimum payment and registration are required.

The light licensing approach is suitable for spectrum bands that can be shared by multiple users and their protection can be established by simple analysis methodology.

Dynamic Spectrum Access (DSA) enables a radio device to operate in spectrum that is not being used in a particular area, at a particular point in time. The development of cognitive radios is making this spectrum sharing possible and it can significantly increase the efficiency of spectrum. A cognitive radio is to some degree aware of the environment by monitoring transmissions across a wide bandwidth, noting areas of unused spectrum and is able to modify its transmission using appropriate modulation and coding methods. From a user standpoint the certainty of finding unused spectrum in congested areas may fall low enough to impair its usefulness as a mainstay communications device.

TV White Space (TVWS) which is currently being deliberated by regulators is a form of DSA. Particularly for analogue TV broadcast, spectrum is allocated exclusively to the broadcasting services but they may not be used all the time in all locations. In some areas, TV channels are unassigned to

[2] Managed Spectrum Park by the New Zealand's Ministry of Business, Innovation and Employment: http://www.rsm.govt.nz/cms/licensees/types-of-licence/managed-spectrum-park

[3] Ofcom: http://licensing.ofcom.org.uk/radiocommunication-licences/fixed-wireless-access/

avoid interference, or channels may be assigned for low power, localised broadcast. There are opportunities therefore for other applications to tap the unused TV spectrum. White-space devices (WSDs) are being developed to use underutilised bands to provide broadband services in rural/remote areas where spectrum is generally less congested.

However, since cognitive radios are not fully mature, regulators that have allowed the use of WSDs have put in place some coordination rules to ensure existing services are not affected. These rules should include detailed technical specifications for white space devices (WSD), protection criteria for existing services and a database providing information on which spectrum bands can be shared with WSDs. WSDs must have geolocation capability and provide location information to the national database which will return a list of channels that the WSDs may operate. WSDs may also be required to have adaptive power control to use the minimum power. Database providers also need to be authorised by the regulators. Primary users are not aware the number of secondary WSDs that are operating but they are assured protection in locations where they are using the spectrum. Below are some examples of countries that have permitted the operation of WSDs. While WSDs currently operate in TV bands, the database-powered spectrum sharing framework has the potential of being extended to other spectrum bands.

Country	Framework
Singapore	TVWS regulatory framework was released in June 2014. TVWS equipment is allowed to operate in the VHF and UHF TV bands (VHF Band III and UHF Band V) and it is exempted from licensing. A set of technical standards has been published. TVWS Equipment registration – TVWS must meet the technical standards. There are three approved TVWS Geo-location Database providers – Network Genetics, Starhub and DNNA Solution.
UK	Moved from Pilot to commercial use of TVWS devices. Ofcom made regulations which enable licence exempt use of WSDs in the 470 – 790 MHz band. The regulations – The Wireless Telegraphy (White Space Devices) (Exemption) Regulations 2015 – came into force on 31 December 2015. Device requirements and operational parameters are covered in the regulations. Ofcom also published a statement on 25 September 2015 confirming its decision to license manually configurable WSDs. This licensing regime is now in force. Whether operating on a licence exempt basis or in accordance with a Wireless Telegraphy Licence, devices must only operate in accordance with operational parameters provided by a White Space Database (WSDB) which is operated by organisations qualified by Ofcom. So far Ofcom has qualified four organisation: Fairspectrum Oy, Nominet UK, Sony Europe Limited and Spectrum Bridge Incorporated. In Europe, the harmonisation of TVWS is undertaken by ETSI through the EN 301 598 standard.

US	TVWS devices (aka TV Band Devices or TVBDs) are allowed to operate on an unlicensed basis in vacant TV spectrum nationwide – since March 2013. FCC issued Part 15 TV Bands Devices which covers the device compliance requirements. TVBDs can operate in an unoccupied TV channel in the range of channels 2 – 51 excluding channels 3, 4 and 37. TVBDs can either be fixed (transmit and receive at a specified fixed location for providing wireless broadband services); or personal/portable (transmit and receive while in motion or at unspecified locations). TVBDs must have geolocation capability and ability to access to a database of protected radio services. Fixed TVBDs can transmit up to 1W whilst personal/portable TVBDs can transmit up to 100mW. TVBDs must be certified by FCC. Database systems that are approved by FCC include those operated by Spectrum Bridge, Google and Key Bridge Global. Fixed TVBDs are required to register their operation specifying their operating locations. However, the National Association of Broadcasters raised an alarm to the FCC in 2015 indicating that the databases are full of errors – there is a lack of a mechanism to ensure that users provide accurate details of their operation.

Table 2: Examples of Countries that have Introduced TVWS

Recommended Action: *PTA/FAB to devise Framework for unlicensed spectrum including Ultra Wide Band (UWB), Wi-Fi, Short Range Devices (SRD) and IoTs*.

Licensed Spectrum Access is also enabled by the development of SDR and cognitive technology. The European Union Radio Spectrum Planning Group (RSPG) defines the LSA concept as follows:

"An individual licensed regime of a limited number of licensees in a frequency band, already to one or more incumbent users, for which the additional users are allowed to use the spectrum (or part of the spectrum) in accordance with sharing rules included in the rights of use of spectrum granted to the licensees, thereby allowing all the licensees to provide a certain level of QoS."

Some spectrum bands are allocated exclusively for specific services but they may not be used all the time and in all geographical areas. Unlike the TV white space and UWB, a new proposition is to enable incumbent and new users (LSA licensees) to fully coordinate the use of spectrum. LSA licenses are required to negotiate with the incumbent on the rights and guarantees for the use of spectrum. For example, a LSA licensee may negotiate a commercial arrangement with the incumbent to allow the LSA licensee to transmit at a given period of time and to get the assurance that the incumbent will not interfere during this time period. In this case, more spectrum resources become available and incumbents are incentivised to offer underutilised spectrum.

There have been interests in applying LSA for spectrum bands such as 2.3GHz and 3.5GHz. These bands have been identified for mobile broadband but they can be occupied by non-mobile incumbents. The incumbents may include many government users who are not using the spectrum everywhere in the country so there is a potential for mobile operators to negotiate with the incumbents to access spectrum for mobile broadband deployment.

In the US, exchanges such as Cantor Spectrum & Tower Exchange allow the private and public sectors to buy, sell and lease licensed radio frequency spectrum rights. This is a transparent platform enabling spectrum rights owners to offer their assets on the system for interested parties to evaluate the assets and make a bid on them.

Spectrum Sharing and Trading Framework: PTA/FAB is in the process of developing Spectrum Sharing and Trading Frameworks. The issues highlighted above including UWB, light licensing, DSA and LSA will be investigated. This is expected to be a longer term process since some of these approaches are fairly new and they have not been widely implemented.

3.3 Spectrum Pricing – Administrative Incentive Pricing (AIP)

Spectrum pricing is another tool that can be used to promote more efficient use of spectrum and also to promote fiberization. Traditionally, spectrum pricing is set on a cost-recovery basis which means that spectrum management organisations collect spectrum charges to cover the cost of managing radio frequency spectrum. One problem with this spectrum pricing principle is that if the price is set too low, it encourages hoarding, denying other users access to the spectrum.

Today, most of the spectrum used to deliver commercial services (e.g., mobile and fixed wireless access) has been assigned via an auction. For some parts of the radio frequency spectrum, some spectrum management organisations have adopted an approach commonly referred to as Administrative Incentive Pricing (AIP) to impose pricing that reflects the economic value of the spectrum.

In Pakistan, spectrum fees are imposed to cover FAB's annual budget. Mobile operators pay the Annual Spectrum Administrative Fee (ASAF) to cover 75% of FAB's annual budget based upon the portion of auctioned access spectrum they hold. Other licensed and private spectrum users cover the remaining 25% of FAB budget on administrative charging basis. Under the current arrangement, the use of Microwave links for Mobile operators is covered under the ASAF. There is no separate annual fees for Microwave backhaul links. ASAF does not correlate with the number of Microwave links Mobile operators have deployed. This results in inefficiency in the utilisation of Microwave frequencies.

AIP Framework: PTA/FAB is considering implementing an AIP-base spectrum pricing framework to replace the current ASAF. As part of the spectrum pricing review, PTA/FAB has already submitted the revised ACR fee levels for principle approval by GoP for implementation. It will be applied to services where auctions and AIP are not implemented.

Recommended Actions: *The current charging regime based on ASAF may continue till the time a market based pricing formula for back-haul spectrum is in place. ASAF is the Administrative cost for managing Access and Back haul spectrums used by mobile operators pursuant to cellular policy 2004. It may be decoupled i.e. separate regimes to be introduced for Access Spectrum Annual Administration Fees and Microwave Backhaul Spectrum (Administrative Incentive Pricing) regime. AIP and revised ASAF regimes to be implemented once finalized.*

4 Mobile Broadband Services

Today, the demand for spectrum by commercial operators is mainly driven by mobile broadband services. The amount of spectrum required is closely correlated to the growth in data traffic. It is noted that in Pakistan, the mobile data traffic grew 165% in 2017 to 69 Petabytes (PB) and 86% in 2018 to 128 Petabytes (PB). Figure 5 compares the projected growth in the amount of mobile traffic per user month in different regions:

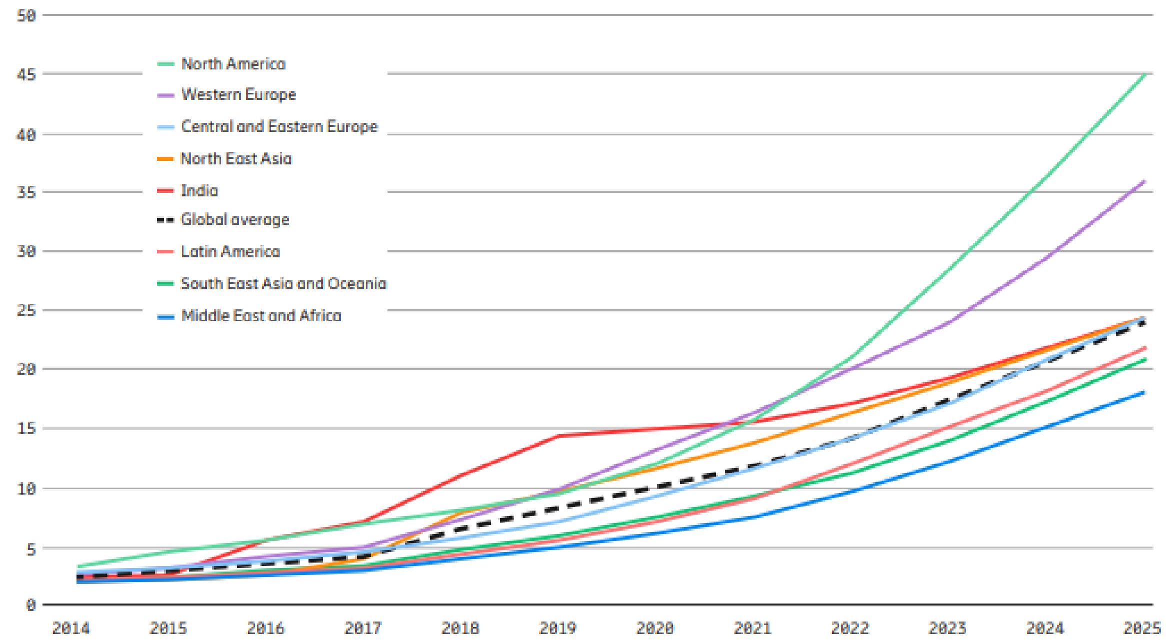


Figure 5: Mobile Data Usage[4]

Pakistan is expected to see exponential growth of data traffic over the next five years to reach close to 1 Gb/month/user, reaching similar levels seen in countries like Saudi Arabia, Malaysia and Thailand. Moreover, with greater availability of content, applications and devices now compared to few years ago, Pakistan has grown at a rate of 1.75Gb/month/user

Country	Data Traffic (Gb/Month/User) in 2018	Spectrum Allocated	Additional Allocation / Auction Planned
Pakistan	1.75	256 MHz	Auctioned 850 MHz spectrum in May 2016; two 10 MHz of 1800 MHz spectrum have also been auctioned in 2014 and 2017 respectively. Granted permissions to Mobile & WLL operators for utilizing more

[4] Source: https://www.ericsson.com/en/mobility-report/reports/june-2019/mobile-data-traffic-outlook

			spectrum efficient technologies like LTE.
Indonesia	0.20	472 MHz	Remaining 2.1GHz spectrum has been Auctioned in 2017
Bangladesh	0.21	258.8 MHz	Remaining 1.8GHz and 2.1GHz spectrum has been auctioned in 2018.
Saudi Arabia	0.98	425.2 MHz	Auctioned 80MHz of spectrum across the 700MHz, 800MHz and 1800MHz bands in 2018.
Thailand	1.20	420 MHz	Thailand has auction in 1800MHz in 2018

Table 3: Mobile Spectrum Allocation Benchmark

It is noted that operators in different countries will require different amount of spectrum depending on the number of operators and the density of the urban areas. It is further noted that the mobile data traffic in Pakistan has increased to 1.75 Gb/month/user in June 2018 as compared to 0.34 Gb/month/user in September 2016. For planning purposes, Pakistan should plan to have at least 400 MHz by 2021. Should Pakistan aspire to be the early adopter of 5G, more spectrum will be required. A number of operators in other markets have started to investigate 5G capabilities through technical trials and work alongside their equipment suppliers with the aim to implement 5G in the early part of the 2020s. Pakistan needs to plan ahead to ensure that the required spectrum is available to support trials and eventually commercial services.

Between now and 5G launch, operators will be looking for spectrum to support the growth of data traffic as well as to offer faster LTE speeds through carrier aggregation. Moreover, with the need to maintain QoS standards imposed by PTA, operators will have to either add smaller cells and/or acquire more spectrum.

Current Utilisation

The table below shows the spectrum bands allocated for mobile services. The spectrum allocated to mobile services for cellular networks include 850MHz, 900MHz, 1800MHz and 2100MHz with a total of 180 x 2 MHz available. Of which, 128 x 2MHz has been assigned to operators.

Spectrum Band	Total Bandwidth	Spectrum Assigned	Spectrum Available
824 – 849 MHz / 869 – 894 MHz	25 x 2 MHz*	Assigned to Telenor (10 x 2 MHz)	850 DL is almost fully assigned (only 3.5 MHz is available) as it overlaps with EGSM UL. EGSM can be mapped with 850

			in order to avoid cross border interference.
880 – 915 MHz / 925 – 960 MHz	35 x 2 MHz	Assigned to Zong, Jazz Ufone and Telenor under a 15-year licence (32.4 x 2 MHz)	2.5 x 2 MHz unassigned due to guard band requirements; Zong, Telenor and Jazz spectrum assignment / License renewal is in process
1710 – 1785 MHz / 1805 – 1880 MHz	75 x 2 MHz	Partly assigned to Jazz, Ufone, Telenor and Zong (55.6 x 2 MHz)	Partially assigned; 12.8 x 2 MHz unassigned; Zong, Telenor and Jazz spectrum assignment / License renewal is in process. Note: Besides 12.7 x 2 MHz unassigned spectrum, 6.6 MHz is temporarily assigned to Zong till Oct 2019.
1920 - 1980 MHz / 2110 – 2170 MHz	60 x 2 MHz	Partially assigned to Zong, Telenor, Ufone and Jazz. (30 x 2MHz)	30 x 2 MHz unassigned and WLL operators are ready to refarm /release (two already done). Telecard & Worldcall are willing to surrender spectrum. Telecard's request has been processed. 10 MHz guard band would be required between WLL downlink and 3G uplink.
Total	*180 x 2 MHz	128 x 2 MHz	49.4 x 2 MHz (27.8 x 2 MHz is readily available)

*15 MHz of 850 DL is not usable due to overlap with 900 (EGSM) UL and guard band requirements

Table 4: Current Mobile Spectrum Allocation

Future Outlook

To meet the demand for future mobile services, PTA/FAB will be making the following changes to its spectrum plan in coming years:

700MHz: The 700MHz band (703 – 803MHz) is harmonised globally for IMT services with the addition of Region 1 in WRC-2015. This is a highly sought after band due to global harmonisation (enabling economies of scale and ease of roaming) and better propagation characteristics. PTA/FAB has earmarked the 700MHz band for mobile services. This band is currently used by government systems and there is a need to refarm this band. The allocation of this band for mobile services will be made depending on the equipment availability.

Recommended Actions: *There is a high chance that devices will hit critical mass before 2020 and it is recommended that MoIT&T/PTA/FAB aim to allocate the band for auction. This band is also crucial for Pakistan operators to extend the coverage to rural areas since it has better propagation characteristics.*

900 MHz: The 900MHz band (882.5 – 914.9MHz / 927.5 – 959.9MHz) has been fully assigned to mobile operators. However, the assignment will expire at different stages. The spectrum assigned to Zong and Telenor expired in 2019 whilst Jazz and Ufone assignment will expire in 2022 and 2029 respectively. This being the case, PTA/FAB will need to renew the spectrum/ Licenses accordingly. Jazz has already applied for renewal of Mobile License.

Recommended Actions*: PTA/FAB need to work for rationalization of spectrum, so that Mobile operators can be provided with standard spectrum blocks.*

Some operators have started to shut down 2G systems. For example, in Australia, Telstra turned off 2G on December 1, 2016 and Optus in April 2017. Telstra in 2019, also started to shutdown 3G in 850 MHz in order to launch IMT (5G). In Singapore, the regulator has stopped the sale of 2G-only devices from January 1, 2017. Whilst 2G will continue to be in use in many places including Pakistan, it will also start to phase out in a few years as mobile operators try to promote smartphones to earn revenue from data services. It is therefore useful to consider the long term use of this band and as far as possible divide the band into separate lots of 2 x 5MHz. .

1427 – 1518 MHz (L-Band): The L-Band has been identified for IMT at WRC-2015 to support future requirements. PTA/FAB is prepared to make this band available in the longer term when deployment begins in other markets and equipment becomes available.

1800 MHz Globally, the 1800 MHz is one of the most popular spectrum bands for mobile communications. The band is now used to deploy LTE by several operators around the world. PTA/ FAB has also received requests for additional spectrum assignments in this band.

Recommended Actions: With widespread global adoption, equipment is readily available and this band is deemed valuable to mobile operators, particularly for the deployment of LTE. PTA/FAB should plan transparent and effective methodology for assignment of vacant portion of this band.

1900 MHz: The 1950 – 1980 MHz / 2140 – 2170 MHz is part of the IMT/3G band which has not been assigned in Pakistan due to the operation of WLL systems. PTA/FAB are refarming the band to move the downlink spectrum from 1960 – 1980 MHz to 1980 – 1995 MHz. This will free up spectrum for mobile operators looking to expand their network.

There is a requirement to auction the available bandwidth in 3GPP Band 1 for proliferation of broadband services in Pakistan.

2300 MHz: The 2300 MHz band offers 100MHzof bandwidth (2300 – 2400 MHz) and it is allocated in several countries for mobile services (3GPP Band 40). It is noted that some operators in other countries have already deployed LTE (TDD-based) systems using this band. In Pakistan, this band is currently used for government systems as well as commercial fixed links. PTA/FAB intend to make this band available in the future but the priority will be lower than other potential bands due the lack of low-cost devices operating in his band. This band has also been identified for deployment of IMT (5G) in all three ITU Regions.

Recommended Actions: *This band is now being used in some countries for LTE systems (mainly TDD). In Region 3, mobile operators in Australia, China, Hong Kong and India have deployed LTE using 2.3GHz. Some handsets now support this band but the availability is lagging behind other bands including the 2.5GHz band. Moreover, some ISPs in developing countries have deployed LTE in this band for providing wireless Internet services. It will also be beneficial for operators in Pakistan to adopt a similar approach to offer broadband services.*

2500 MHz: The 2500MHz offers 190MHz of bandwidth (2500 – 2690 MHz) and it is allocated in many countries for mobile services. This is 3GPP Band 7 for FDD (2500 – 2570 MHz paired with 2620 – 2690 MHz) and Band 38 for TDD (2570 – 2620 MHz). In Pakistan, the 2500MHz band is currently occupied by Southern Network Limited (SunTV) for operating its MMDS system that is used to deliver Pay-TV services. The PTA/FAB is in the process of refarming the 2500MHz band and plans to recover the band but the timing is dependent on the judiciary process. This band has also been identified by ITU for IMT (5G) deployment. GoP in its Policy Directive for Test & Trials of Future Technologies, has also identified it as potential band for IMT deployment in Pakistan.

Recommended Actions: *This band should be a high priority after the 1800MHz has been fully assigned. This band is now being used in many countries for LTE systems, and often being aggregated with other bands to deliver faster LTE speeds. This is crucial for mobile operators in Pakistan. Mobile Operators have also applied with PTA/FAB to conduct 5G trials in this band.*

3000 MHz: 3300 – 3400 MHz has been identified by ITU for IMT (5G). As such, PTA/FAB will stop assigning frequencies in this band and will work with existing users to migrate their systems to alternative bands.

3400 to 3600 MHz has been awarded to operators for mobile or wireless broadband services in several countries. Some operators have deployed LTE systems to offer wireless broadband services (e.g., UK and Canada) but fewer operators use 3500MHz for mobile services (e.g., NTT DoCoMo launched 3500MHz TDD LTE in mid-2016). Mobile devices supporting this band (3GPP Band 22 for FDD and 42 for TDD) are also not widely available at this point. In Pakistan, this band has been allocated to operators for the deployment of fixed wireless broadband services. At this point, the band is not fully utilised with only three operators offering services. This band has also been identified by ITU for IMT (5G) deployment. GoP in its Policy Directive for Test & Trials of Future Technologies, has also identified it as potential band for IMT deployment in Pakistan. PTA/FAB expect this band to see demand from mobile operators in the future for IMT (5G) and will allow more players to bid for the spectrum when the existing licences expire.

Recommended Actions: PTA/FAB to auction the full band when all the licences expire in 2024. In the longer term, there should be a plan for WLL systems to be eventually phased out – for example with the view that legacy WLL will eventually be replaced by mobile services and other relevant 5G use cases. In the meantime, PTA/FAB should make arrangements to hold 5G trials in this band as per 2017 GoP policy.

5 Broadcasting Services

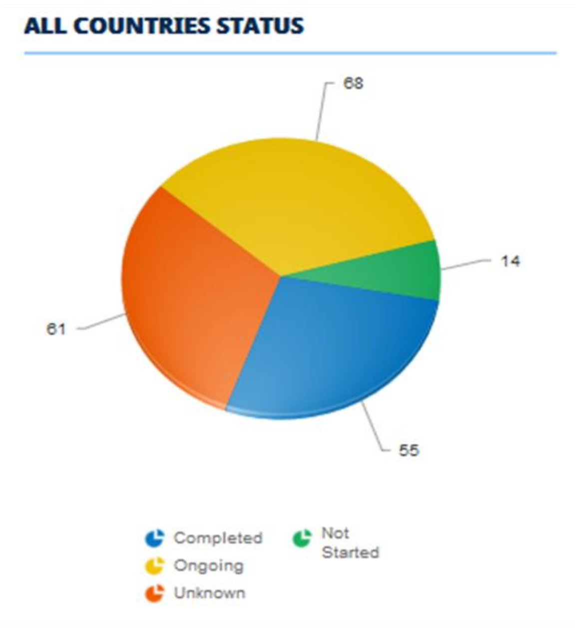
Transitioning from analogue TV to Digital TV

Globally, terrestrial TV broadcasting uses prime spectrum in the VHF band (173 – 230 MHz) and UHF band (470 – 862 MHz). Analogue terrestrial broadcasting stations, typically operated by public broadcasters, have been transmitting in these band for decades. Over the past decade, countries around the world have been transitioning their terrestrial TV from analogue to digital to provide better picture quality (high definition TV, or HDTV), increase number of programme and free up valuable spectrum.

Digital broadcasting is spectrally more efficient and the switchover to digital is freeing up spectrum known as the digital dividend. By implementing single frequency network (SFN) and more advanced modulation and coding techniques (e.g., DVB-T2), the same 8MHz frequency channel (which supports one analogue TV), can now carry a multiplex of up to 20 digital programmes with similar quality. For spectrum management organisations, the digital dividend means spectrum freed up for other services. In Asia, through the Asia-Pacific Telecommunity (APT), administrations have harmonised the band plan for the digital dividend (698 – 806 MHz) which is now harmonised for IMT services globally.

As of September 2016, ITU's records show that 73 countries have already completed the Digital Switchover (DSO) and Analogue Switch Off (ASO) whilst another 63 countries are in the process of doing so.

(https://www.itu.int/en/ITU-D/Spectrum-Broadcasting/DSO/Pages/countries.aspx).



Completed

On-going

Figure 6: Digital Terrestrial TV Broadcasting

It is crucial for broadcasters to move to digital since globally they are losing viewership to other platforms including satellite networks, fixed networks (cable TV or IPTV via DSL or other broadband access), as well as free over-the-top services (through both fixed and mobile broadband). With the additional bandwidth, broadcasters are able to introduce new services to retain viewership and to tap into new revenue streams. For example, broadcasters can offer catch-up TV, electronic program guide (EPG), 3DTV and digital signage. Another major trend is for terrestrial broadcasters to implement hybrid TV or interactive TV to harmonise the broadcast, IPTV, and broadband delivery of entertainment to the end consumer through connected TVs (smart TVs) and set-top boxes. It offers broadcasters the ability to provide video-on-demand, interactive advertising, personalisation, voting, social networking, and so on. In the multiscreen era, people do not just consume content from the TV unit in the living room, so broadcasters are also aware of the need to push content to mobile devices.

In Pakistan, the government has limited terrestrial TV broadcasting services to be carried out by PTV the national broadcaster and ATV (Shalimar Recording and Broadcasting Company and Sports Star International joint venture). Besides terrestrial broadcasting, there are operators offering content via other platforms. PEMRA has issued licences for IPTV, MMDS, Cable TV, mobile TV and satellite TV. PEMRA is also in the midst of issuing DTH licences.

PEMRA also plans to introduce digital terrestrial TV broadcasting on national, provincial and metropolitan city basis. However, the plan has not been finalised and PEMRA has not firmed up its decision on issues such as the technology standard, rollout plan and analogue switch-off date. PEMRA is aiming for 36 content channels including 9 from PTV plus 3rd party channels. There is an ongoing trial using the DTMB technology developed by Chinese manufacturers.

Audio Broadcasting also migrating to Digital

FM analogue radio broadcasting has also existed for a long time and in many countries FM radio services remain popular. With limited bandwidth (88 – 108 MHz), some countries have introduced Digital Audio Broadcasting (DAB) to support new programmes and to offer better sound quality. However, on a global basis, there is mixed level of success. Several European countries have deployed DAB+ but no countries have made a decision on when analogue radio transmission will be switched off. Digital radios offer better sound quality but apart from that, there are no compelling reasons for consumers to purchase a digital radio device which costs more than the analogue radio. On the other hand, FM radio services offer extensive coverage and FM receivers are relatively low cost, often integrated to mobile devices. Moreover there is currently no competing demand for the spectrum. Hence, FM radio services are expected to stay in the foreseeable future.

PEMRA is considering licensing Digital Audio Broadcasting (DAB) / Digital Radio Services (DRS). The broadcasting industry is considering DAB+ to be the more suitable standard due to the availability of receivers.

Current Utilisation

In Pakistan, terrestrial TV broadcasting occupies the VHF and UHF bands but frequencies are assigned only to PTV and ATV. For sound broadcasting, there are around 60 FM radio stations including several non-commercial, localised campus radio stations. Only 3 radio networks provide nationwide coverage.

Spectrum Band	Frequency Range	Utilisation
MW	526.5 – 1606.5 kHz	AM stations operated by Pakistan Broadcasting Corporation for news and current affairs programme.
SW	1.6 – 30 MHz	Mainly operated by Pakistan Broadcasting Corporation
VHF Band II	87 – 108 MHz	60 FM radio stations; 3 nationwide stations
VHF Band I	47 – 68 MHz	These bands are allocated for terrestrial TV broadcasting and it is currently used for PTV (Home and News channels), ATV and DTMB trial
VHF Band III	174 – 230 MHz	
UHF Band	502 – 598 MHz	

Table 5: Current Broadcasting Spectrum Allocation

Future Outlook

TV Broadcasting: PEMRA/FAB will be coordinating the digital TV planning to ensure a smooth migration. With the implementation of digital terrestrial TV broadcasting, there is scope of allowing more programmes to be transmitted over the air which is crucial in enticing consumers to change their TV units that is capable of receiving digital TV signals. PEMRA/FAB will announce its plans for Digital Switchover (DSO) and Analogue Switch-off (ASO) over the next two years.

Audio Broadcasting: There is spectrum available in the VHF Band III for the introduction of digital audio broadcasting services. PEMRA/FAB is considering allocating spectrum for the implementation of digital audio broadcasting. PEMRA/FAB will determine the standards, licensing conditions and assignment process over the next two years.

Recommended Actions:

Many countries have either completed their migration to DTTB or have put in place a plan for the transition from analogue to digital broadcasting. Pakistan is lagging other countries in fleshing out its plans to implement DTTB and switching off analogue TV. With different platforms carrying TV content and limited terrestrial TV (not occupying the 700MHz "digital dividend" band), there is no urgency to switch off analogue TV. However, it is advantageous for Pakistan to plan the migration to DTTB since the transition typically takes a few years to complete. By making plans early, these are the benefits:

1) Ensure that the right TV sets are being imported into the country so that consumers do not have to buy new TV sets to receive digital signals in the future;

2) Enable PEMRA to determine how much spectrum is required during the simulcast period and how much additional capacity is available for new programmes and services;

3) There is also a possibility for DTTB to replace existing MMDS and enable PEMRA to award new licences for commercial TV via an auction (similar approach has been adopted by the Thai regulator, NBTC);

4) This also gives PTV and ATV ample of time to rollout DTTB and for customers to gradually swap out their TV sets thereby remove the need for the government to give out vouchers for people to purchase new TV sets, something that is adopted by countries to speed up digital TV migration. Broadcasters can also have greater visibility of the capacity they have to plan for content production (e.g., HDTV, Mobile TV) and to carry new programmes.

Whilst there is no urgency to switch off analogue to free up spectrum for IMT services, there are advantages to switch off earlier rather than later. Firstly, it lowers the cost for broadcasters to transmit in both analogue and digital format. Secondly, it frees up spectrum for additional broadcasting programmes and services. Sufficient time is required from planning, implementation and consumer education. It is recommended that Pakistan aims to complete digital switchover and analogue switch-off by end 2021[5].

6 Fixed Services

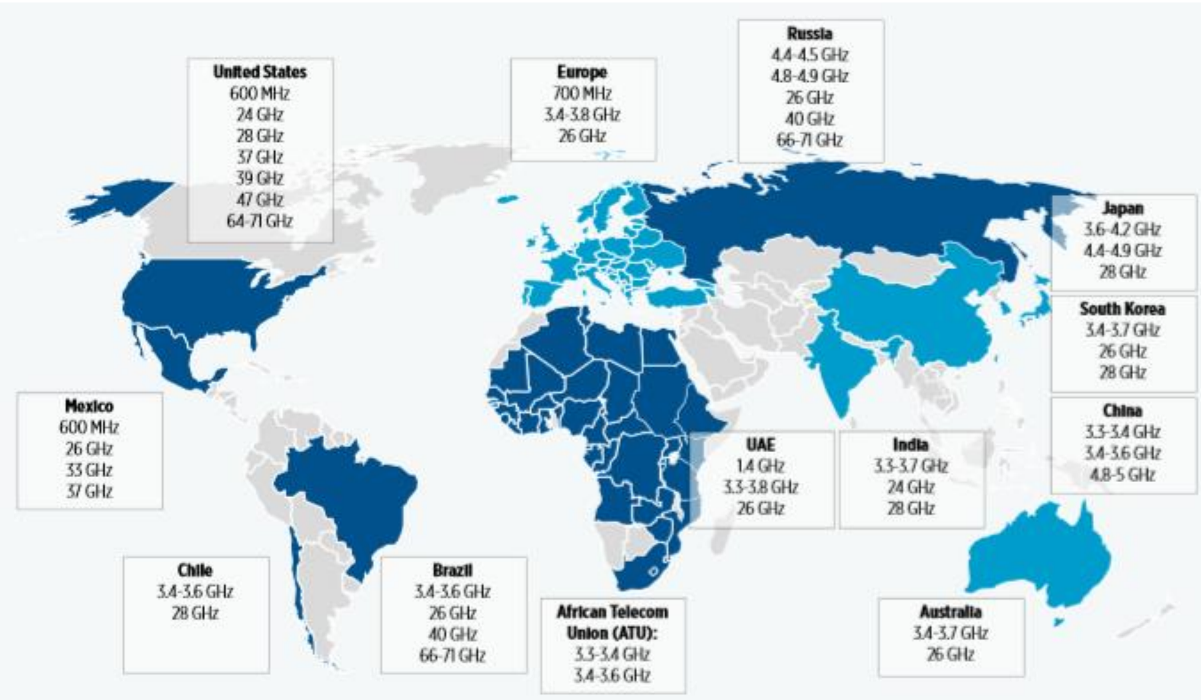
Fixed services operate in various radio spectrum bands from Very High Frequency (VHF) and Ultra-High Frequency (UHF) to Extremely High Frequency (EHF). The VHF and UHF bands are typically used for narrowband applications; for point-to-point links between land mobile base stations or point-to-multipoint in the case of Wireless Local Loop (WLL). In some countries, the 2.3GHz, 2.5GHz and 3.5GHz spectrum bands are also used for Fixed Wireless Access (FWA) / Fixed Broad Band (FBB) to deliver

[5] This is based on international benchmark and a more detailed study is required to determine the exact date, technology and spectrum requirements based on configuration and services to be supported.

wireless broadband Internet access. In fact, FWA is one of the earliest use cases of IMT (5G) technology. Various spectrum bands above 6GHz are used for point-to-point links with lower frequency bands supporting longer communications range. Fixed services are being typically deployed by organisations such as government agencies (Defence and public safety agencies), telecommunications operators and broadcasters.

The demand for fixed services is changing. Firstly, telecommunications networks are gradually being upgraded with fibre-based backbone infrastructure. Fibre networks are replacing microwave links as fibre connections support higher speed (multiple Gbps), and provide higher availability (microwave links are susceptible to fading and other propagation characteristics). In the access networks, Fixed Wireless Access (FWA) is also being replaced by fibre access and mobile access particularly in the urban areas. As a result, some fixed services in the lower frequency bands (<6GHz) have been refarmed for other services. For instance, the 2.3 GHz and 2.5 GHz bands, previously used for FWA are now used to deploy mobile services in many countries. These bands, along with 3.5 GHz have also been identified for IMT (5G) by ITU.

However, in some government funded national broadband projects, wireless networks have been deployed in rural or remote areas where fibre-based solutions are cost prohibitive. There remains demand for microwave links where fibre connectivity is not available. Operators are also looking at higher spectrum bands as the lower frequency bands become congested. In particular, fixed links are a key backhaul option for mobile networks and operators have been exploring higher frequency bands (e.g., 23 GHz, 28 GHz and 38 GHz) for shorter but higher capacity backhaul links. Some of the bands falling in mmWave range (24.25-27.5 GHz, 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 and 66-71 GHz) have also been identified for IMT (5G) during WRC-19. Additional bands to be used for IMT have been proposed for further study and decision will be taken in WRC-23. Summary of priority frequency bands in select countries for 5G is shown below:



Source: GSMA Study on Socio-Economic Benefits of 5G Services Provided in mmWave Bands.

Demand for Fixed Services Being Driven by Mobile Backhaul

To cope with the rising demand for Mobile Broad Band (MBB) services, operators are adopting the "network densification" strategy. This means implementing a large number of cells using small-cell solutions. This is crucial when there is a shortage of mobile spectrum. However, this approach will require a backhaul solution that is cost-effective and easy to install. Wireless backhaul is a feasible option for connecting these small cells. As the data consumption increases, the capacity for backhaul will also increase and each base station would require over 1 Gbps as the operator move from LTE to LTE-Advance and IMT2020. In urban areas, operators use primarily fibre backhaul for their base stations. However, with the deployment of a large number of outdoor small cells (e.g., street furniture, bus stops, lamp post or external walls of buildings) fibre connection may not always be available. With the upgrade of mobile networks to IMT-Advanced and IMT2020, the backhaul capacity will grow quickly as well.

Wireless backhaul will complement fixed backhaul solutions particularly in countries that do not have extensive fixed/fibre infrastructure. For example, wireless backhaul will play a smaller role in North America and China where fibre network has been widely deployed but it will continue to play a significant role in mobile networks in other regions.

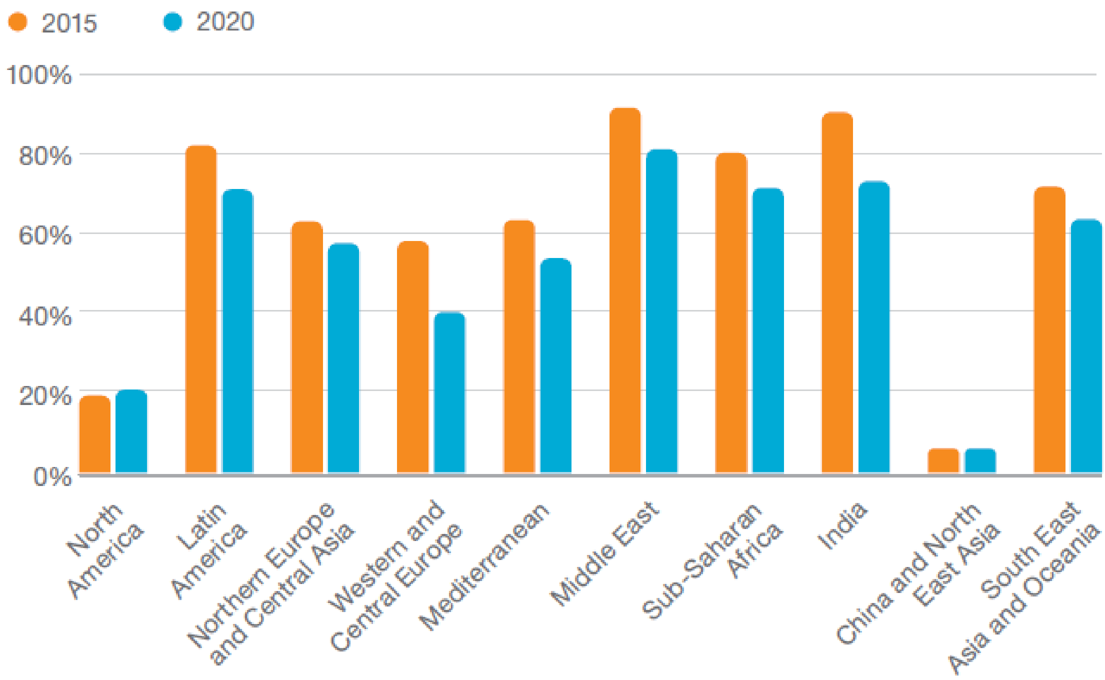


Figure 7: Microwave Backhaul Share in Different Regions (source: Ericsson 2015[6])

There are different microwave spectrum bands that are now being used for wireless backhaul. There is growing interest in using 59 – 64 GHz (V-band) as well as 71 – 76GHz/81-86GHz (E-band) for short, high capacity backhaul links. At such high frequency, atmospheric absorption limits the propagation of the signal and the antenna has to be highly directional. This means that the same frequency can be reused multiple of times within a small area. In many countries, the use of these bands are also subject to minimal regulations.

[6] Ericsson, 'Microwave Trends 2020', September 2015

Current Utilisation

Fixed services are widely deployed across Pakistan. Systems under fixed services are used by government bodies, private entities as well as commercial operators. Fixed services in Pakistan can be broadly categorised into three types:

Services	Spectrum Bands	Users
Specialised fixed communications systems for private entities	Several bands below 1 GHz	Various users including companies in the oil & gas and utility sectors, government agencies and telecoms operators.
	2025 – 2110 MHz	
	2200 – 2290 MHz	
	2300 – 2480 MHz	
Wireless Local Loop including wireless broadband (WiMAX & LTE)	450 – 470 MHz (5MHz x 2)	WLL providers such as PTCL using CDMA; as well as WiMAX / LTE based providers such as Sharp and Wi-Tribe
	479 – 493.48 MHz (5MHz x 2)	
	1900 – 1915 / 1980 – 1995 MHz[7]	
	3400 – 3600 MHz	
Point-to-point microwave	3800 – 5000 MHz	These bands used by commercial telecommunications operators (including PTCL and mobile operators) mainly for backhaul transmission. There are also government users in these bands.
	5925 – 7100 MHz	
	7425 – 9000 MHz	
	10.15 – 10.65 GHz	
	10.7 – 11.7 GHz	
	12.75 – 13.25 GHz	
	14.4 – 15.35 GHz	
	17.7 – 19.0 GHz	
	21.2 – 23.6 GHz	
	24.5 – 26.5 GHz	
	27.5 – 29.5 GHz	
	31.8 – 33.4 GHz	
	37.0 – 39.5 GHz	
	51.4 – 52.6 GHz	
	55.78 – 57.0 GHz	
	71 – 76 / 81 – 86 GHz (E Band)	

Table 6: Current Fixed Service Spectrum Allocation

Future Outlook

2300 – 2400 MHz: This band has been identified by ITU for IMT (5G). As such, PTA/FAB will stop assigning frequencies in this band and will work with existing users to migrate their systems to alternative bands.

[7] Pending the completion of the refarming process.

3300 – 3400 MHz: This band has been identified by ITU for IMT (5G). As such, PTA/FAB will stop assigning frequencies in this band and will work with existing users to migrate their systems to alternative bands.

3400 – 3600 MHz: This band is currently allocated for Wireless Local Loop (WLL) services. Spectrum was awarded through an auction in 2004. The spectrum is however not extensively used as the number of subscribers on these services remain small and the coverage is not widespread. This band has also been identified by ITU for IMT (5G). GoP in its Policy Directive for Test & Trials of Future Technologies, has also identified it as potential band for IMT deployment in Pakistan. PTA/FAB expect this band to see demand from mobile operators in the future for IMT (5G) and will allow more players to bid for the spectrum when the existing licences expire.

7 Public Safety and Land Mobile

Land mobile systems continue to play a critical part in public safety and emergency services. Agencies involved in public safety require radio networks that are secure, reliable and support closed group communications. Increasingly, public safety agencies are implementing mobile broadband systems to improve their operations. For example, live video streaming between the ground operations and the central command centre provides situational awareness and helps to improve decision making and more efficient deployment of resources. Whilst commercial mobile services are technically possible to support public safety applications, there are usually concerns around quality of service to support mission critical, emergency operations.

In many countries, different government agencies still operate their own system which require a separate set of frequencies. By encouraging these agencies to consolidate their networks, there will be efficiency gained, resulting in less spectrum required.

At the international level, through ITU and APT, administrations have been working towards harmonising the spectrum for public protection and disaster relief (PPDR) systems. ITU-R Resolution 646 defines public protection radiocommunication as radiocommunications used by responsible agencies and organisations dealing with maintenance of law and order, protection of life and property and emergency situations. Disaster relief radiocommunication refers to radiocommunications used by agencies and organisations dealing with serious disruption of the functioning of society, posing a significant widespread threat to human life, health, property or the environment, whether caused by accident, natural phenomena or human activity, whether developing suddenly or as a result of complex, long-term processes. At WRC-2015, the band 694 – 894 MHz was identified to facilitate mobile broadband communications for mission critical emergency services in PPDR, such as police, fire, ambulances and disaster response teams. The harmonisation of spectrum for PPDR enables economies of scale and lower costs for PPDR systems; as well as interoperability for cross-border operations in emergency situations.

There is general consensus that LTE should be the technology for public safety mobile broadband systems. Whilst the band 694 – 894 MHz is identified for broadband PPDR implementation, the exact bands allocated differ in different countries. Some examples are shown in the Table below:

Countries	Bands	Notes
CEPT	410–430 MHz / 450–470 MHz 700MHz (694 – 791 MHz)	ECC Report 218 covers three elements: • Common LTE technical standard • National flexibility to decide the amount of spectrum to allocate • Choice of implementation (dedicated, commercial or hybrid)
France	698-703 MHz / 753-758 MHz 733-736MHz / 788-791 MHz	Aim to add 400MHz in the future
United Kingdom	No dedicated spectrum	Procuring an Emergency Services Network (ESN) to replace the current narrowband network. ESN will carry voice and broadband data through contracting with commercial networks, but with priority access to ensure quality of service.
USA, Canada	758–768 MHz / 788–798 MHz	In the US, Congress allotted $7b and 20MHz for the implementation of FirstNet to facilitate interoperability across different public safety departments in the US
Australia	806–824 MHz / 851–869MHz	Whilst 800MHz is identified as the potential band for PPDR, Australia is still working through the model, whether it should have a dedicated network, commercial or hybrid.

Table 7: Public Safety Mobile Broadband Allocation in Different Countries

Future Outlook

806 – 824 MHz / 851 – 869 MHz: This band is part of the globally harmonised band for broadband PPDR and it is being considered for PPDR allocation by regulators in Region 3. In view of the global harmonisation, PTA/FAB has allocated this band for the deployment of a public safety communications system. This being the case, this band will not be available for commercial mobile services.

Recommended Actions: *It is noted that this band is already earmarked for broadband PPDR implementation. To ensure efficient use of spectrum, the 800MHz PPDR band should be used to deploy a system that is shared amongst various public safety agencies. For future expansion, PTA/FAB should also consider the hybrid model and encourage public safety agencies to contract mobile network operators to deliver part of the broadband requirements through priority access.*

8 Satellite Services

Satellite communications remain vital for niche applications particularly for communications across a vast area where other means of communications are not available. For example, maritime, mining, oil and gas exploration industries rely heavily on satellite communications. In addition, satellite is also widely used for broadcasting content over a large geographical area. Internationally, the satellite communications are categorised into the following:

- Mobile satellite service (MSS)
- Fixed satellite service (FSS)
- Broadcasting satellite service (BSS)

Similar to terrestrial communications, satellite operators are also offering broadband access to meet user demand. There has been a growing demand for satellite bandwidth. WRC-19 included several agenda items related with Satellite Services.

Key Outcomes of WRC-19

Earth exploration-satellite (EESS) service – Earth Exploration Satellite Service (EESS) was seeking protection from GEO operators. Satellite operators are looking for reasonable protections to be imposed after an adequate grandfathering period. Protection accorded to EESS with the possibility of providing worldwide primary allocation in the frequency band 22.55-23.15 GHz in order to allow its use for satellite tracking, telemetry and control.

Non-Geostationary Satellites – Mega-constellations of satellites consisting of hundreds to thousands of spacecraft in low-Earth orbit are becoming a popular solution for global telecommunications, as well as remote sensing, space and upper atmosphere research, meteorology, astronomy, technology demonstration and education. Regulatory procedures established for non-geostationary satellite constellations in the fixed-satellite service, opening the skies to next-generation communication capabilities.

Regulatory changes introduced to facilitate rational, efficient and economical use of radio frequencies and associated orbits, including the geostationary-satellite orbit.

Broadcasting-satellite service (BSS) – Protection of frequency assignments, providing a priority mechanism for developing countries to regain access to spectrum orbit resources.

Earth stations in motion (ESIM) – The decision on ESIMs will connect people while in planes, ships, and trains to communication links with geostationary satellites. Earth stations in motion (ESIM) address a complex challenge: how to provide reliable and high-bandwidth Internet services to what are – literally – moving targets. They provide broadband communications, including Internet connectivity, on platforms in motion.

There are currently three types of ESIM: ESIM on aircraft (aeronautical ESIM), ESIM on ships (maritime ESIM) and ESIM on land vehicles (land ESIM). They connect people on ships, aircraft and land vehicles and ensuring their safety, security and comfort on the move.

To address the increasing need for radio-frequency spectrum for ESIM, while protecting other services, delegates at WRC-19 decided on the regulatory and technical conditions under which the frequency bands 17.7-19.7 GHz (space-to-Earth) and 27.5-29.5 GHz (Earth-to-space) can be used by the three types of ESIM communicating with geostationary (GSO) space stations in the fixed-satellite service (FSS). However, the Resolution also cautions that the frequency bands 17.7-19.7 GHz (space-to-Earth) and 27.5-29.5 GHz (Earth-to-space) "are also allocated to terrestrial and space services used by a variety of different systems, and these existing services and their future development need to be protected, without the imposition of undue constraints, from the operation of ESIMs."

The proposed agenda for WRC-23 also includes ESIM related items i.e., conditions to be further defined for communications of ESIMs with non- geostationary space stations in the fixed-satellite service to provide reliable and high-bandwidth Internet services to aircraft, ships and land vehicles.

FAB and Pakistan Space & Upper Atmosphere Research Commission (SUPARCO)

FAB is the designated Notifying Administration for the PAKSAT satellite networks at the ITU. FAB is therefore responsible for the frequency coordination of PAKSAT. SUPARCO is the national space agency mandated to conduct R&D in space science, space technology and their peaceful applications in the country. SUPARCO is also responsible for the operation of PAKSAT and it works closely with FAB in satellite coordination.

PAKSAT-1R was launched in August 2011 operating at 38°E in the C and Ku bands.PAKSAT-1R Satellite has a total capacity of 30 transponders, 12 in C-Band and 18 in Ku-Band. The second satellite PAKTES-1 was launched in 2018. This satellite is planned to operate in various bands including L, S C, X, Ku, Ka. In addition, the Low Earth orbit (LEO) satellite for remote sensing – the Pakistan Remote Sensing Satellite 1 (PRSS-1) was launched on same day as PAKTES 1A. It operates in S and X band. PAKSAT MM1 Gap filler satellite is in geostationary orbit along with PAKSAT-1R. PRSS-1 carries a high-resolution, electro-optical payload with designed service life of 5 years.

Future Outlook

C-Band & Satellites:

The C-band (3.6 – 4.2 GHz) is a core spectrum band for 5G deployment. Many national regulators globally have either assigned this spectrum for mobile or have started preparations to do so. Portions of this is being used by different satellite and fixed services as well. The current use of the C-band band varies across regions and by country.

Identification of 3300-3400 MHz, 3600-3800 MHz in addition to 6425-7025 MHz, 7025-7125 MHz and 10.0-10.5 GHz for all ITU Regions is also included in WRC-23 Agenda. Within ITU Region-1 (Europe, Middle East and Africa), UAE decided in November 2018 to award 100 MHz Bandwidth within this frequency band for each Mobile Service Provider in the UAE to facilitate the early deployment of IMT (5G) networks. Oman (December 2018), Qatar (January 2019), and Saudi Arabia (March 2019) have also identified 3.5 GHz for IMT assignment.

The fixed satellite service (FSS) applications in the C-band include:

• Large satellite earth stations which serve as a gateway that carry trunk or network traffic (feeder links) to and from satellite space stations

• Telemetry, tracking, and command (TT&C) stations used for communication between spacecraft and the ground.

• VSATs, which are small two-way satellite systems, primarily used by businesses, but also for military and government applications.

• Satellite Master Antenna Television (SMATV), a system that uses multiple satellite and broadcast signals to create a single integrated cable signal for distribution to a cabling network within a building (e.g. apartment block, hospital etc.).

• TV receive-only (TVRO), used for reception of broadcast signals such as free-to-air television.

There are two general approaches to release the spectrum for mobile use, namely:

1. Accommodate both mobile and existing users through sharing.

2. Clear the band (or parts of it) by migrating existing users to alternative bands or technologies.

The potential to share between IMT and incumbent users depends on the services themselves, the extent of their deployment and the type of sharing envisioned (co- or adjacent-channel)

In addition to guard bands, other possible measures to ensure coexistence between IMT and FSS include;

• Earth station site shielding

• Restriction zones to protect FSS

• Improved FSS receivers

• Addition of filters to FSS receivers

The C-Band Alliance (CBA), a lobbying consortium made up of satellite giants SES, Intelsat and Ottawa-based Telesat, has been pitching to the Federal Communications Commission (FCC) for permission to sell a chunk of their satellite capacity over the US for use by would-be 5G operators. The CBA was planning to auction off a total of 300 MHz of their 500 MHz C-band satellite capacity, On 18 Nov, 2019, FCC announced that they would host a public auction and it would then pay out a percentage of its proceeds from the sale to incumbent satellite operators for executing the complex task of reconfiguring and transitioning their networks.

Recommended Actions: *PTA/FAB/MoIT in consultation with SUPARCO should carry-out a cost-benefit analysis to assess the optimum approach for the release of C-band for 5G. It should include the cost of implementing coexistence measures or a band clearance. In some cases, a hybrid of the two approaches may be appropriate. For example, in its plans for releasing the 3575-3700 MHz band, the Australian regulator ACMA decided to clear existing FSS and FS users in metro and regional areas over a transition period of up to seven years while specifying coexistence measures to protect incumbent users during this period.*

9 Aeronautical and Maritime

Aeronautical Services

Civil and military aviation are key users of spectrum and the radio systems on board aircraft as well as for air-traffic control are generally harmonised globally through international bodies such as the ITU and the International Civil Aviation Organization (ICAO is also a specialised agency of the United Nations). ICAO has been developing standards for aeronautical radio communication, navigation and surveillance systems and equipment, installed on aircraft or on the ground. In this regard, ICAO is actively involved in the ITU processes to secure the radio-frequency spectrum required for aviation purposes. In Pakistan, PTA/FAB together Civil Aviation Authority (CAA) ensure that the aviation industry have access to spectrum that is globally harmonised through ITU and ICAO.

With the changes in aviation technologies, there will be new requirements that will impact the spectrum allocation for aeronautical services. There were two major development at the WRC-15 related to the aeronautical:

Wireless Avionics Intra-Communications (WAIC): WRC-15 approved a worldwide primary allocation of 4200 – 4400 MHz to aeronautical mobile (route) service to support WAIC. WAIC replaces wiring with wireless systems to reduce the weight of the aircraft, resulting in greater fuel efficiency. WAIC is intended to support data, voice and video communications between systems on an aircraft to monitor different areas and to provide communications for the crew. Wireless sensors locate at various points on the aircraft will enable the monitoring of the health of the aircraft structure and all its critical systems – to ensure flight safety. WAIC is based on short-range radio technology with low power levels. WAIC is mostly for internal, within fuselage communications and it does not support communications for passengers or in-flight entertainment.

Unmanned Aircraft Systems (UAS): UAS or drones are finding more commercial applications (from crop surveys, counting wildlife, fire detection and monitoring to goods delivery). There is a need for reliable terrestrial and satellite links for controlling UAS. WRC-12 allocated spectrum for the terrestrial component in 5GHz and WRC-15 approved the use of FSS spectrum for UAS. Eight spectrum bands including Ku (970 MHz globally and 1520 MHz regionally) and Ka (1000 MHz globally) were designated for UAS. However, the bands can only be used after the development of ICAO standards and recommended practices. This paves the way for large-scale commercial utilisation of UAS after 2023.

The major agenda items of WRC-19 related with Aeronautical Services and their key outcomes are as follows:

High-altitude platform stations (HAPS): Additional frequency bands Identified for High Altitude Platform Systems – radios on aerial platforms hovering in the stratosphere – to facilitate telecommunications within a wide coverage area below for affordable broadband access in rural and remote areas. HAPS systems can be used to provide both fixed broadband connectivity for end users and transmission links between the mobile and core networks for backhauling traffic. Both types of HAPS applications would enable wireless broadband deployment in remote areas, including in mountainous, coastal and desert areas.

Delegates at WRC-19 agreed that allocations to the fixed service in the frequency bands 31-31.3 GHz, 38-39.5 GHz will be identified for worldwide use by HAPS. They also confirmed the existing worldwide identifications for HAPS in the bands 47.2 – 47.5 GHz and 47.9 – 48.2 GHz are available for worldwide use by administrations wishing to implement high-altitude platform stations. They agreed to the use of the frequency bands 21.4-22 GHz and 24.25-27.5 GHz by HAPS in the fixed service in Region 2. They also agreed to limitations regarding link directions, and inclusion of technical conditions of operation of HAPS systems for the protection of other services.

Some of the Agenda Items for WRC-23 related with Aeronautical Services are mentioned below:

High-altitude IMT base stations (HIBS) – Possible use of same frequency bands as ground-based IMT base stations on HAPS for extended mobile broadband connectivity to underserved communities and remote areas.

Aeronautical Mobile Applications – Modernizing aeronautical HF radio, new non-safety aeronautical mobile applications for air-to-air, ground-to-air and air-to-ground communications of aircraft systems, and possible new allocations to the aeronautical mobile satellite service to support aeronautical VHF communications in the Earth-to-space and space-to-Earth directions.

Maritime Services

The maritime mobile services are used by vessels operating in international waters, coastal areas and inland waterways. Maritime systems are also used in onshore facilities for ensuring safety and security purposes. To ensure safety of life as vessels move across international waters, the maritime systems and frequency requirements are also coordinated internationally through the ITU and the International Maritime Organisation (IMO). For example, the Global Maritime Distress and Safety System (GMDSS) and emergency position indicating radio beacons (EPIRBs) are globally harmonised systems. Similarly, PTA/FAB together with the Maritime Security Agency (MSA) ensure that the maritime industry has access to spectrum that is globally harmonised through ITU and IMO.

Like the aeronautical sector, the maritime industry also constantly enhance their communications and navigation technologies to improve operation and safety.

At WRC-15, two major issues were tackled:

(1) Maritime On-board Communications: The on-board communications in the UHF band is facing congesting since only six frequencies around 460 MHz were available. WRC-15 did not allocate more frequencies but adopted measures to enable more efficient usage of existing frequencies. These measures include the introduction of new channelling arrangements of 6.25kHz and 12.5kHz through Rec. ITU-R M. 1174-3; as well as the recommendation to use new digital technologies such as digital coded squelch. These measures will increase the number of channels thereby alleviating congestion.

(2) Maritime Automatic Identification Systems (AIS): The development of new AIS applications requires new frequency allocation. These applications are aimed at improving maritime communications and navigation safety. WRC-15 made the following provisions to enable AIS:

- Enable application-specific messages (ASM) in Appendix 18 channel 2027 and 2078; and protecting AIS by prohibiting channel 2078, 2019, 2079, 2020 for ships

- Identification of bands for terrestrial VHF Data Exchange System (VDES): 157.200–157.325/161.800–161.925 MHz in Region 3.
- Secondary allocation to uplink maritime mobile-satellite service in 161.9375–161.9625 MHz/161.9875–162.0125 MHz for satellite component of VDES; downlink will be considered at WRC-19.

VDES regional solution: identification of Appendix 18 channels 80, 21, 81, 22, 82, 23 and 83 for digital systems in Regions 3.

At WRC-19, the agenda item related with Global Maritime Distress and Safety System (GMDSS) resulted in expanded coverage and enhanced capabilities for GMDSS. For WRC-23, one of the proposed agenda items is to improve communications and allocate additional spectrum and satellite resources to enhance maritime capabilities in GMDSS, such as e-navigation.

Future Outlook

Aeronautical & Maritime: PTA/FAB will implement the changes to the aeronautical and maritime spectrum allocation in accordance with the decisions made by WRC-19. Together with Pakistan Civil Aviation Authority (CAA), PTA/FAB will monitor the standards development by the ICAO and make available spectrum in the FSS bands for UAS accordingly. PTA/FAB shall participate in studies and trials for High Altitude Platform System (HAPS).

10 Unlicensed Bands for Short-Range Devices

Short range devices are low power devices that have low capability of causing interference to other radio equipment. Short range devices are not considered a radio service under the ITU Radio Regulations. In some countries, spectrum bands are designated as “unlicensed spectrum bands” whilst in some countries, the short range devices are exempted from licensing under a class licence. The level of power permissible and the types of applications are usually specified in published standards. Only equipment that meets the standards are permitted to be imported.

SRDs are used in many areas including remote control, RFID, wireless microphones, health monitoring devices and wireless LAN. Increasingly, manufacturers are working through the ITU and other standardisation bodies to harmonise the frequency ranges and the technical standards. Bluetooth, ZigBee and Wi-Fi (802.11) are some examples of global standards that are widely used and the economies of scale have driven down the cost of hardware tremendously. At WRC-15, the 79GHz frequency band was allocated for the operation of short-range high-resolution automotive radar. This is part of the work to develop standards for Intelligent Transport System (ITS) and the vehicle radar is part of the connected cars and road safety agenda.

Today, wireless LAN has moved from IEEE 802.11b in 2.4GHz offering 11 Mbps to IEEE 802.11ac in 5GHz offering over 500 Mbps to 1 Gbps (using wider bandwidth and techniques such as MIMO and 256 QAM). The development of IEEE 802.11ay is underway, pushing wireless connectivity to 20Gbps by utilising 60GHz spectrum. Wireless LAN is now widely deployed in offices and used in households for sharing the bandwidth with multiple users or devices. In large campuses, such as universities, wireless LAN can help students to get access anywhere within the campus. Consumers now switch their mobile devices from 3G/4G to WiFi when they are at home or in the office. Mobile operators have also been using WiFi to offload mobile data traffic from their cellular networks. With connected homes, household appliances will also become more connected (air conditioners, lighting sensors, garage openers) to enable home automation. Sensors will also be embedded everywhere to enable process automation.

Moreover, the industry is now working with regulatory bodies to enable LTE systems to operate in the unlicensed bands, particularly the 5GHz bands. In January 2016, the FCC in the US gave the green light for Verizon and Qualcomm to conduct LTE-U tests. With the popularity of wireless LAN, the industry is also pushing for the consideration of 5350 – 5470 MHz and 5850 – 5925 MHz for Wi-Fi operation. Under the agenda item 1.16 of WRC-19, regulatory provisions were revised to accommodate both indoor and outdoor usage and the growth in demand for wireless access systems, including RLANs for end-user radio connections to public or private core networks, such as WiFi, while limiting their interference into existing satellite services..

Current Frequency Bands Designated for SRDs in Pakistan

PTA/FAB allow the operation of SRDs in several frequency bands. For example, the spectrum approved for RFID applications is listed in Table 8.The use of SRDs in other spectrum bands have been approved on a case-by-case basis. The use of SRD will be on a license-exempt, type approval exempt basis if the power and distance limits are met.

No.	Frequency Band	Allowed Power	Max. Range	Applications
1	<135 KHz	0.022 W	Passive Tags = 0.5m Active Tags = 2m	RFID
2	433MHz	10 – 100 mW	Passive Tags = 2 – 5m Active Tags = 100m	RFID
3	865 -868 MHz	2W		RFID
4	2.4 GHz	0.5W outdoor; 4W indoor W	Passive Tags = 2 – 5m Active Tags = 30m	RFID
5	5.7 GHz ISM band	2W		RFID

Table 8: Frequency Bands Permitted for RFID

Future Outlook

5470 – 5725 MHz: New wireless LAN equipment (802.11n and ac) supports the 5470 – 5725 MHz band. Many countries have already permitted the use of wireless LAN in this band if the equipment has dynamic frequency selection (DFS) and transmit power control (TPC) capabilities. PTA/FAB are in the process of formulating a framework for permitting this band for wireless LAN.

SRD Framework and Guidelines: PTA/FAB are in the process of preparing a Framework for Un-Licensed Bands including SRDs that provides the industry a list of frequencies that are approved for SRDs. This will include the technical parameters and standards, types of applications approved and other operational restrictions.

Recommended Actions: With the growing demand for wireless LAN, there is a strong case for allowing wireless LAN to share the spectrum in the 5GHz band with existing users. However, there *have been instances where wireless LAN can interfere existing systems. For example, in the US, wireless LAN was found to interfere with Terminal Doppler Weather Radars (5600 – 5650 MHz) used around airports and the FCC had to impose a moratorium on new certifications and closed the band temporarily to mitigate the problem. Hence the conditions of use need to be carefully consulted with existing users.*

11 Spectrum Outlook and Work Plan

The Spectrum Outlook table provides an indication of MoIT&T/PTA/FAB's plan on a band-by-band basis over the next five years. The table also provides an indication of the demand and difficulty to change the allocation.

	Demand	Difficulty
High	Multiple parties asking for the spectrum; expressing urgency in using the spectrum	Many existing users; technical studies need to be conducted; or potential legal issues need to be considered
Medium	One or two parties enquiring the availability of spectrum, but the need is not immediate	Some existing users, simple technical analysis required
Low	Future demand based on industry feedback and/or international trends	Very few users and system migration is straightforward

Timeline	The timeline in the table refers to the timeframe anticipated for each work item to be completed.

Table 9: Level of Demand for Spectrum, Difficulty and Timeline

Spectrum Outlook Table

Work Item	Plan	**Demand**	Difficulty	**Timeline**
Spectrum Sharing and Trading Framework	As stated in Telecom Policy 2015, PTA/FAB will develop the spectrum sharing and trading framework to encourage more efficient use of spectrum.	High	High	2020 – 2021
AIP Framework & Spectrum Pricing Review	PTA/FAB will review the current spectrum pricing framework to introduce AIP and other changes based on international best practices.	N/A	High	2020 – 2021
700 MHz Band (703 – 803MHz)	To refarm this band and allocating the band for mobile services.	Medium	Medium	2020 – 2022

Work Item	Plan	**Demand**	Difficulty	**Timeline**
900 MHz Band And 1800 MHz Band reassignment policy/license renewal	Reassignment/renewal is in progress by MoIT&T/PTA/FAB	High	Low	2020 – 2021
L-Band (1427 – 1518 MHz)	The L-Band has been identified for IMT at WRC-2015. Also being considered for Supplementary Down Link for mobile operations. PTA/FAB is prepared to make this band available in the longer term when equipment becomes available.	Low	Medium	Beyond 2021
1800 MHz Unassigned Spectrum	MoIT/PTA/FAB can potentially make spectrum available for auction in the near future. Re-farming will be required to make block size standardized.*	High	Low	2020 – 2021
Below 2.7 GHz	High-altitude IMT base stations (HIBS) – Possible use of same frequency bands as ground-based IMT base stations on HAPS for extended mobile broadband connectivity to underserved communities and remote areas.	Low	Low	2024-2029
2100 MHz Band (1950 – 1980 MHz / 2140 – 2170 MHz)	PTA/FAB is refarming the band and will make the spectrum available for mobile services.*	High	Medium	2020 – 2021
2300 MHz Band (2300 – 2400 MHz)	2300-2400 MHz is allocated to the mobile service on a co-primary basis in the three ITU Regions. IMT (5G) has already been deployed or is being considered for deployment in some countries in this frequency band and equipment is readily available. PTA/FAB intend to make this band available in the future when there is adequate demand.	Medium	Medium	2020 – 2022

* Availability status of these bands is attached as Annex-A

Work Item	Plan	**Demand**	Difficulty	**Timeline**
2500 MHz Band (2500 – 2690 MHz)	MoIT&T/PTA/FAB is working to refarm the band with the intention of allocating it for IMT services. Further GoP Policy has identified this band for trials of 5th generation networks; the same is under consideration for auction for IMT.	High	High	Depending on the judiciary process
3.5 GHz Band (3300 MHz to 3400 MHz)	3300-3400 MHz is identified for the implementation of International Mobile Telecommunications (IMT)	Low	High	2021-2022
3.5 GHz Band (3400MHz to 3600MHz)	PTA/FAB is considering expanding the usage of the band to include mobile when the licences expire. Further GoP Policy has identified this band for trials of 5th generation networks; the same is under consideration for auction for IMT.	High	Medium	Beyond 2024
Digital TV Broadcasting	MoIB/MoIT&T/PEMRA/PTA/FAB will be coordinating the digital TV planning to ensure a smooth migration and make known the plans for digital switchover.	Medium	High	2020 – 2022
Digital Audio Broadcasting	There is spectrum available in the VHF Band III for the introduction of digital audio broadcasting services. MoIB/PEMRA/FAB is considering allocating spectrum for the implementation of digital audio broadcasting.	Medium	High	2020 – 2022
5470 – 5725 MHz	PTA/FAB will be consulting the industry for permitting this band for wireless LAN and the conditions to impose (e.g., DFS and TPC)	Medium	Medium	2020 – 2021
57 – 66 GHz	To introduce point-to-point outdoor application (V-Band)	Low	Low	2020 – 2022
31-31.3 GHz38-39.5 GHz , 47.2 -47.5 GHz, 47.9-48.2 GHz	WRC has identified the frequency band 31-31.3 GHz and 38-39.5 GHz for worldwide use by High Altitude Platform Stations (HAPS). The existing worldwide identifications for HAPS is in the bands 47.2 – 47.5 GHz and 47.9 – 48.2 GHz. This identification does not preclude the use of this frequency band by other	Low	Low	2024-2029

Work Item	Plan	Demand	Difficulty	Timeline
	fixed-service applications or by other services to which this frequency band is allocated on a co-primary basis, and does not establish priority in the Radio Regulations.. The existing worldwide identifications for HAPS in the bands 47.2 – 47.5 GHz and 47.9 – 48.2 GHz are available for worldwide use by administrations wishing to implement high-altitude platform stations.			
24.25-27.5 GHz, 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 and 66-71 GHz	GoP Policy has identified mmWave bands for trials of IMT (5G); WRC 19 has identified these band for IMT. Depending upon development of eco-system and raise in demand, FAB will make available the said spectrum for IMT services protecting incumbent services. Furthermore, while identifying IMT bands for agenda of IMT-2023, WRC-19 has also identified 3300-3400 MHz, 3600-3800 MHz, 6425-7025 MHz, 7025-715 MHz and 10.0-10.5 GHz for studies of coexistence of IMT. Use of C-band for IMT will be decided in coordination with SUPARCO due to existing and future satellite operations.	Low	Low	2024-2026
SRD Framework / Guidelines	PTA/FAB shall finalize the framework.	Medium	Low	2020 – 2021
Unlicensed Spectrum for IOT	Framework for LPWAN shall be finalized by PTA/FAB	High	Medium	2020-2021

Table 10: Spectrum Outlook Table

12 Conclusions

Telecom Policy 2015 provides clarity on various regulatory issues, as well as providing forward policy directions for the next four years. Crucially, the Telecom Policy positions MoIT&T/PTA/FAB as forward-thinking policy maker and/or regulator that also promotes transparency. This is essential to create a conducive environment to encourage investment and spur growth within the ICT industry.

12.1 Spectrum Master Plan – Transparency and Predictability

The Telecom Policy requires that a rolling Spectrum Strategy will be published every year. This Spectrum Master Plan document provides the groundwork for developing the Spectrum Strategy. In particular, Section 4 to 11 can be used to develop the Spectrum Strategy document. It is proposed that PTA/FAB issues a draft document for consultation and get feedback on the strategy. This process is necessary to ensure transparency and to receive additional inputs from the industry regarding potential future requirements that may not have been captured during the interviews conducted during this exercise.

12.2 Spectrum Demand versus Revenue

Previous auctions were not met by strong interests from mobile operators and in some cases there were either no competition or leftover spectrum. The lack of demand for spectrum was partly because the mobile operators were making their revenues mainly from voice services and data services were mostly 3G-based. With intense competition and a low ARPU, operators were therefore more averse to making huge investment in acquiring more spectrum. This is expected to change. As highlighted in Section 4, the future demand for spectrum will be driven by mobile broadband services. Over the next few years, 4G/LTE will drive the demand for spectrum and the adoption of mobile broadband is expected to accelerate in future. Pakistan has crossed the 38.5 Million 4G subscriber mark through expanding its 4G coverage across the country. The availability of service has also triggered the development and adoption of applications (e.g., Careem taxi app).

There are ways the government of Pakistan can help to boost the usage of mobile broadband services. The government can take the lead to promote the use of the Internet through enabling of government services via electronic means, i.e., E/M-government. Several countries in Asia (e.g., Thailand and Indonesia) are also initiating national broadband projects to improve the broadband infrastructure particularly in rural areas, and to bridge the digital divide. Most of these national broadband projects are choosing to use LTE in rural areas to lower project costs and enable faster rollout. As the demand for mobile broadband grows, operators will gain additional revenues which will put them in a better position to bid for spectrum to grow their networks.

12.3 Spectrum Trading Framework

The spectrum trading framework clarifies the rules with regard to spectrum trading between licensees. The framework is comprehensive but there are areas that PTA/FAB could consider:

- The framework does not permit spectrum trading between a WLL licensee and a mobile licensee. In light of the convergence of services and technology neutrality, it is beneficial for operators to be able to maximise the use of spectrum through trading.

- The framework also does not allow trading by regions. This could be assessed on a case-by-case basis; allowing an operator that are not serving customers in a particular region to sell the spectrum to another party that has a need for spectrum. This will further improve the utilisation of spectrum.
- The framework for leasing does not specifically mention whether geo-spatial leasing is allowed. The sharing of spectrum between different services are also not covered in this framework (e.g., TVWS). This is an advance area which could be considered when cognitive radios become more common in the marketplace.
- The trading framework could also include bands that PTA/FAB face difficulties refarming administratively (e.g., 2500 MHz). This will allow operators with strong commercial incentives to access the spectrum to acquire the resources from the incumbent based on commercial terms.

12.4 Spectrum Management System for Developing Country – SMS4DC

PTA's Frequency license process including invoicing is currently a manual one and the records are not stored in a structured database that can be integrated with FAB's assignment database. The implementation of a database and using frequency evaluation software will help to improve accuracy of data and efficiency in processing applications. As Pakistan move into the digital age, there will be an expectation for people and organisations to be able to transact with the Government of Pakistan through the online channel.

There are several options of implementing an electronic system for licensing. Developing a system in-house gives the greatest flexibility to add or change features based on changing requirements. However, this is often a costly approach since the software is only developed for one organisation. There are also commercially available software that may also provide integration with technical spectrum analysis tools. Such software can also be costly depending on the complexity of the software, map resolution and the level of maintenance required.

Another more cost-effective option is the ITU's SMS4DC – an automated technical and administrative tool for spectrum management. SMS4DC adopts ITU-R recommendations which facilitates the registration of assignment with ITU. It is recommended that PTA conduct a free trial of this software and evaluate if this is the right option in terms of functionality and useability.

Recommended Actions: *MoIT&T and PTA should urgently look at automating the licensing process. This should include automating the invoicing of licences. If PTA intends to develop a system in–house, they should still evaluate the SMS4DC to determine the key parameters and requirements for a comprehensive platform. Once the system is in operation, the next phase could include an integration with an online application portal and/or continued reconciliation of distributed records between FAB and PTA. In order to implement the light licensing regime for Un-licensed Spectrum (UWB, Wi-Fi, IoT, SRD, etc), an online system also needs to be deployed by*

PTA/FAB. Another web-based system, similar to TOWAIR developed by FAA/FCC in USA needs to be deployed by CAA/PTA/FAB for expediting site clearance process in vicinity of airports. BTS approval process needs to be made on-line as well in order to shorten time consumed by FAB Board Members in decision making.

12.5 Human Capacity Building

To implement the work outlined in Section 11 (Spectrum Outlook and Work Plan) it is necessary for officers in PTA and FAB to have the knowledge and skillset to handle those tasks. The areas of expertise required range from technical knowledge of different technologies and services; understanding of economic issues and market dynamics; legal and regulatory framework; and strategic planning and policies around wireless innovation.

The ITU has a few human capacity building initiatives. The Spectrum Management Training Programme (SMTP) for instance, is developed by the ITU Academy to assist spectrum management professionals to enhance their knowledge while working in this field. Trainees entering the SMTP may be from different institutional levels, from technical to managerial, and from different background (engineering, legal, economics, etc.). The development of this programme is being coordinated by the Human Capacity Building division within the Projects Support and Knowledge Management department of the ITU's Telecommunications Development Bureau (BDT), in close collaboration with BDT's focal point for the Spectrum Management and Radiocommunication Bureau (BR), subject matter experts, academia representatives and other stakeholders.

The ITU also has a Centres of Excellence (CoE) programme that supports capacity building in the field of information and communications technologies (ICT). Designed to offer continuous education to ICT professionals and executives in the public and private spheres through face-to-face or distance learning programmes, the Centres serve as regional focal points for professional development, research, and knowledge sharing, as well as provide specialist training services to external clients. With the support from multilateral and regional organizations, CoE networks have been established in a number of regions including Africa, the Americas, Arab States, Asia-Pacific, Commonwealth of Independent States (CIS) and Europe.

It is proposed that PTA and FAB consider leveraging the ITU Academy programmes to develop staff capabilities on an on-going basis. This will help the two organisations to expose the spectrum management specialists to international best practices and determine the best approaches for Pakistan.

ITU Academy
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Glossary

2G	*Second-generation mobile network or service.* A general term for second-generation networks, for example GSM.
3G	*Third-generation mobile network or service.* Generic term of the next generation of broadband digital mobile cellular systems, which will have expanded broadband capabilities for mobile data applications. See IMT-2000
3GPP	*3rd Generation Partnership Project.* A cooperation between regional standards bodies to ensure global networking for 3G systems
4G	*Fourth-generation mobile network or service.* Mobile broadband standard offering both mobility and very high bandwidth.
5G	*Fifth-generation mobile network or service.* Denotes the next major phase of mobile telecommunications standards beyond the current 4G/IMT-Advanced standards. 5G has speeds beyond what 4G can offer.
ACR	*Administrative Cost Recovery*
AIP	*Administrative Incentive Pricing*
AIS	*Automatic Identification Systems***.** An automatic tracking system used on ships and by vessel traffic services for identifying and locating vessels by electronically exchanging data with other nearby ships
APT	*Asia-Pacific Telecommunity.* APT was founded on the joint initiatives of UNESCAP and ITU to promote regional harmonisation of ICT programmes and activities in the region.
ASAF	*Annual Spectrum Administrative Fee*
ASO	*Analogue Switch-Off*
Bluetooth	A radio technology that enables the transmission of signals over short distances between mobile phones, computers and other devices. It is typically used to replace cable connections.
CAGR	*Compound Annual Growth Rate*
DAB	*Digital Audio Broadcasting.* A technology for broadcasting of audio using digital radio transmission.
DSA	*Dynamic Spectrum Access.* A technique that enables a radio device to operate in spectrum that is not being used in a particular area, at a particular point in time
DSO	*Digital Switch-Over*
DTMB	*Digital Terrestrial Multimedia Broadcast.* A TV standard for mobile and fixed terminals use mainly in China.
DTTB	*Digital Terrestrial TV Broadcasting*
DVB	*Digital Video Broadcasting.* An open standard for digital television maintained by the DVB Project industry consortium.
eMMB	*Enhanced Mobile Broad Band*
eMBMS	*Evolved Multimedia Broadcast Multicast Services.* Point-to-multipoint transmission delivered through an LTE (Long Term Evolution) network.
EIPRB	*Emergency position-indicating radio beacon station.* A station in the mobile service used in search and rescue operations.
FAB	*Frequency Allocation Board*
FBB	*Fixed Broad Band*

FDD	*Frequency Division Duplex.* A duplex technique where the traffic in each direction carried on two way telecommunications link is carried on two different carriers frequencies each dedicated to the traffic in one direction.
FWA	*Fixed Wireless Access.* A wireless access application in which the location of the end user terminal and network access point to connect to the end user are fixed.
GADSS	*Global Aeronautical Distress and Safety System*. A system to enhance search and rescue services to timely determine that an aircraft is in distress, locate it and rescue survivors in the event of an incident. GADSS entails aircraft tracking system, autonomous distress tracking system and flight data recovery.
GoP	*Government of Pakistan*
GMDSS	*Global Maritime Distress and Safety System*. An internationally agreed-upon set of safety procedures, types of equipment, and communication protocols used to increase safety and make it easier to rescue distressed ships, boats and aircraft..
GSM	*Global System for Mobile Communications.* Digital mobile standard developed in Europe. It describes the protocols for 2G digital cellular networks used by mobile phones, first deployed in Finland in July 1991.
IMT-2000	*International Mobile Telecommunications-2000.* Third-generation (3G) "family" of mobile cellular standards approved by ITU.
IoT	*Internet of Things.* A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving, interoperable information and communication technologies.
ISP	*Internet Service Provider.* ISPs provide end users access to the Internet. ISPs may offer their own proprietary content and access to online services such as e-mail.
ICAO	*International Civil Aviation Organization.* A specialised agency of the United Nations for civil aviation.
IMO	*International Maritime Organisation*. A specialised agency of the United Nations for maritime.
ITU	*International Telecommunication Union.* The United Nations specialized agency for telecommunication.
LTE	*Long-Term Evolution*. Commonly marketed as 4G LTE, is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements. The standard is developed by the 3GPP.
LTE-Advanced	LTE Advanced is a mobile communication standard and a major enhancement of the Long-Term Evolution (LTE) standard. It was formally submitted as a candidate 4G system to ITU-T in late 2009, as meeting the requirements of the IMT-Advanced standard, and was standardised by the 3GPP in March 2011 as 3GPP Release 10.
LSA	*Licensed Spectrum Access.* An individual licensed regime of a limited number of licensees in a frequency band, already to one or more incumbent users, for which the additional users are allowed to use the spectrum (or part of the spectrum) in accordance with sharing rules included in the rights of use of spectrum granted to the licensees, thereby allowing all the licensees to provide a certain level of QoS.
M2M	*Machine-to-machine.* Information exchange between a subscriber station and a server in the core network (through a base station) or between subscriber station, which may be carried out without any human interaction.
MBB	*Mobile Broad Band*
MIMO	*Multiple-Input Multiple-Output.* A wireless technology that uses multiple transmitters and receivers to transfer more data at the same time.
mMTC	*Massive Machine Type Communication*
MoIB	*Ministry of Information Broadcasting and National Heritage, Pakistan.*

MoIT&T	*Ministry of Information Technology and Telecom, Pakistan.*
MVNO	*Mobile Virtual Network Operator.* A company that does not own a licensed frequency spectrum, but resells wireless services under their own brand name, using the network of another mobile phone operator.
OTT	*Over-the-Top.* OTT designates the carriage of telecom services, such as voice telephony, on top of a general purpose communication path, such as the Internet.
PEMRA	*Pakistan Electronic Media Regulatory Authority.* Regulator for electronic media services in Pakistan.
PPDR	*Public Protection and Disaster Relief.* Public protection radiocommunication is used by agencies and organisations dealing with the maintenance of law and order, the protection of life and property with emergencies; and disaster relief radiocommunication is used for dealing with serious disruptions to the functioning of society that pose a significant and widespread threat to human life, health, property or the environment, whether caused by accident, natural phenomena or human activity, and whether developing suddenly or as a result of complex, long-term processes.
PTA	*Pakistan Telecommunications Authority.* The telecommunications regulator in Pakistan.
PTV	*Pakistan Television.* The state-owned broadcaster in Pakistan
QoS	*Quality of service.* The overall performance of a telephony or computer network, particularly the performance seen by the users of the network.
RCS	*Rich Communications Services.* RCS include instant messaging, chat, live video and file sharing – work across all networks and on any device, and mark a transition from circuit switched technology to an all-IP world that is changing the way people communicate.
RFID	*Radio-frequency identification.* A system of radio tagging that provides identification data for goods in order to make them traceable. Typically used by manufacturers to make goods such as clothing items traceable without having to read bar code data for individual items.
S/N	*Signal to Noise Ratio.* A measure of signal strength relative to background noise. The ratio is typically measure in decibels (dB).
SDR	*Software Defined Radio.* A radio communication system which uses software for the modulation and demodulation of radio signals.
SFN	*Single Frequency Network.* S
SRD	*Short-range device.* Radio transmitters which provide either unidirectional or bidirectional communication and which have low capability of causing interference to other radio equipment.
SUPARCO	*Space & Upper Atmosphere Research Commission.*
TDD	*Time Division Duplex.* A duplex technique where the traffic in each direction of a two-way telecommunications link is carried on a single carrier radio frequency, in discrete time intervals each dedicated to traffic in one direction.
TPC	*Transmit Power Control.* A technical mechanism used within some networking devices in order to prevent too much unwanted interference between different wireless networks.
TVWS	*TV White Space.* A portion of spectrum left unused by broadcasting, also referred to as interleaved spectrum.
UAS	*Unmanned Aircraft Systems.* An aircraft and its associated elements which are operated with no pilot on board.
uRLLC	*Ultra Reliable Low Latency Communication.*

UWB	*Ultra-Wide Band.* Wireless communications technology that can currently transmit data at speeds between 40 to 60 megabits per second and eventually up to 1 gigabit per second. It uses ultra-low power radio signals.
VDES	*VHF Data Exchange System.* A
VoLTE	*Voice over LTE* which is based on the IP Multimedia Subsystem (IMS) network, with specific profiles for control and media planes of voice service on LTE. VoLTE will facilitate far richer, multi-media voice services, increasing the service quality (by offering HD Voice) and interest delivered to consumers.
WAIC	*Wireless Avionics Intra-Communications.* System intended for wireless communications applications between points on a single aircraft impacting the safety or regularity of flight.
Wi-Fi	*Wireless Fidelity.* A mark of interoperability among devices adhering to the 802.11b specification for wireless LANs from the Institute of Electrical and Electronics Engineers (IEEE). However, the term Wi-Fi is sometimes mistakenly used as a generic term for wireless LAN.
WiMAX	*Worldwide Interoperability for Microwave Access.* Fixed wireless standard IEEE 802.16 that allows for long-range wireless communication at 70Mbps over 50 kilometres. It can be used as a backbone Internet connection to rural areas.
WLL	*Wireless Local Loop.* Typically a phone network that relies on wireless technologies to provide the last kilometre connection between the telecommunication central office and the end-user.
WRC	*World Radiocommunication Conference.* An ITU conference held every three to four years. The role of WRC is to review, and, if necessary, revise the Radio Regulations, the international treaty governing the use of the radio-frequency spectrum and the geostationary satellite and non-geostationary satellite orbits.
ZigBee	An IEEE 802.15.4 specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios.