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South Asia

Pakistan: Telecommunications Advisory Assistance

5G Readiness Plan for Pakistan:

Accelerating the release of mobile spectrum, facilitating investment in 5G networks and accelerating 5G use cases

FINAL DRAFT

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Importantly, the opinions, recommendations and conclusions expressed in this publication do not necessarily reflect the views of Government of Pakistan, the PTA and/or FAB.

1 Executive Summary

Introduction

5G is a transformative technology that allows communities to realise the socio-economic benefits of an advanced, data-intensive, digital economy. 5G promises improved connectivity, greater network speeds and bandwidth, and very low latency.

It is projected that by the end of 2026, 5G will attract 3.5 billion subscriptions, generating 45 percent of the world's total mobile traffic data.[1] 5G is rapidly advancing worldwide, especially in Asia, Europe and North America. In Asia-Pacific 4G surpassed 60 percent of total connections in the region in 2019; while 5G will overtake both 2G and 3G in 2022.[2] There are ongoing activities in South Asian and Middle Eastern countries looking into the release of the 3.5 GHz and other frequency bands to support 5G investment and deployment. Necessarily Pakistan needs to participate in this transition to new technologies including 5G.

Benefits of 5G for Pakistan

This World Bank report commissioned by the MoITT has been created to examine Pakistan's Readiness for 5G. The Pakistan economy exhibits multiple characteristics that strongly suggest 5G deployment will generate significant economic benefits. Pakistan has a large population and good potential for further economic growth, a currently congested mobile communication network, dynamic urban centres, the ability to access suitable 4G/5G spectrum relatively easily, under-developed fixed line infrastructure and significant barriers to rapid deployment of fixed line infrastructure.

5G Market assessment and spectrum issues

Pakistan's current telecommunications market has been analysed in this report to determine readiness for 5G through comparison with neighbouring countries and global benchmarks. Based on the analysis, and comparisons with other comparable markets it is possible to conclude that the Pakistan market as at August 2021 is not yet 5G ready. There exists a considerable number of factors to address in facilitating Pakistan's market readiness especially the lack of large contiguous blocks of affordable spectrum, broader access to fibre backhaul and widespread availability of affordable 5G smartphones and other devices which are necessary preconditions in order to make 5G a success.

The above view is shared by the Pakistani MNOs who have jointly stated that "*The state of readiness of any project is fundamentally intertwined with both demand and supply side factors and the enabling framework (often a collaboration between public and private sector initiatives) and commercial viability.*"[3] Their joint submission went on to highlight the need for *inter alia*:

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[1] *Ericsson Mobility Report*, June 2021.

[2] GSMA, *the Mobile Economy Asia Pacific*, 2020.

[3] PTCL, Jazz, Ufone, Telenor Pakistan, and Zong, *Consultation on 5G Readiness,* 22 February 2021. Page 1

- Spectrum in the prime 5G bands including 700 MHz, 2.6 and 3.5 GHz and mmWave bands at significantly reduced prices in order to allow the MNOs to concentrate on service rollout and 5G ecosystem development in Pakistan;
- Mandated 5G Coverage and QoS levels to be kept at reasonable levels;
- Handset and data taxes to be removed to facilitate the rapid adoption and uptake of services; and
- Fibre proliferation to be done urgently along with a plan to enhance wireless backhaul frequencies.[4]

Readiness for 5G in Pakistan or in any country does not occur at a single point of time or as the result of a binary decision. Building a country's digital economy and support for 5G and other service innovations is a journey. Built on the Government's sector policy and regulation, successive deployments of technology – 2G, 3G and 4G – combine to create the environment where future 5G and in the 2030 timeframe future 6G services, will see investments from industry stakeholders, new services and applications and increased customer and enterprise demand.

An important question posed is the necessary preconditions to make 5G a success for emerging markets such as Pakistan, particularly in regard to the state of 4G deployment. This report's analysis unfortunately points to Pakistan's IMT spectrum management policy as being the key factor which has held back the sector in fully investing in 4G deployment and sector competition. Furthermore, IMT Spectrum has been priced such that only the market leaders can afford to participate, further hindering Pakistan's 5G-readiness. The economic benefits of making additional 4G and 5G services available at reasonable prices in Pakistan significantly outweigh any revenue foregone from maximizing 5G spectrum prices.

The corollary of the above is that Pakistan requires a more bespoke approach to its investment and launch of 5G services than other countries with more competitive mobile markets. There should be an announcement that there is strong government support for Pakistan to deploy 5G services by 2022, whilst concurrently addressing the three key necessary conditions for this to successfully take place, namely –

(i) larger contiguous blocks of reasonably priced spectrum in accordance with a spectrum roadmap so that Pakistan should have a goal to have 840 MHz of IMT spectrum allocated in low and mid-bands by end of 2022/early 2023. Any mmWave spectrum would be additional. This is consistent with ITU Guidelines for total IMT spectrum assignments;

(ii) fiberisation/transmission capacity upgrades of backhaul capacity and

(iii) policy support for consumers to gain access to more affordable 4G and 5G capable smartphones and other devices.

Importantly, taking such steps now will also advantage existing 3G and 4G customers in Pakistan. Concurrently with the above, there is a need to remove any regulatory or other obstacles for Pakistani MNOs should they wish to switch off legacy 2G or 3G networks.

[4] *Ibid,* pages 3 and 4

Improving market readiness

Regulatory interventions and enacting supportive policies to facilitate key recommendations can accelerate market readiness and 5G adoption in Pakistan – policies such as promoting collaboration on network infrastructure. The PTA has the opportunity to facilitate sector investment in high-speed services by promoting mobile competition as well as fixed competition with the acceleration of 5G fixed wireless access (FWA) services. Such deployments will have a positive economic impact.

In order to realise the gains associated with 5G, significant investments in digital infrastructure must be made. The Government of Pakistan, PTA and the FAB should support the introduction of 5G services in Pakistan by encouraging MNOs to invest in this transformational technology and take further facilitative steps as required including in relation to spectrum management. Importantly, the Government should also facilitate domestic content creation which utilises 4G and 5G connectivity in strengthen the use and highlight the benefits of having high-speed wireless broadband services.

Summary and Recommendations

So, in summary It is possible to conclude that the Pakistan market as at August 2021 is not yet 5G ready. However, it can be and must be because of the considerable benefits which highspeed wireless broadband including 4G and 5G will bring to Pakistan and its people. Becoming 5G ready is possible for Pakistan with significant industry investment and stakeholder collaboration.

To achieve such 5G Readiness, this World Bank *5G Readiness Plan for Pakistan* recommends the following.

Overall policy parameter recommendations

(1) The Government of Pakistan, PTA and the FAB support the introduction of 5G services in Pakistan encouraging MNOs to invest in this transformational technology and take further facilitative steps as required including in relation to spectrum management, facilitating improvements to backhaul transmission and make 4G/5G handsets more affordable ensuring affordable 5G services are widely available in the 2022 and beyond timeframe.

(2) The Government of Pakistan should facilitate the creation of domestic content and exemplar applications which highlight the possible use of high speed wireless broadband services including 5G in the country in order to 'seed' the market for a range of innovative and productive use cases/applications.

Spectrum management recommendations

(3) It is critical to increase regulatory certainty and provide Pakistan with a 5G spectrum future, by the Government of Pakistan, PTA and FAB committing to a IMT spectrum roadmap required to achieve the ITU's IMT Spectrum Target of 840 MHz (excluding mmWave spectrum) as shown below. This roadmap could be done by an update to the 2020 Spectrum Rolling Strategy. Specifically:

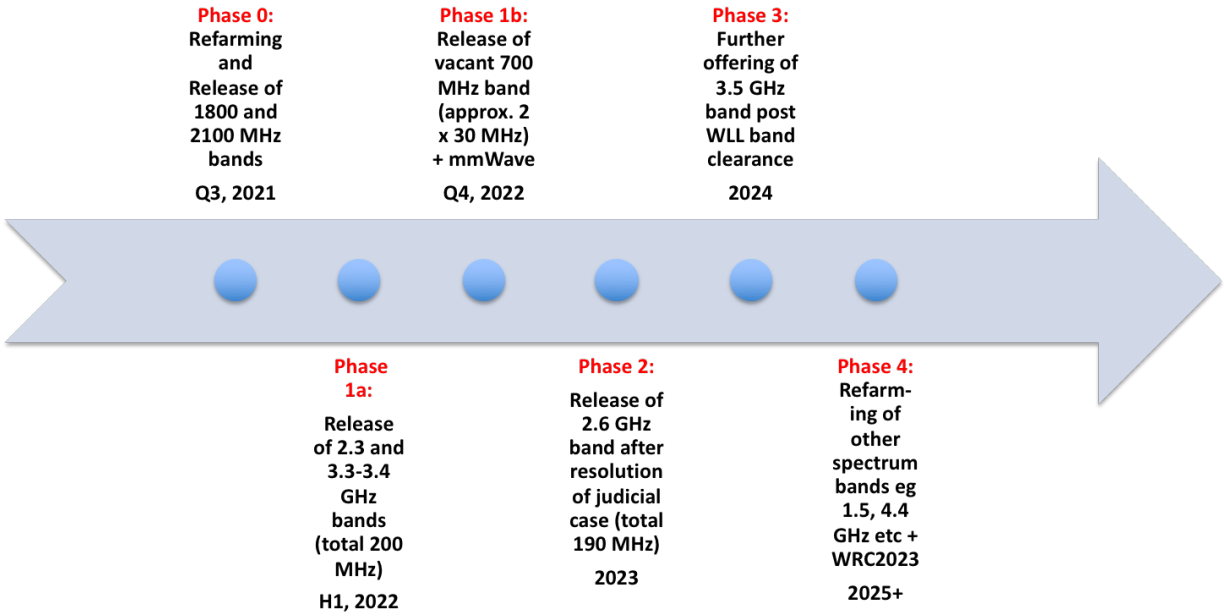
(a) Ensure that IMT spectrum reserve pricing for the 1800/2100 MHz bands is reasonable and other auction rules are set so as to provide an opportunity for non-market leaders to acquire IMT spectrum. It is critical for suture sector competition that all MNOs be able to offer competitive 4G services and in the future 5G services;

(b) Given device availability and affordability and the focus on Pakistan's urban areas first (given available backhaul and higher income levels), the optimal pioneer 5G bands for Pakistan are the 3.5 GHz (n78) and the 2.3 GHz (n40) bands. Both are TDD capacity bands and available now. n40 has the advantage of it being used by MNOs initially for 4G services before transitioning to 5G services;

(c) In the next phase, making the 2.6 GHz band (n41) available would add additional 4G/5G capacity spectrum in urban areas; while the 700 MHz (n28) band is optimal for coverage and would help to extend 4G/5G services outside Pakistan's cities/towns.[5] Subject to the resolution of the court case, the 2.6 GHz band could be concurrently released with the 2.3 GHz band, if so desired; and

(d) While the 3.5 GHz band can only be used for 5G given harmonisation, the 2.3, 2.6 GHz and 700 MHz bands can be used for 4G and/or 5G as well. Thus the MNOs are able deploy 4G and then convert the band to 5G where possible based on 5G device penetration, demand etc in Pakistan. mmWave could be made available to the market in late 2022, if demand exists from MNOs and enterprises.

Recommended timeline for the release of IMT spectrum for 5G services



[5] Note Phase 1a and Phase 1b could be done simultaneously depending on the timing of the availability of 700 MHz spectrum.

(5) Within Pakistan any allocation of 2.3, 2.6 and 3.5 GHz TDD spectrum, synchronisation between MNOs should be mandated with a 4:1 frame structure with it to be reviewed say in 5 years. Further, as required, Pakistan and its neighbouring countries with the assistance of the ITU, should agree synchronisation and frame structure for TDD systems in order to avoid harmful interference;

Other telecommunications policy recommendations

(6) The MoITT and the PTA should facilitate 5G deployment in Pakistan by instituting a range of policy and regulatory reforms detailed in this Report permitting improved (i) fiberisation of backhaul and (ii) site access for tower and small cell rollout over the next 12-24 months or so especially in relation to public land, sites etc. Recent policy announcements on infrastructure sharing should be fully implemented; and

(7) The PTA along with the Ministry of Health and other stakeholders should engage in a public education campaign in relation to 5G reassuring the public about the safety of the technology and that it is similar in terms of spectrum use that existing mobile services.

Facilitating Digital infrastructure

(8) In this area of digital infrastructure, there are four additional key recommendations which should be adopted by Government and the PTA for the success of 5G in Pakistan:

(a) Improving ROW to facilitate 5G deployment. A national infrastructure database should be established to avoid costly damage to infrastructure, disruption of service and possibly personal injury;

(b) Need for improved access to towers and sites for 5G deployment. The PTA should also facilitate the establishment of industry bodies to develop uniform conditions/self-regulatory models for infrastructure sharing, as well as provide financial incentives to encourage infrastructure rollout and sharing in Pakistan. Any active sharing should be agreed upon in commercial terms, rather than mandated by government.;

(c) Support continued investment in International transmission capacity and cloud infrastructure. Having cloud infrastructure located within Pakistan is valuable for companies operating within Pakistan for convenience and lower latency; and

(d) Support for the deployment of Internet of Things (IoT) in Pakistan by MNOs.

Supporting use cases in Pakistan

(9) In relation to use cases, there are innumerable opportunities to improve development challenges in Pakistan through 5G networks. Even before 5G reaches market maturity, there are several ways that the Government can support to speed up the use case discovery process that can subsequently accelerate the uptake of the technology. These include:

(a) Supporting 5G trials can stimulate the innovation capacity of industry verticals;

(b) Exploring a regulatory sandbox to encourage 5G use case development and applications in each sector. Further, addressing regulatory bottlenecks in each of the sectors and offering regulatory flexibility can be useful in exploring new business models and a faster path to digital transformation of the sector;

(c) The government can offer digital skills training. Digital skills are important to 5G technology adoption and utilization. Existing training programs within the Ministry of Information and Technology can incorporate digital skills that can support the 5G use case discovery process; and

(d) The government can facilitate multi-stakeholder collaboration. The use of 5G goes beyond the purview of the ICT sector. A strengthened partnership among enterprises, MNOs, governments, academia and Civil Service Organizations (CSO) can stimulate new business models and converged services that require diverse expertise.

2 Introduction

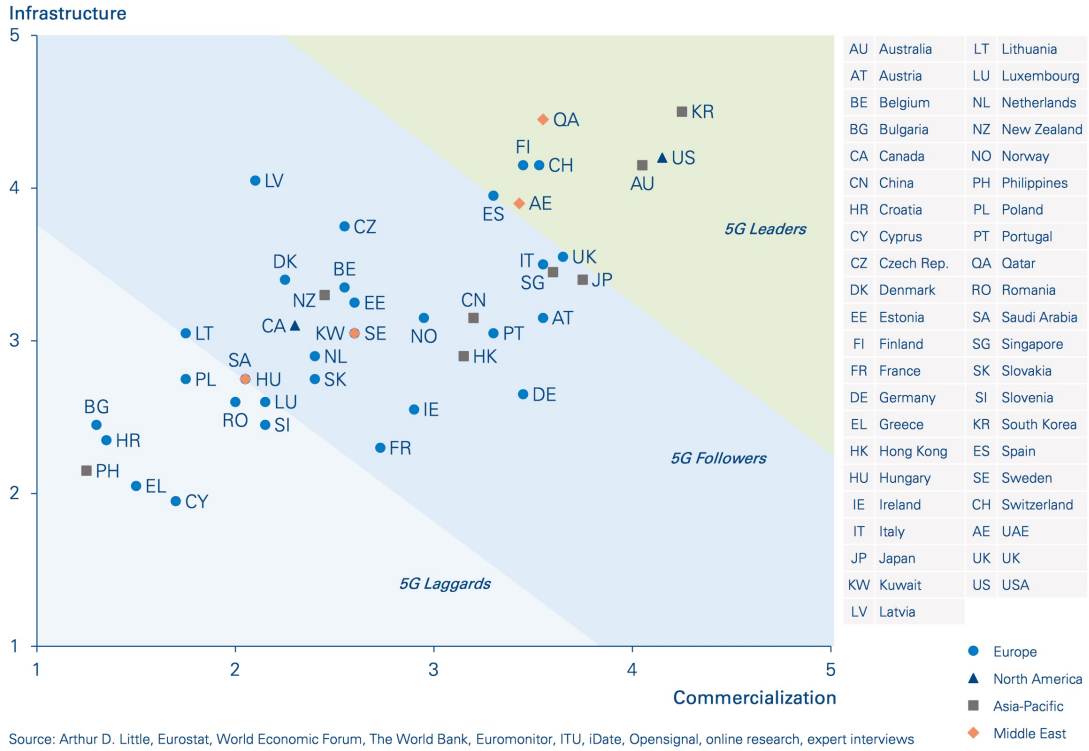
2.1 5G Deployment in a Global Perspective

As defined by the ITU, the IMT-2020 for 5G encompass the systems, components, and related elements that support enhanced capabilities for the next generation of communications technology surpassing IMT-2000 (3G) and IMT-Advanced (4G) systems.

2.2 Global Approaches to 5G

Globally, many countries and regions like South Korea, the United States, Japan, China, and the European Union are in a "race" to deploy 5G and to secure country economic benefit – including manufacturing, innovation, and services/applications from doing so. This has resulted in many Governments enacting a range of supportive policies to encourage 5G, including favourable spectrum policies, infrastructure deployment rules and setting ambitious adoption goals. A comparison of global 5G leadership has been developed by Arthur D Little (see Exhibit 1). Pakistan could, with good 5G decision-making, join this leadership index.

Exhibit 1: 5G Leadership Index by Arthur D Little (March 2019)[6]



Source: Arthur D. Little, Eurostat, World Economic Forum, The World Bank, Euromonitor, ITU, iDate, Opensignal, online research, expert interviews

[6] Arthur D. Little, *The Race for 5G*, March 2019. The 5G Leadership Index is based on detailed analysis of technical infrastructure and tendency for 5G commercialization. 5G Leaders have 5G spectrum allocated, high performance backhaul infrastructure deployed, have announced ambitious goals for 5G launch or launched already, and have successfully trailed multiple use-cases. They demonstrate a willingness to adopt new services and have the right level of competition to foster commercialization. Available at www.adlittle.com/sites/default/files/reports/adl_the_race_to_5g_report_-min.pdf

2.3 Pakistani Framework for 5G and Digital Economy

5G Pakistan Plan Committee

In January 2020, the Ministry of Information Technology and Telecommunications (MoITT) constituted the Advisory Committee for 5G Planning in Pakistan (5G Pakistan Plan Committee) to define a roadmap and finalise recommendations for 5G Technology readiness in the country. The Committee comprises members from Ministry of IT and Telecommunication, PTA, Frequency Allocation Board (FAB), PM Office SRIU (Strategic Reforms Implementation Unit), PM Taskforce on IT & Telecom, academia, mobile operators as well as telecom vendors.

The Committee will develop strategic plan and roadmap for 5G technology in Pakistan with the formulation of working groups for 5G spectrum management, telecom infrastructure development, telecom regulations review including health and safety and 5G applications and use cases.[7]

Their first meeting was held in March 2020. The meeting discussed the way forward, a roadmap with timelines and key challenges for the introduction of 5G technology in Pakistan.[8]

Rolling Spectrum Strategy 2020-2023

The Rolling Spectrum Strategy 2020-2023 was released by the PTA in November 2020. It noted that C-band (3.6 – 4.2 GHz) is a core spectrum band for 5G deployment and recommended for a cost-benefit analysis to assess the optimum approach for its release for 5G.[9]

The Rolling Spectrum Strategy 2020-2023 also discussed the following:

- global trends around wireless communications, highlighting the challenges faced by spectrum managers;
- approaches being adopted/investigated by various countries to overcome some of the challenges;
- the different radio services, the current utilisation in Pakistan and the future outlook for various spectrum bands. For example, some spectrum bands will need to be refarmed before they can be allocated and these issues are being detailed in the report.[10]

[7] https://moitt.gov.pk/NewsDetail/NDc3NTMzYWUtYTg5OS00NjNkLTk3NmMtMzMyMzc4ZWYwMTM4
[8] https://nation.com.pk/10-Mar-2020/ministry-holds-1st-meeting-of-advisory-committee-for-5g-planning-in-pakistan
[9] https://propakistani.pk/2020/11/04/pta-reveals-rolling-spectrum-strategy-2020-2023-for-faster-4g-lte-5g-in-pakistan
[10] https://moitt.gov.pk/SiteImage/Misc/files/PakistanRollingSpectrumStrategyFinal23Nov2020.pdf

Digital Pakistan Policy

A Digital Pakistan Policy was introduced in July 2018 with the vision "to become a strategic enabler for an accelerated digitization ecosystem to expand the knowledge based economy and spur socio economic growth".[11]

It also included the following policy objectives, *inter alia*:

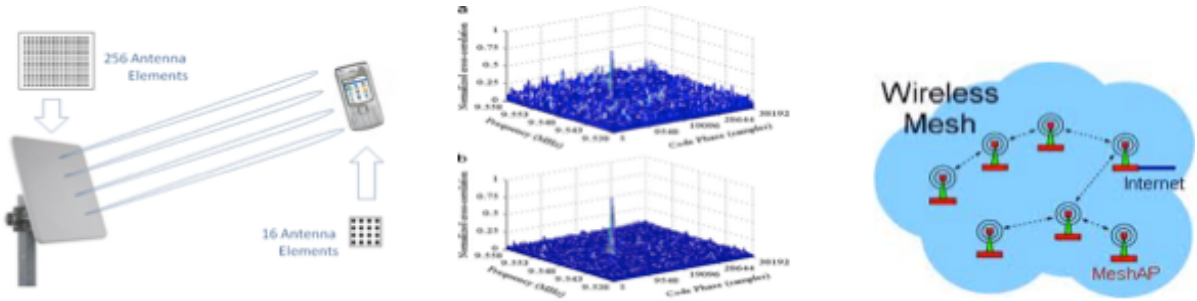
- to create a digital ecosystem with infrastructure and institutional frameworks for the rapid delivery of innovative digital services, applications and content;
- to promote the use of technology in education, health, agriculture and other key socio economic sectors;
- to improve Pakistan's ICT ranking based on international indices and benchmarks; and
- to bridge the digital divide; and
- to generate sustainable innovation, entrepreneurship and employment opportunities in the country.[12]

2.4 5G in the Context of Mobile Technologies

Discussions on 5G commenced in 2008 while 4G/LTE and WiMAX were still vying to become the 4G technology standard. 5G at that time did not describe any particular specification in any official document published by any telecommunication standardization body, but it was anticipated to involve many things including (see Exhibit 2):

- *Spectrum efficiency and performance*, e.g. higher order spectrum aggregation, interference cancellation and scheduling, massive MIMO;
- *Radio design and performance optimization*, e.g. small cells, Heterogeneous Networks, Mesh, software defined, multi-standard, dynamic spectrum and flexible duplexing, self-optimizing and organizing networks; and
- *Network traffic optimization* – quality of service (QoS), policy tools, end-to-end, RAN-aware IP and media optimization, and improved codecs.

Exhibit 2: Examples of 5G technologies



[11] https://moitt.gov.pk/SiteImage/Misc/files/DIGITAL%20PAKISTAN%20POLICY.pdf
[12] *Ibid.*

There were then three serious visions for 5G networks, namely:

(i) Super-efficient universal mobile network;

(ii) Super-fast mobile network with densely clustered small cells for data rates >1 Gbps; and

(iii) Converged wireless fiber network using mm wave band to allow data rates up to 10 Gbps.

In June 2018, the 3GPP — the international group that governs cellular standards — officially signed off on the standalone 5G New Radio (NR) specification (3GPP Release 15).[13] This followed the December 2017 specification for the non-standalone (NSA) version of 5G NR, which would still be built on top of existing legacy LTE networks. Release 16 was completed in July 2020 after being delayed by three months due to the Coronavirus pandemic.[14] This is the culmination of a program agreed in 2012, by ITU's Radiocommunication sector (ITU-R) to develop IMT standards for 5G by 2020. The evolution of mobile networks is detailed in Exhibit 3 below. Release 17 occurred in March 2021.[15]

Exhibit 3: Evolution of mobile networks

	1G	2G	3G	4G	5G
Approximate deployment date	1980s	1990s	2000s	2010s	2020s
Theoretical download speed	2kbit/s	384kbit/s	56Mbit/s	1Gbit/s	10Gbit/s
Latency	N/A	629 ms	212 ms	60-98 ms	< 1 ms

Source: ITU 5G Paper, 2018

5G is expected to increase data rates dramatically and reduce latency compared to 3G and 4G. The technology is expected to significantly reduce latency to below 1ms, suited to mission-critical services where data are time-sensitive. Its high-speed capability means 5G networks can provide a range of high-speed broadband services and offer an alternative to last-mile access such as FTTH or copper connections. The high speeds and low latency promised by 5G are expected to propel societies into a new age of smart cities and the extensive use of the Internet of Things (IoT).

It should also be noted that 5G itself is likely to be surpassed in the 2030 timeframe by 6G with some work already commencing on it, as summarized in Exhibit 4 below.

[13] www.3gpp.org/release-15
[14] www.3gpp.org/release-16
[15] www.3gpp.org/release-17

Exhibit 4: Summary of 6G developments

6G, a term used for the globe's "sixth-generation mobile" wireless internet network, will be the successor to 5G. It is not clear yet what 6G will entail. Previous generations of mobile networks have enabled existing wireline applications to be mobile at a reasonable cost. 6G involves applications that do not yet exist in any form.[16] It will include relevant technologies considered too immature for 5G or which are outside the defined scope of 5G. The University of Oulu in Finland released a paper based on the views of 70 experts following a first 6G Wireless Summit in Finnish Lapland in March 2019. The paper, *Key Drivers and Research Challenges for 6G Ubiquitous Wireless Intelligence*, says that research should look at the problem of transmitting up to 1 Tbps per user. The paper claims that this can be possible through the efficient utilization of the spectrum in the THz range.

Artificial intelligence and machine learning will play a major role both in link and system-level solutions of 6G wireless networks, he added. Both AI and machine learning will be used alongside radio sensing and positioning to learn about the static and dynamic components of the radio environment. 6G, however, is not only about moving data around, says the paper. It will become a framework of services, including virtual reality and communication services where all user-specific computation and intelligence may move to the edge cloud. The integration of sensing, imaging and highly accurate positioning capabilities with mobility will open a range of new applications in 6G. According to the white paper, the societal and business drivers for 6G will include the UN SDGs. It envisions that new developments will enable ubiquitous services and says one of the key research areas is to make the 2030 vision for Ubiquitous Wireless Intelligence a reality.

Technical success of 5G has relied on new developments in many areas and will deliver a much wider range of data rates to a much broader variety of devices and users, while 6G will require a substantially more holistic approach to identify future communication needs, embracing a much wider community to shape the requirements of 6G. Nevertheless, there will also be major challenges including physical layer and radio hardware needs great improvement in order to cope with faster speeds. It also highlights the issues of increased energy consumption and data processing.

Despite these challenges, however, there have been significant 6G developments in 2020. Next G is an industry intuitive that aims to advance North American mobile technology leadership over the next decade through private sector-led efforts was launched in October 2020. Its founding members include industry giants such as Apple, Google, Ericsson, Facebook, and T-Mobile.[17] Much 6G work today is in the form of laboratory explorations and discussions among industry consortia. In Asia, South Korea seeks to become the first country to launch 6G commercial services, with Samsung and LG Electronics setting up research centres and Seoul considering a 976 billion won (USD800 million) development project. Similarly, Beijing unveiled a research and development program in November, while Chinese tech giants such as Huawei, ZTE and China Unicom have started research on 6G independently.[18] The Japanese Government announced that it will earmark ¥50 billion to promote research and development on 6G advanced wireless communications services.[19]

In the EU, Nokia is leading a group of companies and universities in a new European 6G flagship research project called Hexa-X to help jump-start 6G. The project brings together a strong consortium of major ICT, industry and academic stakeholders to lay 6G groundwork and set the direction for future research and standardisation focus areas. The group includes Ericsson, Orange, Telefonica SA, Intel and Siemens, the University of Oulu and the University of Pisa. The Hexa-X project starts on 1 January 2021, with a planned duration of 2.5 years. [20]

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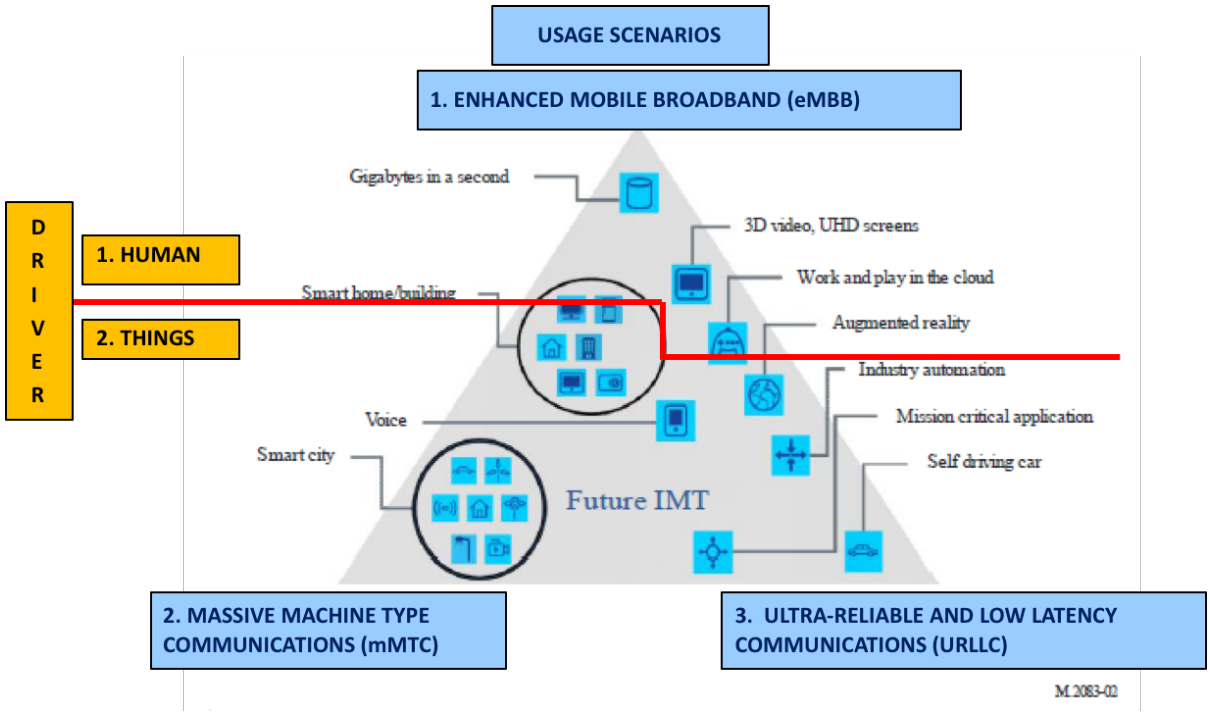
[16] Larry Goldman, *6G Networking is Starting to Take Shape*, Analysys Mason, 24 February 2021.
[17] https://nextgalliance.org/faq/
[18] https://internationalfinance.com/china-is-aiming-at-6g-what-next/; https://asia.nikkei.com/Business/Technology/Race-for-6G-South-Korea-and-China-off-to-early-leads
[19] www.japantimes.co.jp/news/2020/12/10/business/japan-earmark-%C2%A550-billion-6g-development/.
[20] www.ericsson.com/en/news/2020/12/6g--hexa-project; www.smh.com.au/technology/nokia-leads-a-6g-wireless-project-for-european-union-20201208-p56lgm.html

2.5 5G Use Cases

Industry stakeholders have identified several potential use cases for 5G networks, and the ITU-R has defined three important categories of these to be (see Exhibit 5 below):

1. **Enhanced mobile broadband (eMBB)** – enhanced indoor and outdoor broadband, enterprise collaboration, augmented and virtual reality;
2. **Massive machine-type communications (mMTC**) – IoT, asset tracking, smart agriculture, smart cities, energy monitoring, smart home, remote monitoring; and
3. **Ultra-reliable and low-latency communications (URLLC)** – autonomous vehicles, smart grids, remote patient monitoring and telehealth, industrial automation.[21]

Exhibit 5: Main 5G Use cases



Source: Recommendation ITU-R M.2083-02 (09/2015) IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond

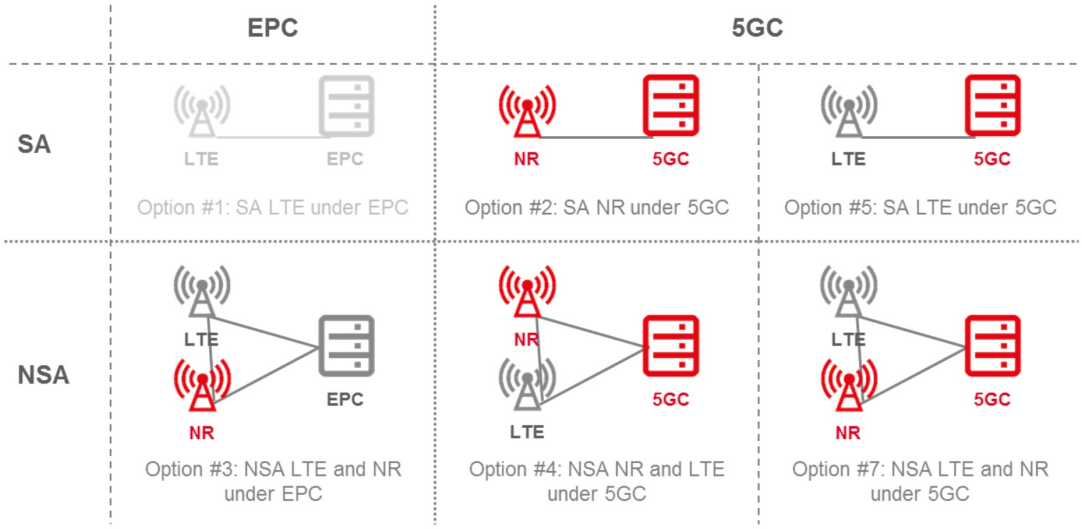
2.6 5G Deployment Scenarios

In terms of 5G deployment scenarios, the 3GPP has defined both a new 5G core network (5GC) as well as a new radio access technology called 5G "New Radio" (5G NR). It is therefore possible to integrate elements of different generations of mobile technology in different configuration with 5G, namely 5G SA (standalone) and 5G NSA (non-standalone).

[21] ITU, *Setting the Scene for 5G Report: Opportunities and Challenges*, 2018

SA scenario uses only one radio access technology (5G NR or the evolved LTE -Long Term Evolution radio cells) and the core networks are operated alone. In contrast, the NSA scenario combines NR radio cells and LTE radio cells using dual-connectivity to provide radio access and the core network which could be either (EPC) or 5GC as shown in Exhibit 6 below.

Exhibit 6: Main 5G deployment scenarios (5G in red)



Source: GSMA, 2018[22]

In practical terms, the 5G deployment cases are their implications for MNO costs are explored in Exhibit 7 below.

Exhibit 7: Case Study: Different 5G deployment strategies and cost implications

With the aim of assessing the implications of 5G deployment on the cost of wholesale services, Network Strategies of New Zealand developed a Bottom-Up Long Run Incremental Cost (BU-LRIC) model of a hypothetical mobile network in a country which is presented here. The model calculates the incremental cost, over the period from 2021 to 2026, which a hypothetical operator would incur by carrying an additional minute of voice call and additional megabyte (MB) of data for two scenarios:

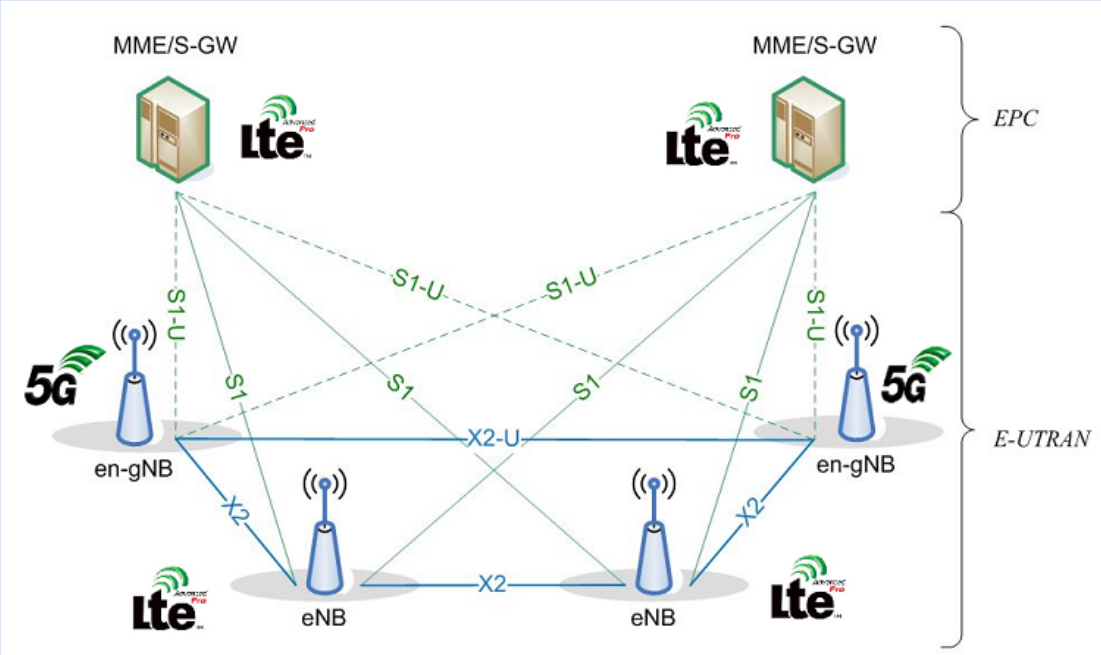
- **4G scenario** – in which the operator deploys a full 4G Radio Access Network (RAN) based on LTE-A technology
- **5G scenario** – a non-stand-alone scenario where 4G RAN is deployed for providing coverage, and 5G RAN for serving additional traffic beyond the 4G RAN coverage capacity.

[22] GSMA, *Road to 5G*, *Introduction and Migration,* June 2018, page 6. Available at www.gsma.com/futurenetworks/wp-content/uploads/2018/04/Road-to-5G-Introduction-and-Migration_FINAL.pdf

Case Study continued:

The model assumes that the hypothetical operator implements a NSA architecture for 5G deployment (see Exhibit 7). The 5G standard allows 5G RAN to operate alongside existing LTE RAN infrastructure and EPC. The NSA architecture is an intermediate step towards a full 5G architecture, and may be chosen by MNOs seeking to leverage existing 4G deployments. It supports LTE services but with the added capabilities offered by the 5G RAN.

Exhibit 7: 5G NSA Architecture



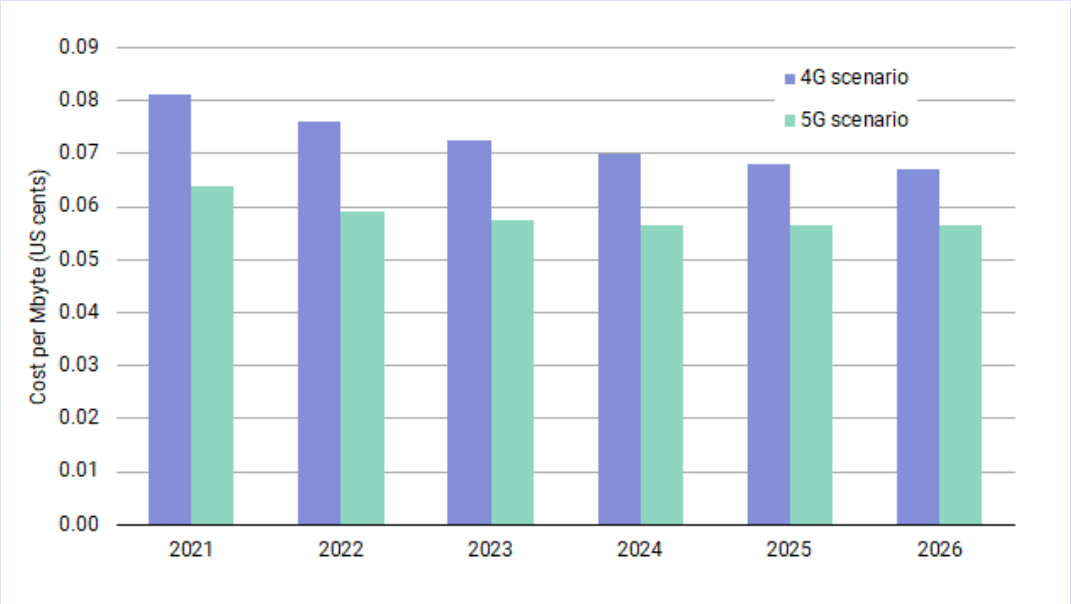
The capacity expansion required to carry the total projected demand and provide service to the coverage area (capacity network) is met by network densification on top of the coverage network, enabled by macro, micro and small cell deployments operating at sub-1GHz and above 1GHz spectrum. In the case of the 4G scenario which was modelled, LTE-A cells operating at 850 MHz and 2600 MHz are deployed. For the 5G NSA scenario, densification is achieved with 5G cells operating at 700MHz and 3.5GHz.

The results from the Network Strategies model indicate that by using 5G technology, operators can achieve considerable reductions in the cost of wholesale voice and data services compared with LTE-A. The Total Service Long Run Incremental Cost (TSLRIC) results for the modelled 5G scenario are 15% to 21% lower than the 4G scenario for data services and 8% to 11% for voice services.

The difference in service cost is mainly driven by the lower level of investment in RAN and backhaul networks required for the 5G scenario. 5G offers a higher spectral efficiency in comparison to LTE-A, therefore given the same amount of spectrum 5G capacity per sector is higher than LTE-A.

As a result, fewer base stations are required when deploying 5G rather than LTE-A for capacity expansion. For the modelled network in the case study, the number of base stations required in the 5G scenario is 15% lower than the 4G scenario for the year 2021, with this difference increasing over time to 17% in 2026 driven by growth in traffic. See Exhibit 8 below.

Exhibit 8: Data service – incremental cost per Mbyte (US cents per Mbyte)



In conclusion, the model results from Network Strategies indicate that 5G improvements in spectral efficiency have a significant impact on the cost of wholesale services when compared to LTE-A, therefore MNOs have an economic incentive to deploy 5G. The NSA option not only allows operators to bring to market some of the features of 5G quickly without the need to invest heavily in a completely new network; it also helps operators to cope with increasing mobile traffic in a more cost efficient way than if using LTE-A.

Source: Network Strategies, May 2020[23]

2.7 Why are 4G and 5G important for Pakistan?

A 2019 UNCTAD Report on the digital economy highlighted the following potential impacts on value creation on embracing the digital economy (see Exhibit 8):

[23] Available at http://strategies.nzl.com/industry-comment/5g-what-will-it-cost/

Exhibit 8: Potential implications of the digital economy for the economy

Table Potential impacts on value creation and capture from an expanding digital economy, by its components and actors

	ACTORS				
DIGITAL ECONOMY COMPONENT	Individuals (as users/ consumers and workers)	MSMEs	Multinational enterprises/ digital platforms	Governments	ECONOMY-WIDE IMPLICATIONS
Core, digital sector	New jobs for building and installing ICT infrastructure. New jobs in telecom and ICT sector, especially ICT services.	Greater inclusion under suitable circumstances or spillovers/domestic linkages. Increased competition from cloud-service providers.	Investment opportunities for companies that meet high capital, technological and skills requirements.	Attracting investment. Tax revenues from the economic activity created.	Increased growth, productivity and value added. Employment creation. Investment and diffusion of technologies; R&D likely located in high-income countries. Mixed trade impacts.
Digital economy	New jobs in digital services, especially for highly skilled people. New forms of digital work, including for the less skilled.	New opportunities in digital ecosystems. Increased competition from foreign digital firms.	Enhanced productivity from data-driven business models. Greater control of value chains using platform-based business models. New opportunities in the sharing economy.	More tax revenue resulting from increased economic activity and formalization of enterprises. Lost customs revenue from digitalization of products.	Higher growth, productivity and value added. Employment creation/ losses. Higher investment. Aggregation of digital firms in some locations. Mixed trade impacts. Market concentration.
Digitalized economy	New jobs in ICT occupations across industries. Need for new skills as higher-value roles are redesigned using digital tools. Greater efficiency of services received. Job losses or transformation due to digitalization. Risk of worsened working conditions. Improved connectivity. More choice, convenience, customization of products for users and consumers. Lower consumer prices.	Platform-enabled market access. Reduced transaction costs. Risk of "race to the bottom" in markets vs. ability to find a niche. Lost opportunities due to automation (e.g. logistics, business processes). New roles in service provision. New business opportunities for digitalized enterprises.	Emergence of platform firms with data-driven models. Gains from efficiency, productivity and quality. Opportunities for the monetization of data. Increased competitive advantage of digital platforms Increased market power and control of data value chain. Leading digitalization in different sectors.	Increased efficiency of services through e-government. Increased revenue from customs automation. Unclear impact on tax revenue: increases from higher economic activity; losses from tax optimization practices by digital platforms and MNEs. Data-driven opportunities to meet various SDGs.	Growth through improved efficiency in sectors and value chains. Productivity improvements. Innovation impacts. Potential crowding out of local firms in digitally disrupted sectors Potential automation in low and medium-skill jobs. Wider inequality. Mixed trade impacts. Impacts on structural change.

Source: UN, *Digital Economy Report 2019, Value Creation and Capture for Developing countries*. Available at https://unctad.org/en/PublicationsLibrary/der2019_overview_en.pdf

In addition, there are economic benefits of additional 4G and 5G deployment specific Pakistani context. For instance, the economic condition in Pakistan listed below impact on the potential benefits arising from 4G and accelerated 5G deployment:

- Large population and good potential for further economic growth
- Attracting direct foreign investment
- Currently congested mobile communications
- Regional peer countries rolling out high visibility 4G/5G deployments
- Dynamic urban centres driving economic development
- Under-developed fixed line infrastructure and significant barriers to rapid deployment of fixed line infrastructure
- Telecommunications services are inferior to regional economic competitors
- 4G/5G suitable Spectrum can be accessed relatively easily in Pakistan

In summary, the Pakistan economy exhibits multiple characteristics that strongly suggest that 4G/ 5G deployment will generate significant economic benefits. Almost all indications are that the country in particular is very well positioned to benefit from high speed broadband services like 5G, and that this would have an impact on the economy that is likely to be even more positive than similar deployments in peer nations.

The ITU has recently indicated that the acceleration of 4G — and in the future 5G deployment and the transition from legacy 2G/3G networks — is a key way to accelerate the transition to the new normal after COVID-19 (see Exhibit 9 below).[24]

Exhibit 9: Selected Key COVID-19 recovery recommendations

Accelerate the assignment of available globally harmonized IMT spectrum
COVID-19 has meant that many people are more homebound than ever before, and this created new demands to allocated IMT spectrum to support higher bandwidth speeds, capacity, and improved Quality of Service (QoS) and Quality of Experience (QoE)

Accelerate 4G/5G deployment and the transition from legacy 2G/3G networks
To further support online demand created through the pandemic, there is a need to reform existing 2G/3G spectrum to 4G and 5G services. Such transitions should receive Governmental and regulatory support as it will provide significant additional wireless broadband speed and capacity.

Deployment of FWA and complimentary and substitute broadband networks
This measure was recommended in the COVID 1.0 paper to augment coverage and capacity over cities and urban areas subject to social distancing requirements. FWA services are particularly important in emerging markets due to its quick delivery and affordability.

Facilitate innovative and future technologies to bridge the 'digital divide'
The 'digital divide' has been highlighted during the pandemic because of the essential nature of fixed and mobile broadband service coverage. The resurgence of the pandemic in many parts of the world led to school shut downs and students learning from home, which further spotlighted the need to bridge the divide.

Source: Summary of ITU, GSR-20 Discussion Paper, Pandemic in the Internet Age: communications industry responses, June 2020

[24] See ITU GSR-20 Discussion Paper, *Pandemic in the Internet Age: communications industry responses,* June 2020. https://reg4covid.itu.int/wp-content/uploads/2020/06/ITU_COVID-19_and_Telecom-ICT.pdf. See also Zong, *5G Readienss and Support Required From Government,* 22 June 2021.

Key points

- Worldwide, many governments are working to deploy 5G and harness its benefits. 5G has been envisaged to provide a super-efficient universal mobile network, super-fast mobile network with densely clustered small cells for data rates >1 Gbps and converged wireless fibre network using mmWave band to allow data rates up to 10 Gbps.
- The 5G network has a variety of use cases, but the ITU-R has defined three categories of particular importance: enhanced mobile broadband (eMBB), Massive machine-type communications (mMTC) and ultra-reliable and low-latency communications (URLLC).
- Pakistan is at a key moment in its 5G planning: the Digital Pakistan Policy demonstrates a clear appetite for improving Pakistan's ICT sector and to generate opportunities for Pakistan through the digital economy, while the creation of the 5G Pakistan Plan Committee has created a roadmap for the creation of a 5G network.
- Indicators point to the conclusion that Pakistan would derive significant economic benefits from the deployment of a 5G network. It could be used develop new jobs, attract investment, generate tax revenue and increase growth, productivity and value. It is also more cost efficient than a 4G network according to a study by Network Strategies of New Zealand for wholesale services for voice calls and data.
- The ITU has recently indicated that the acceleration of 4G — and in the future 5G deployment and the transition from legacy 2G/3G networks — is a key way to accelerate the transition to the new normal after COVID-19.

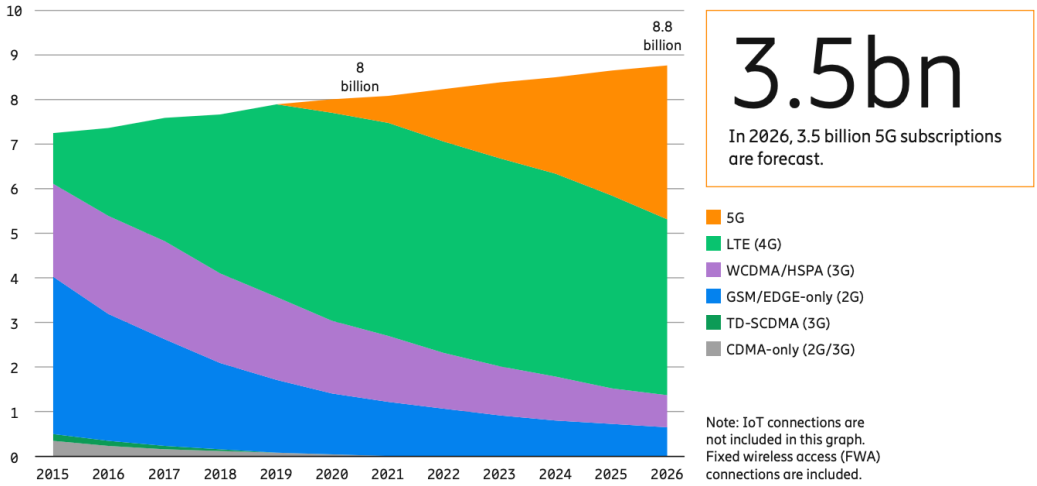
3 Global and Regional Developments in 5G

3.1 Global Forecasts and Deployments

The 2021 Ericsson Mobility Report projects that by the end of 2026, 5G will attract 3.5 billion subscriptions, generating 45% of the world's total mobile traffic data (Exhibit 10).[25] In contrast, by 2025, the GSMA expects 5G connections to reach 1.2 billion, and 5G networks are expected to cover one-third of the world's population.[26]

Exhibit 10: Mobile subscriptions by technology (billion)

Figure 1: Mobile subscriptions by technology (billion)



Source: Ericsson Mobility Report, June 2021

Globally, 5G is rapidly advancing especially in Asia, Europe and North America. The GSA reported that as of July 2021, 438 operators in 133 countries are investing in 5G. Following multiple announcements of 5G launches in 2020, 174 operators have now launched 3GPP compliant commercial 5G services in 71 countries.[27] The 174 operators from 71 countries in all continents (see Exhibit 11 over) include:

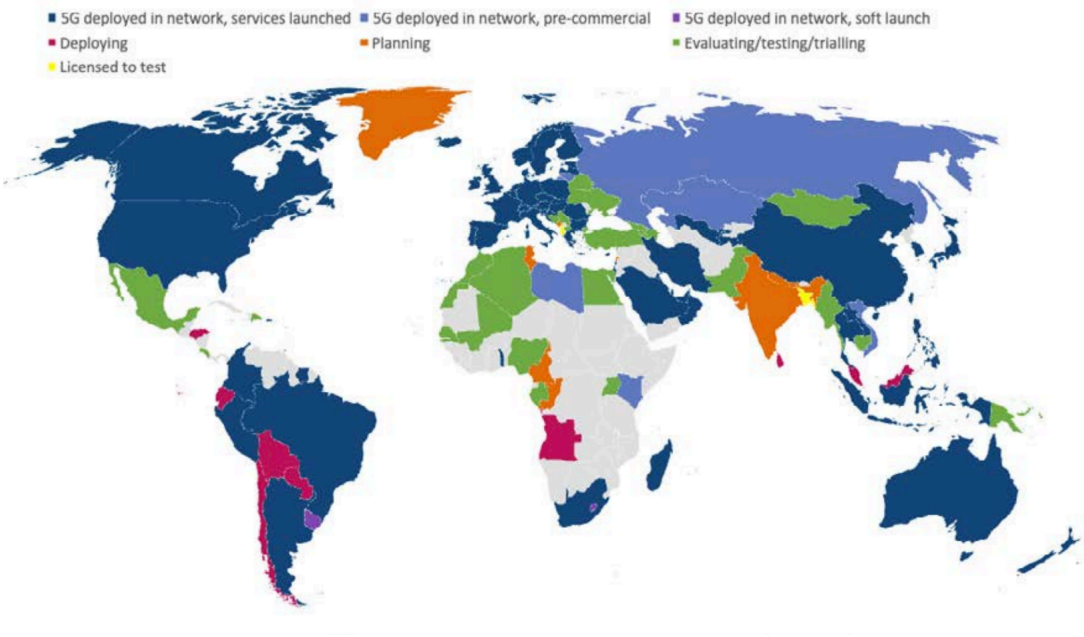
- Americas: Canada (Rogers Communications), Puerto Rico (T-Mobile), Uruguay (Antel), USA (AT&T Mobility, Sprint, T-Mobile US, Verizon Wireless);
- Asia-Pacific: Australia (Optus, Telstra, Vodafone), China (China Mobile, China Telecom, China Unicom), Hong Kong (China Mobile Hong Kong, Hutchison, HKT, SmarTone), Indonesia (Telkomsel), Japan, (KDDI, NTTDocomo, Softbank, Rakuten), Maldives (Dhiraagu), New Zealand (Spark, Vodafone), Philippines (Globe, Smart), Singapore (Singtel, Starhub, M1), South Korea (SK Telecom, KT Corp, & LG Uplus), Taiwan (APT, Chunghwa Telecom, Far EasTone, Taiwan Mobile, Taiwan Star) and Thailand (AIS, dtac, TrueMove);

[25] https://wcm.ericsson.net/4acd7e/assets/local/mobility-report/documents/2019/emr-november-2019.pdf
[26] www.gsma.com/futurenetworks/ip_services/understanding-5g/5g-innovation/
[27] GSA, *Networks, Technologies & Spectrum Snapshot*, July 2021. Available at https://gsacom.com/technology/5g/.

- Europe: Austria (3 Austria, Hutchison, T-Mobile), Bulgaria (Vivacom), Croatia (HT), Czech Republic (Vodafone), Denmark (TDC), Estonia (Elisa), Finland (Elisa, TeliaSonera), Germany (T-Mobile, Vodafone, Telefonica), Ireland (Eir, Vodafone, Three), Italy (TIM, Vodafone), Latvia (Tele2), Netherlands (VodafoneZiggo, T-Mobile) Norway (Telenor), Poland (T-Mobile), Romania (RCS & RDS [Digi Mobil], Vodafone), Slovenia (Telekom Slovenije), Spain (Vodafone, Telefonica, Orang, MASMOVIL), Sweden (Hutchison, Telenor, Telia, Tele2), Switzerland (Sunrise Communications, Swisscom), UK (3 UK, EE, O2, Hutchison, Vodafone);
- Middle East: Bahrain (Batelco, Viva), Kuwait, (Ooredoo, Viva, Zain), Monaco (Monaco Telecom), Oman (Omantel), Qatar (Ooredoo, Vodafone), Saudi Arabia (STC, Zain), United Arab Emirates (Du, Etisalat); and
- Africa: Lesotho (Vodacom), Seychelles (Cable & Wireless), South Africa (MTN, Rain, Vodacom).

Additionally, 63 operators had launched 3GPP-compliant 5G FWA or home broadband services as at June 2021.[28]

Exhibit 11: Operator investment 5G status, July 2021



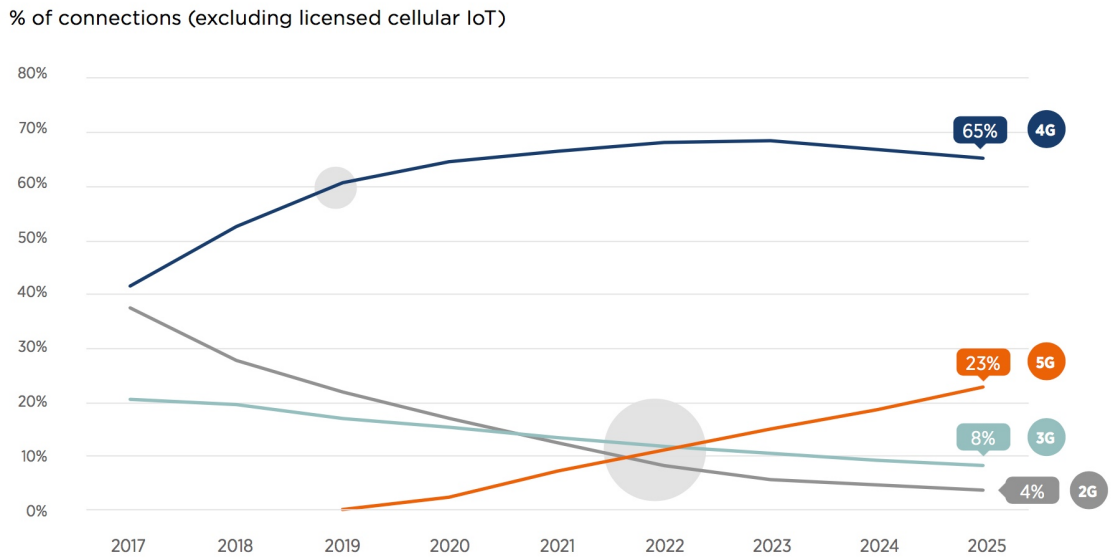
Source: GSA, July 2021

3.2 Regional Forecasts and Deployments

In Asia Pacific it should be noted that 4G surpassed 60 percent of total connections in the region in 2019; while 5G will overtake both 2G and 3G in 2022 as shown in Exhibit 12 below.

[28] GSA, *Fixed Wireless Services: Industry report to determine the extent of FWA services*, June 2021, page 3

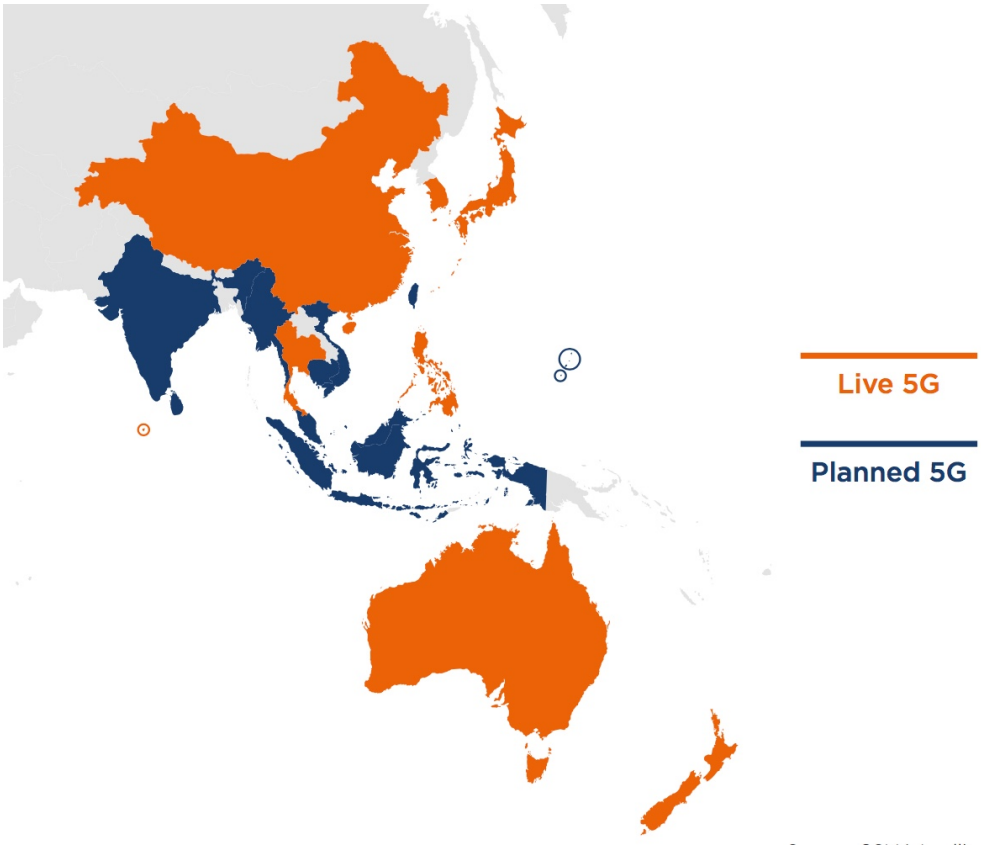
Exhibit 12: GSMA Asia-Pacific Forecast Connection by technology



Source: GSMA, the Mobile Economy Asia Pacific, 2020, page 12

Twelve markets in Asia Pacific have launched commercial mobile 5G services; 10 plus have officially announced plans to launch as shown in Exhibit 13 below.

Exhibit 13: GSMA Asia-Pacific Live and Planned 5G



Source: GSMA, the Mobile Economy Asia Pacific, 2020, page 13

3.3 South Asia and Middle East 5G Developments and Trials

There are ongoing activities in South Asian and Middle Eastern countries looking into the release of the 3.5 GHz and other frequency bands to support 5G rollout. The situation is summarized in Exhibit 14 below.

Exhibit 14: Selected South Asian and Middle Eastern 5G updates

Country	Summary of its current 5G initiatives focusing on C-Band/3.5 GHz band
Bangladesh	Bangladesh regulators, BTRC, aim to cover Bangladesh with 5G technology commencing in 2021 and provide national 5G coverage by 2026. The new 5G licensing guidelines were released in draft in February 2021. Currently, operators have trialed 5G. The BTRC are expected to invite proposals for assignment of spectrum later in 2021. The 2.6 GHz and 3.5 GHz spectrum auction are scheduled to be in later in 2021.
India	In March 2018, the government launched a three-year program, Building an End-to-End 5G Test Bed, to advance innovation and research into 5G. Indian Government initiatives, such as Make in India, Smart Cities and Aatmanirbhar Bharat ('self-reliant India'), are designed to further laying the groundwork to develop mmWave-enabled 5G applications. India's 5G spectrum auction has however been postponed and is expected in 2021 due to the COVID-19 pandemic. Jio, Airtel and Vi have asked the Indian government to lower the base price for the spectrum. Trials are expected at a similar timeline and Jio has sought spectrum frequencies of 100 MHz in the 3.5 GHz band for running field trials in urban centres like Delhi and Mumbai. It is expected that the assignment of 5G mmWave spectrum – with the 26, 28 and 40 GHz bands as priorities and, later, 50 and 66–71 GHz bands – will provide the increased bandwidth and capacity required by 5G use cases in India.
Qatar	The 5G rollout launched in Qatar in 2018. Qatar awarded 5G frequencies in the 3.5-3.8 GHz band to Ooredoo and Vodafone Qatar in early 2019. Under the licenses, each company have rolled out 5G networks before the end of 2020. Ooredoo have announced its 5G mobile network coverage has reached more than 90% of the country's populated areas at 2.25Gbps' 5G data speeds.
Saudi Arabia	The CITC launched a 5G mobile network in 2019, making Saudi Arabia one of the first countries in the world to introduce the technology. The government have awarded spectrum with auctions of the 2.3 GHz, 2.6 GHz and 3.5 GHz bands completed in early 2019. As of 2020, the CITC has reported 5G has reached more than 30 cities and MNOs have access to more than 1000 MHz of licensed spectrum. Saudi Arabi delivered an average 5G download speed of 377.2 Mbps. As more than 10 GHz of frequency bands have been identified and allocated for commercial use by technologies like IMT-2020 and World Radiocommunications Conference (WRC-19) the CITC is working on releasing further spectrum for mobile broadband services.
Sri Lanka	In October 2018, Mobitel demonstrated 5G technology in the 3.5 GHz band. In addition, the regulator TRCSL have allowed Dialog Axiata to use 3.5GHz spectrum for pilot trials of pre-commercial 5G services in 2020. Such efforts are expected to pave the way for innovation in Sri Lanka for new 5G related products and services.
United Arab Emirates	5G services are currently available in the UAE. Both incumbent operators, Etisalat and Du, are both deploying 5G on the 3.5 GHz frequency band. In 2018, the regulator TRA issued 100MHz to each of the two incumbent operators in the 3.3 to 3.8 GHz frequency range. In February 2019, Etisalat awarded contracts to both Huawei and Ericsson for the rollout of its 5G mobile network. In 2020, there has been a shift in focus towards 5G as highlighted in the UAE announcing allocation of a new frequency band which will allow UAE telecom operators to further expand the application of 5G. Further, Etisalat said it will focus on rolling out its 5G NSA network for the next 2 years.

Source: WPC analysis for industry and press reports, March 2021

Key points

- 5G is rapidly advancing especially in Asia, Europe and North America. 438 Operators in 133 countries are investing in 5G as of July 2021 according to the GSA. Additionally, 63 operators had launched 3GPP-compliant 5G FWA or home broadband services as at June 2021. By the end of 2021 5G is expected to generate 45 percent of the world's total mobile traffic data
- Many South Asian and Middle Eastern countries have begun 5G testing, and some have even rolled out their 5G network. Popular 5G spectrum bands include 3.5 GHz , and 2.6 GHz.

4 Market Assessment and Readiness

4.1 Overview

The number of mobile subscribers in Pakistan was 169 million as of August 2020, representing a teledensity of 79.65 percent. At the same time, broadband penetration in Pakistan is 40.95 percent, which equates to 87 million people. The telecoms sector generated over PKR553.75 billion in revenue in the 2018-19 period, which was an increase from PKR488.8 billion in the 2017-18 period.

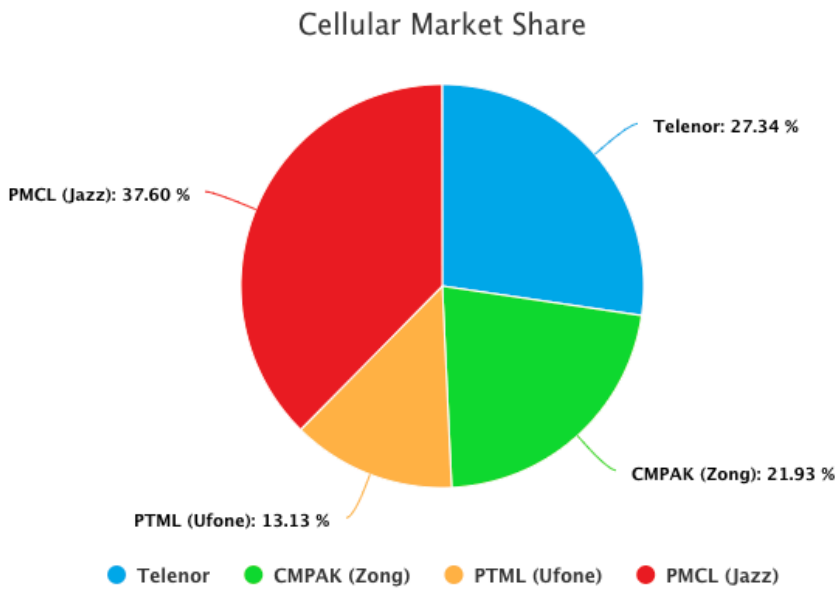
However, telecommunications sector contribution to the national exchequer dropped in the 2018-19 period, from PKR148.1 billion to PKR102.4 billion. Total investment in the sector also decreased over that period, from USD792.6 million to USD635.2 million. Of that total investment, Foreign Direct Investment (FDI) also dropped from USD288.5 million to USD235.5 million.[29] Therefore, although subscriber numbers continue to grow in Pakistan, total investment has been decreasing, due to a slump in the economy which has since been exacerbated by COVID-19.[30]

Market Share

Jazz mobile continues to lead the market, holding 37.6 percent of the cellular market shares as of August 2020 (refer to Exhibit 15).[31] Ufone, who holds the smallest market share out of the four operators, is under pressure to merge in the future with either another provider or with its majority shareholder, Pakistan Telecommunication Company Limited (PTCL).[32] Ufone only converted spectrum to 4G services in 2019 which impacted its ability to compete with the other three providers, along with rising operational costs and falling sales figures.[33]

[29] PTA, *Telecom Indicators,* August 2020.
[30] Reuters, *Exclusive: Pakistan to Auction Extra Telecom Spectrum; Seeks $1 Billion,* 30 September 2020.
[31] *Ibid*.
[32] Comms Update, *Ufone Preparing for Potential Merger,* 18 September 2020.
[33] The Express Tribune, *Merger on the Cards in Telecom Sector,* 18 September 2020.

Exhibit 15: Cellular Market Share in Pakistan



Source: PTA, Telecom Indicators: Market Share, August 2020

4.2 Current IMT Spectrum Allocations in Pakistan

Pakistan's MNO spectrum holdings as at December 2020, are detailed in Exhibit 16 below. This is prior to the IMT spectrum auction of 1800 and 2100 MHz spectrum scheduled for September 2021. Firstly, it must be highlighted that comparison will show that almost all countries – other than micro states - have significantly larger total IMT allocations greater than Pakistan as shown in Exhibit 17 below. On a per capita basis the amount of IMT spectrum would be one of the lowest if not the lowest globally.

Exhibit 16: Pakistan MNO spectrum holdings December 2020

Operator	850 MHz	900 MHz	1800 MHz	2100 MHz	TOTAL
Telenor Pakistan	20	9.6	17.6	10	**57.2**
Zong	-	15.2	32	20	**67.2**
Jazz	-	24.8	49.6	20	**94.4**
Ufone	-	15.2	12	10	**37.2**
Vacant	0	0	38.8	60	**98.8**
Guard Band	-	5.2	-	-	**-**
TOTAL	**20**	**70**	**150**	**120**	**354.8 (256 MHz licensed) (279.2 in use)**

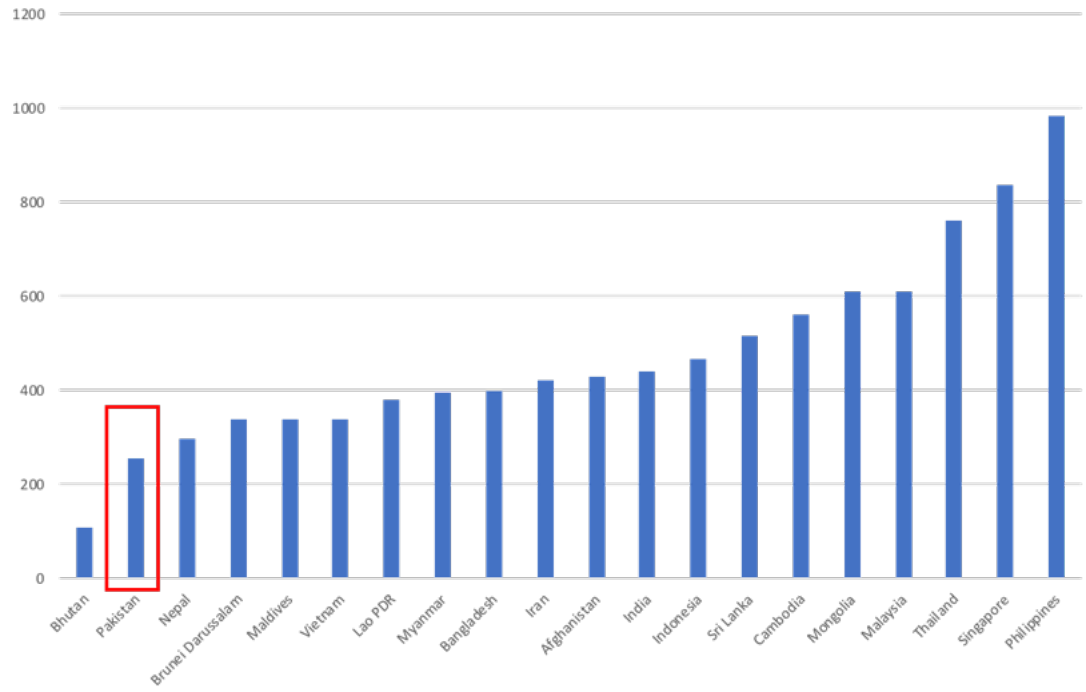
Source: PTA February 2021

All successful MNOs need a spectrum portfolio. Globally, previously 100-150 MHz in total IMT spectrum may have been enough for a successful MNO. It will not be in the future. All Pakistan MNOs are sub-scale in terms of IMT spectrum allocations which has adverse implications from an efficiency and QoS perspective (see Exhibit 12 over). It also undermines their ability to support the participation of the country in the global digital economy.

Potentially MNOs will need more than 1,000 MHz of spectrum (including 3.5 GHz and mmWave spectrum) and prices cannot increase by that same factor (in essence they need to stay the same in overall terms in order to keep up necessary investment and earn a return on capital).

Australia, China, Japan, Nepal, New Zealand, Singapore, South Korea, Sri Lanka, Taiwan, Thailand and Saudi Arabia have released significant quantum of IMT spectrum since 2018/19.[34] Notably Thailand (700, 2.6 GHz and mmWave) and Singapore (3.5 GHz and mmWave) released spectrum in 2020. Australia, South Korea, Japan, Singapore, Taiwan, and Thailand in Asia have released mmWave spectrum.

Exhibit 17: IMT Spectrum Holdings, selected Asian markets, August 2020



Source: WPC August 2020 update of LSTelcom, April 2019 including an update on Pakistan. Does not include any mmWave holdings (eg Singapore and Thailand). Available ITU-ADB Webinar, 23 September 2020[35]

A number of countries including Bangladesh (2.6 and 3.5 GHz), Vietnam (an additional 370 MHz of spectrum comprising 700 MHz, 2.3 and 2.6 GHz), Nepal (700 MHz and 2.6 GHz), India, Indonesia (700 MHz (2 years) and 2.6 GHz latest by 2024) , Myanmar (700 MHz, 2.6 and 3.5 GHz), and Malaysia (700 MHz and 3.5 GHz) have plans to release more spectrum in the near term. Importantly the 2018 information contained in *Mobile Spectrum Allocation Benchmark* on pages 13/14 of the *Rolling Spectrum Strategy 2020-2023* is now out of date, given significant spectrum releases since 2018 as detailed in Exhibit 18 over.

[34] Australia successfully auctioned 2.4 GHz of mmWave spectrum in the 26 GHz band in April 2021. Refer to www.acma.gov.au/auction-summary-26-ghz-band-2021

[35] From www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Documents/Events/2020/ITU_ADB%20ICTconnectivity%20gap/ITU_WPC_DigitalTransformation_COVID-19_APAC_23Sep2020fnl.pdf

Exhibit 18: Updated *Mobile Spectrum Allocation Benchmark*

Country	2018 Total IMT Spectrum Allocated	2020Total IMT Spectrum Allocated	Additional Spectrum Allocation / Auction Planned
Pakistan	**256 MHz**	**269.2 MHz**	• To be determined but plans for the release of vacant 1800 MHz spectrum (**2 x 12.8 MHz or 25.6 MHz**) and 2100 MHz spectrum (**2 x 30 MHz or 60 MHz.**)
Indonesia	472 MHz	**467 MHz**	• The Indonesian Parliament passed a law in October 2020, providing for the analogue to digital TV transition to occur in 2 years. This will release **2 x 45 MHz (70 MHz) in the 700 MHz band**. • Indonesian regulator, SDPPI is negotiating with the current satellite spectrum holder in the 2.6 GHz band to handback the spectrum earlier than 2024. This would **free up an additional 190 MHz of spectrum**. • SDPPI in negotiating with satellite operators to free 3.5 GHz spectrum
Bangladesh	258.8 MHz	**398.8 MHz**	• By end of 2020, the BTRC is scheduled to have refarmed the 3.5 GHz band so that an **additional 370 MHz spectrum will be available**. • **There remains 65 MHz and 85 MHz of 2.3 and 2.6 GHz spectrum vacant respectively (150 MHz)**
Saudi Arabia	425.2 MHz	**1,100 MHz**	• Between 2017 and 2019 the KSA 4 ran spectrum auctions • Releasing 850 MHz of spectrum for IMT use. **They released spectrum in the 700, 800, 1800, 2300, 2600, and 3500 MHz bands** • **2.3 and 2.6 GHz bands allocated to 4G/5G and 3.4 to 3.8 GHz is entirely allocated to 5G services**.
Thailand	420 MHz	**800 MHz plus another 2,600 MHz (mmWave) Total 3,400 MHz**	• NBTC had auctions in 700 MHz in 2019 (60 MHz) and in 700 and 2600 MHz and 26 GHz in February 2020 **(230 MHz in 700 and 2600 MHz spectrum and 2600 MHz in 26 GHz mmWave band).** • NBTC is working on refarming 300 MHz in 3.5 GHz spectrum by 2022.

NB. Bangladesh's IMT allocation total Includes 35 MHz in the 2.3 GHz band allocated to BWA (Augere) and 105 MHz in the 2.6 GHz band allocated to Government, ISPs, Metro Rail and BWA services

By way of further comparison, Australia's major three MNOs have almost more IMT spectrum than the entire total of IMT spectrum allocations in Pakistan without including the 3.6 GHz and mmWave band which has now be successfully auctioned in Australia (see Exhibit 19). The same is the case in other developed markets like Singapore, USA, Germany, United Kingdom etc. It should be highlighted that Pakistan has the same amount of IMT spectrum as other world markets, but it has not been allocated in an efficient and timely manner. The key role of the PTA should be concerned with making more IMT spectrum available to be utilised by the economy and society.

Exhibit 19: IMT Spectrum Holdings of Australia's major MNOs

Spectrum band (total spectrum available)	MAJOR CITIES (Sydney, Melbourne, Adelaide, Perth, Brisbane)			REGIONAL (including Canberra, Darwin and Hobart)			
	Telstra	Optus	VHA/TPG	Telstra	Optus	VHA/TPG	NBN Co
Minimum (MHz)	264.8	309.8	236.4	374.3	291.8	126.4	93
Maximum (MHz)	329.3	354.8	256.4	517.3	367.3	231.4	198

Source: ACCC, February 2020. Note in Australia all IMT spectrum over 1 GHz is assigned regionally. As such MNO spectrum holdings vary across the country - the minimum and maximum figures refers to their IMT spectrum holdings on a regional basis.

All IMT bands will become 4G and 5G bands over time as it is likely that legacy 2G and 3G networks will be switched off. Best practice is for IMT spectrum to be allocated on a technology neutral basis. In this context, it is recommended that the PTA should be maximising the IMT spectrum it makes available to industry stakeholders for 4G/5G services.

To optimally supply 5G services there is a need to allocate spectrum which is best suited for coverage (eg n28, n71), capacity (eg n41, n77/78) and high-capacity services (eg n258, n261). It is worth highlighting a key recommendation from the ITU White Paper, entitled *Digital Infrastructure Policy and Regulation in the Asia-Pacific Region, September 2019,* which in Recommendation 6 *Releasing More IMT Spectrum for Wireless Broadband and 5G Deployment* states:

> *"Subject to demand, to ensure that there is more IMT Spectrum for wireless broadband and 5G deployment in Asia-Pacific markets availability should be increased to at least 840 MHz of total IMT spectrum plus allocations of mmWave spectrum by the end of 2021 (except smaller markets). Such allocations should be in larger contiguous blocks consistent with future best practice. Knowing that there will be sufficient spectrum in the future to support 3G, 4G and 5G Service offerings, MNOs can confidently make the necessary long-term investments in digital infrastructure. Such spectrum should be allocated on a technology neutral basis and MNOs should also have the flexibility to use their allocated IMT spectrum for mobile broadband and/or FWA services."*[36]

Therefore is strongly recommended that Pakistan should have a goal to have 840 MHz of IMT spectrum allocated in low and mid-bands by end of 2022/early 2023. **This is consistent with ITU Guidelines for total IMT spectrum assignments.** This is a substantial increase from the 279.2 MHz in total IMT spectrum allocated currently in Pakistan.

36 Available at www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/Events/2019/RRITP2019/ASP/ITU_2019_Digital_Infrastructure_5Sep2019FNL.pdf pages 6 and 30. See also ITU, *Guidelines for the preparation of national wireless broadband masterplans for the Asia Pacific region,* October 2012. Available at www.itu.int/pub/D-PREF-THEM.05-2013

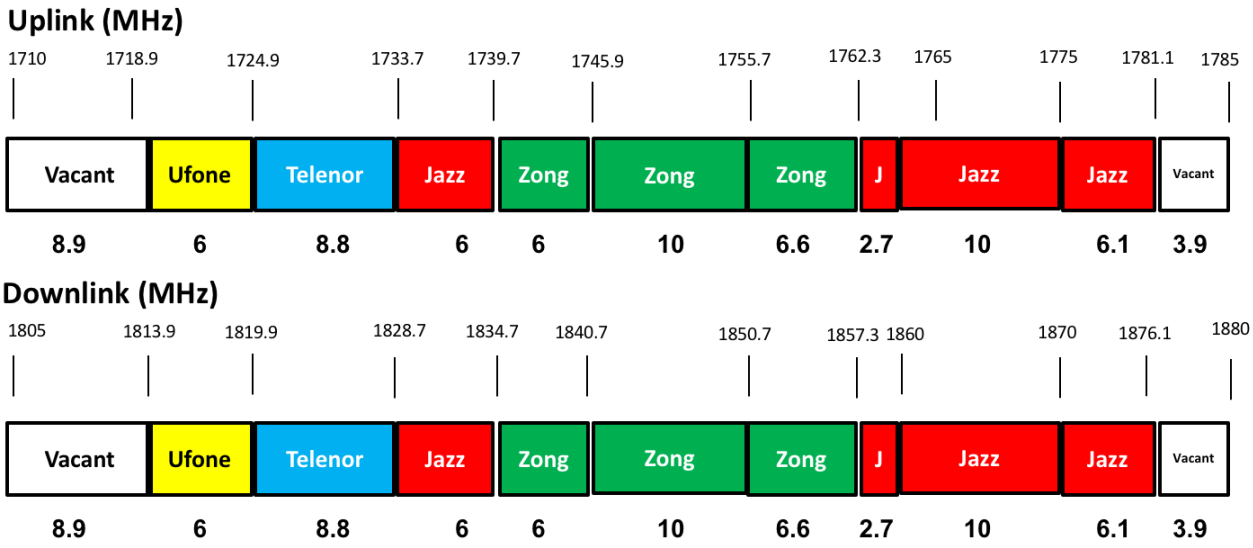
4.3 Refarming current IMT spectrum assignments in Pakistan

An assessment of the existing IMT allocations in Pakistan finds that the 900[37] and 1800 MHz and the 3.5 GHz bands all are sub-optimally allocated with either legacy 2G or non-standard allocations (not in 5 MHz blocks or larger 3GPP supported spectrum blocks).

4.3.1 Need to refarm the 1800 MHz band

As shown in Exhibit 20 below, Pakistan's current 1800 MHz spectrum band allocations are fragmented, non-contiguous and in non-standard formats reflecting the legacy 2G use of the band. Prior to, or concurrently with the proposed auction processes, it would be optimal to refarm the band to create larger contiguous bands consistent with 5G NR and to promote competition and investment.

Exhibit 20: Pakistan's current 1800 MHz spectrum band allocations



Source: PTA. Note the Zong 2 x 6.6. MHz were temporary assignments, which have expired. Zong is currently utilizing the same by virtue of litigation in the court of law.

There is currently 2 x 19.4 MHz vacant (the inclusion of the 2 x 6.6 MHz is subject to conclusion of the legal process) , with Ufone holding 2 x 6 MHz, Telenor 2 x 8.8 MHz, Zong 2x 16 MHz and Jazz 2 x 24.8 MHz (in 2 non-contiguous lots of 2 x 6 MHz and 2 x 18.8 MHz). Because new spectrum licences will be issued for a substantial duration of time, it is important that 1800 MHz spectrum allocations are 'future-proofed' such that they:

- Are to the extent possible made in 2 x 5 MHz blocks so that spectrum use of a key IMT band is maximized and is consistent for use with 4G and 5G services;

[37] The 900 MHz band (n8) is also a 5G coverage should optimally be refarmed so that allocations are preferably 2 x 5 MHz except in relation to the block adjacent to the guard band and the two Jazz allocations should be made contiguous.

- Support 5G NR spectrum allocations which support larger contiguous blocks of spectrum in 5 MHz increments from 2 x 5 MHz up to 2 x 40 MHz as detailed in NR Frequency bands for FR1 38.104 (Rel 17 Jun 2021);[38]
- Encourage the availability of affordable devices. It should be noted that 1800 MHz band (n3) is the most supported global band for 4G/LTE devices with 13,579 supported devices[39] and the fifth most supported 5G band in terms of the 5G devices;[40] and
- Support sector investment and enhance competition by allowing smaller MNOs in the Pakistan market to have sufficiently large allocations (eg 2 x 10 MHz) to offer 4G and 5G services into the future utilising this spectrum band now and when legacy 2G services are switched off.

As a consequence, it is important that both the spectrum roadmap and spectrum auction rules for the band permit e.g. (i) Ufone to acquire at least 2 x 4 MHz or (ii) Telenor Pakistan to acquire at least 2 x 1.2 MHz of contiguous spectrum in order to have an economically viable (and spectrally efficient) block of spectrum to support 4G and 5G services. The approach by Indonesia and Malaysia to refarm their respective 1800 MHz bands in order to create contiguous spectrum consistent with 5G NR spectrum management approaches and to support sector competition provides a good precedent for Pakistan.

Subject to the advice of the newly appointed spectrum consultant, depending on MNO demand and the release of further IMT spectrum in *inter alia* the 2.6 and 3.5 GHz bands in Pakistan, the PTA should consider whether each existing MNO with allocations in the 1800 MHz should be permitted to acquire additional spectrum in order to create 5G NR usable blocks (by rounding up to the nearest blocks) during the auction process. Adopting such an approach would result in Ufone being able to acquire 2 x 4 MHz, Telenor Pakistan 2 x 1.2 MHz, Zong 2 x 2.4 MHz and Jazz 2 x 0.2 MHz of 1800 MHz spectrum respectively. One vacant block of 2 x 5 MHz of spectrum could then be auctioned by the PTA. Further blocks of spectrum could be auctioned if MNOs were not interested in acquiring additional spectrum or a spectrum cap was set. All final spectrum allocations should result in contiguous spectrum allocations.

The scheduled 1800/2100 MHz spectrum auction process if it is consistent with the Government's Policy Directions for this spectrum auction (refer to Exhibit 21). This approach is similar to the approach adopted by the BTRC in Bangladesh of offering spectrum lots in the 1800 MHz band which permit the MNOs to create 4G/5G NR compatible spectrum assignments followed by a requirement of restacking the band so that the 1800 MHz allocations of the MNOs are contiguous.[41]

[38] Refer to www.sqimway.com/nr_band.php
[39] Refer to GSA, *LTE Ecosystem Report: Status Update*, 30 June 2021, page 3
[40] GSA Snapshot H1 2021, Review: 5G Networks, Spectrum and Devices, 24 June 2021
[41] See www.btrc.gov.bd/sites/default/files/notice_files/Instructions%20for%20Radio%20Frequency%20Auction%20from%201800%20MHz%20%26%202100%20MHz%20Spectrum%20Band.pdf

Exhibit 21: Case study for Pakistan's upcoming 1800 MHz and 2100 MHz auction

PTA issued an Information Memorandum in early August 2021 specifying the detailed procedure of the auction of 1800 and 2100 MHz spectrum, including eligibility criteria and steps for participating in the auction process. The spectrum will be awarded by means of a two-stage process.

- ***Stage One*** of the Spectrum Auction requires applicants to submit an application form, sealed-bid form and pre-bid deposit.
- ***Stage Two*** of the Spectrum Auction is an Electronic Auction Stage involving a Clock Auction for the 1800 MHz spectrum and a SMRA for the 2100 MHz spectrum.

The Spectrum Auction shall be conducted by PTA in minimum possible time after issuance of the Policy Directive by the Government (currently forecast to be in September 2021).[42]

Overview of the Spectrum Auction

The successful bidder will be awarded a new licence for the auctioned spectrum for a duration of fifteen years (which may be renewable on terms and conditions under Government policy applicable at the time of renewal). Existing MNOs and new entrants are eligible to participate in the auction subject to a spectrum cap of 40 percent in relation to the 1800 MHz band. Spectrum will be assigned as specific Spectrum Blocks, structured on the following basis:

- 1800 MHz = 2 x 12.8 MHz
- 2100 MHz = 2 x 15 MHz

The base price for 2 x 1 MHz spectrum in 1800 MHz is USD31 million while the base price for 2 x 1 MHz spectrum in 2100 MHz is USD29 million respectively. The base price, lot numbers and lot sizes for each Spectrum Block are detailed in the Figure below.

Figure. Base price and size of spectrum lots to be auctioned

Spectrum band	Number of Lots	Lot size	Base Price per lot
1800 MHz – Blocks in Product 1	39	2 x 0.2 MHz	USD6.2 million
1800 MHz – Blocks in Product 2	1	2 x 5.0 MHz	USD155 million
2100 MHz Blocks	3	2x5.0 MHz	USD145 million

Source: Information Memorandum, Spectrum Auction for NGMS in Pakistan, August 2021

Policy directive for the Spectrum Auction

The Federal Government of Pakistan in exercise of its powers conferred under section 8(2) of the Pakistan *Telecommunication Act 1996 (Amended 2006)* issued a policy directive for auctioning the available radio frequency spectrum in 1800 MHz and 2100 MHz bands. Policy directives assert that the spectrum assignment shall be 'Technology Neutral' and usable for all existing and upcoming advanced generations/technologies, within the applicable policy framework of the Government of Pakistan. On top of this, to ensure optimal utilization of radio frequency spectrum, PTA is required to endeavour to provide each MNO with the opportunity to acquire such additional spectrum that will enable it to hold, in total, spectrum in multiples of standard 5 MHz paired spectrum blocks.

Importantly, post spectrum auction, all MNOs shall be required, within a reasonable time as determined by the PTA, to comply with the rationalisation plan as may be issued by the PTA in consultation with FAB to ensure optimal utilisation of contiguous spectrum holdings in 1800 MHz band. Furthermore, license terms and conditions relating to improved Coverage and Quality of Service etc. shall be incorporated by PTA to enhance mobile broadband proliferation in the country.[43]

[42] PTA, *Information Memorandum, Spectrum Auction for NGMS in Pakistan*, August 2021. Available at: www.pta.gov.pk/assets/im_spectrum_auction_pak_05082021.pdf

[43] *Policy Directive for the Auction of Next Generation Mobile Services Spectrum in Pakistan for Improvement of Mobile Broadband Services*, August 2021. Accessible at: https://moitt.gov.pk/SiteImage/Misc/files/POLICY%20DIRECTIVE%20FOR%20THE%20AUCTION%20OF%20%20NGMS%20SPECTRUM%20IN%20PAKISTAN%20Dated%204%20A___(1).pdf

Another good example is the process in Myanmar. In late 2017/early 2018, Myanmar's spectrum regulator the Posts and Telecommunications Department (PTD), in order to facilitate the creation of contiguous spectrum blocks consistent with 5G NR and to support sector competition, included the following licence condition In Myanmar's 1800 MHz Spectrum Licences:

> *"In order to provide contiguous spectrum allocations in the 1800 MHz Spectrum Band, the Licensee commits to reorganising, at its own expense and in a timely manner (no longer than 6 months from the issue of any such written request from the Regulator) the above spectrum assignment so as ensure that this assignment and any spectrum assignment arising from the exercise by itself or an Other Licensee of any Spectrum Option are contiguous."*

Similar processes were adopted in Indonesia and Malaysia, further spectrum auctions in the 3.5 GHz and other bands in Myanmar will include such condition. Importantly, processes to create contiguous spectrum blocks are found in other markets. For example, Ofcom in United Kingdom was working last years on ways to defragment key 5G spectrum in the 3.4 – 3.8 GHz band (n77/78) in order to create contiguous spectrum blocks.[44]

In Australia, in July 2021 consistent with regulatory practice detailed in the *Radiocommunications Act 1992* of supporting the highest value of use of spectrum, TPG[45] and Telstra undertook a voluntary spectrum restacking in their respective spectrum holdings in the 1800 MHz and 2100 MHz bands in early 2021 in major Australian cities excluding Sydney and Melbourne. The goal behind the MNO-driven restacking was improving user data speeds and network capacity. Additionally, restacking these bands would allow a smoother migration of 4G to 5G implementation in the future.

By adopting such exemplar spectrum management approaches, the PTA avoids (i) costs (including possible compensation payments), (ii) the complexity and (iii) the administrative burden of having to do such defragmentation processes in the future. Such an approach increases regulatory certainty and provides a quality foundation for increasing sector investment in 4G and 5G wireless broadband services in Pakistan. Lastly, the deployment of affordable higher speed wireless services, as recommended by the ITU, are increasingly best practice to support stronger recovery in the post-COVID-19 environment.[46]

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[44] Ofcom, *Consultation: Defragmentation of spectrum holdings in the 3.4-3.8 GHz band*, July 2019. Available at www.ofcom.org.uk/consultations-and-statements/category-3/defragmentation-spectrum-holdings. Defragmentation is also supported by the GSMA. Refer to www.gsma.com/spectrum/wp-content/uploads/2020/03/5G-Spectrum-Positions.pdf

[45] In 2020, TPG Telecom and Vodafone Australia merged. Both previously had their own IMT spectrum allocations as well as jointly owning spectrum in the 3.6 GHz band.

[46] ITU, *Pandemic in the Internet Age, June 2020.* See page 26.

4.3.2 Need to refarm the 2100 MHz band

The 2100 MHz spectrum band (n1) comprising 2 x 60 MHz is only partly allocated in Pakistan. Currently, only 6 carriers of 2 x 5 MHz are allocated to the major MNOs with Zong and Jazz each being assigned 2 x 10 MHz while Telenor Pakistan and Ufone have 2 x 5 MHz of spectrum assigned to them in this band. Unfortunately due to two sources of interference namely (i) the use of 1900 MHz band for WLL services (PTCL and World Call Telecom Ltd have allocations in this band to 2024), and (ii) interference from illegal DECT systems (see below), some 2 x 15 MHz may not be able to be assigned at this time.

The further complication is that Zong wishes to move from 1920: 1930 MHz paired with 2110: 2120 MHz to another frequency in the band and has only partly done this pending MoITT approval. It is recommended that this occur as soon as possible so that maximum 2100 MHz spectrum blocks are available to be auctioned by the PTA. Consideration should be had to auctioning the clear blocks plus the compromised blocks (1920: 1930 MHz paired with 2110: 2120 MHz) for a lower price. Post 2024, the remaining 2 x 10 MHz of the band unassigned should be auctioned as there is increasing interest in this band for 5G services.

Addressing DECT Interference in the 2100 MHz band

It is understood that in DECT devices, typically cordless phones and telephone systems, baby monitors, and cordless headsets, which are permitted in the USA and Canada are illegally imported into Pakistan. It is a well known problem in Europe and globally that such devices cause harmful interference due to co-channel operation of DECT 6.0 equipment and MFCN within the range 1920-1930 MHz, with some cases also above 1930 MHz. In Europe the maximum reported interference distances were from 2100 to 6200 metres with the majority of cases below 500 metres.[47] No detailed analysis has yet been provided in Pakistan.

Private imports typically online of the DECT 6.0 equipment are likely to be most common means of obtaining equipment. It is also likely that the owner of DECT 6.0 equipment is unaware that the use of such type of equipment is not allowed in Pakistan.

As the optimal approach to resolve the issue and eliminate the harmful interference is for the DECT 6.0 equipment to be switched-off it is recommended that the PTA (i) undertake a public information campaign including with online advertisements alerting the public that such devices are illegal[48] and that fines may be levied (ii) the PTA's radio monitoring group undertake more monitoring and interference of such DECT devices in order that they can be switched off and (iii) the PTA should consider a modest illegal DECT radio handback amnesty campaign.

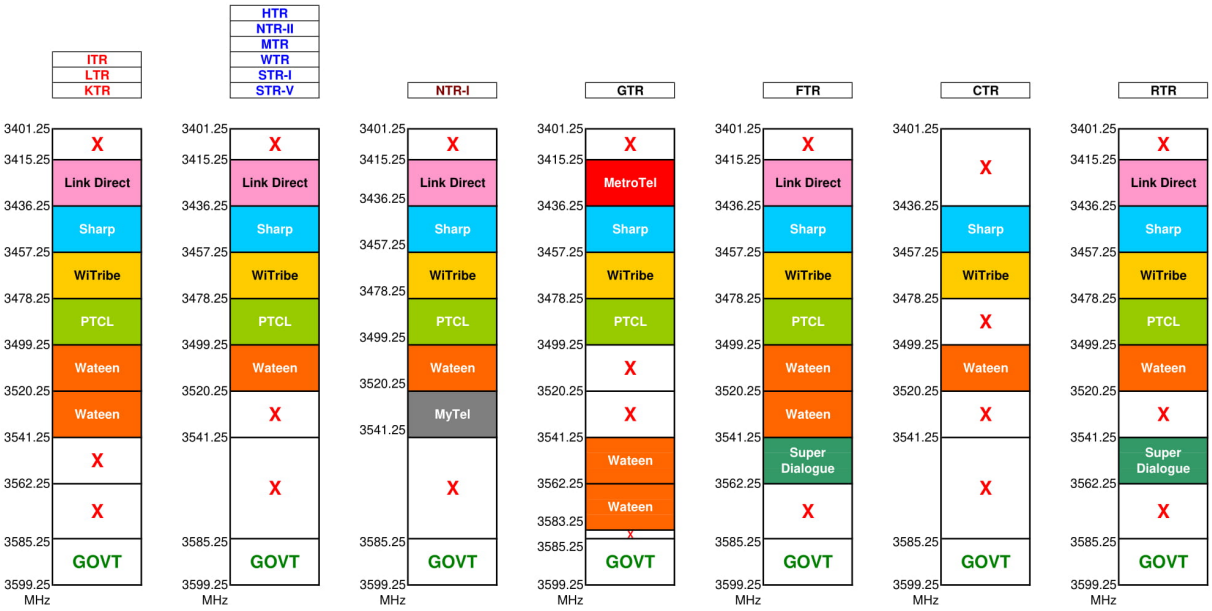
[47] Refer to WGFM Questionnaire to CEPT Administrations on interference cases caused by DECT 6.0 equipment in the 1920-1980 MHz frequency range (2014).

[48] See for example, https://fijisun.com.fj/2018/03/03/improved-border-control-vital-to-confiscate-illegal-devices/

4.3.3 Need to refarm 3.5 GHz band and address the legacy WLL licences

From a national/public interest perspective there are a compelling set of arguments that the current WLL spectrum licences should expire in 2024 especially in relation to the 3.5 GHz band (see existing assignments in Exhibit 22 below). Specifically such 3.5 GHz spectrum should be made available going forward via a spectrum auction in larger contiguous blocks for 5G NR services. Such a process will see this key IMT spectrum be allocated to its highest value use in Pakistan. It will also see the Government secure a good price for the scarce spectrum which is being offered, which may be useful to possibly offset some of losses of revenue due to the COVID-19 pandemic.

Exhibit 22: Current Frequency Allocations for the 3.5 GHz Band WLL



Source: FAB, 2020

It should be noted that globally technology changes have allowed MNOs to gain significant economies of scale and scope from the transition to 4G and future 5G wireless broadband services and challenged the viability of standalone FWA operators. In such circumstances, there are few if any, global precedents for regulatory regimes which would safeguard the current declining WLL business in Pakistan. Accordingly, regulatory policy implemented by the PTA may need to acknowledge this outcome.

In terms of equity, WLL operators should also be able to bid for such spectrum in any future auction. Further, the non-extension of existing spectrum licensees in the 3.5 GHz band beyond 2024 should be communicated, in accordance with the law and regulation as soon as practicable. This would provide a high degree of regulatory certainty.

Given questions about the viability about a number of WLL licensees, the PTA could encourage the early return of 3.5 GHz spectrum by such licensees. Depending on what is possible in law and regulation, the PTA could provide compensation to such WLL licensees who wished to participate in an early handback of 3.5 GHz spectrum program from the proceeds of the future spectrum auction.

There is also a good argument that existing WLL players should be able to become MVNOs – reselling FWA services – at the end of their licences.

This would be similar to the USA's incentive based auction[49] for 600 MHz spectrum band managed by the Federal Communications Commission (FCC) or Brazil's auction of 700 MHz where new licensees were required to pay the cost of clearing the 'dirty' UHF spectrum in order to secure the digital dividend. Other countries including Indonesia are considering the use of such mechanisms to clear both 3.5 GHz and 700 MHz spectrum which is needed urgently for 4G and 5G services.

One option would be to obtain independent valuations of the spectrum based on the remaining years of the spectrum licences to 2024 based on discounted cash flow (DCF) analysis, or an assessment of current spectrum holdings and population coverage. Such an approach would accelerate the making available of key IMT spectrum in Pakistan and allow those WLL operators which are loss making to secure a compensation payment for the early release of their 3.5 GHz spectrum.

Depending on whether the WLL licensees receive compensation payments for the early handback of their spectrum, the WLL licensees directly or the PTA may also wish to provide a voucher of say PKR8,000 to PKR10,000[50] to each existing WLL customer to help defray the cost of them purchasing new CPE. If paid to consumers by the PTA, any new CPE subsidy would need to be computed in the costs of any compensation. The costs of such a CPE voucher program can be funded from the revenue from the issuing of new 3.5 GHz spectrum licences.

In conclusion, having a smaller number of national as opposed to regional licences for the 3.5 GHz band ensures that each licensee will have a large contiguous block of spectrum consistent with 5G NR principles and the synchronisation and frame structure issues are more easily addressed by the PTA. It is recommended that the licence terms and conditions for any 3.5 GHz spectrum licence (and indeed any TDD spectrum) issued by the PTA include the ability for the PTA to determine synchronisation and common frame structure if the licensees in the band are unable to do so by themselves.

4.4 Desired/Recommended 4G broadband penetration for 5G deployment

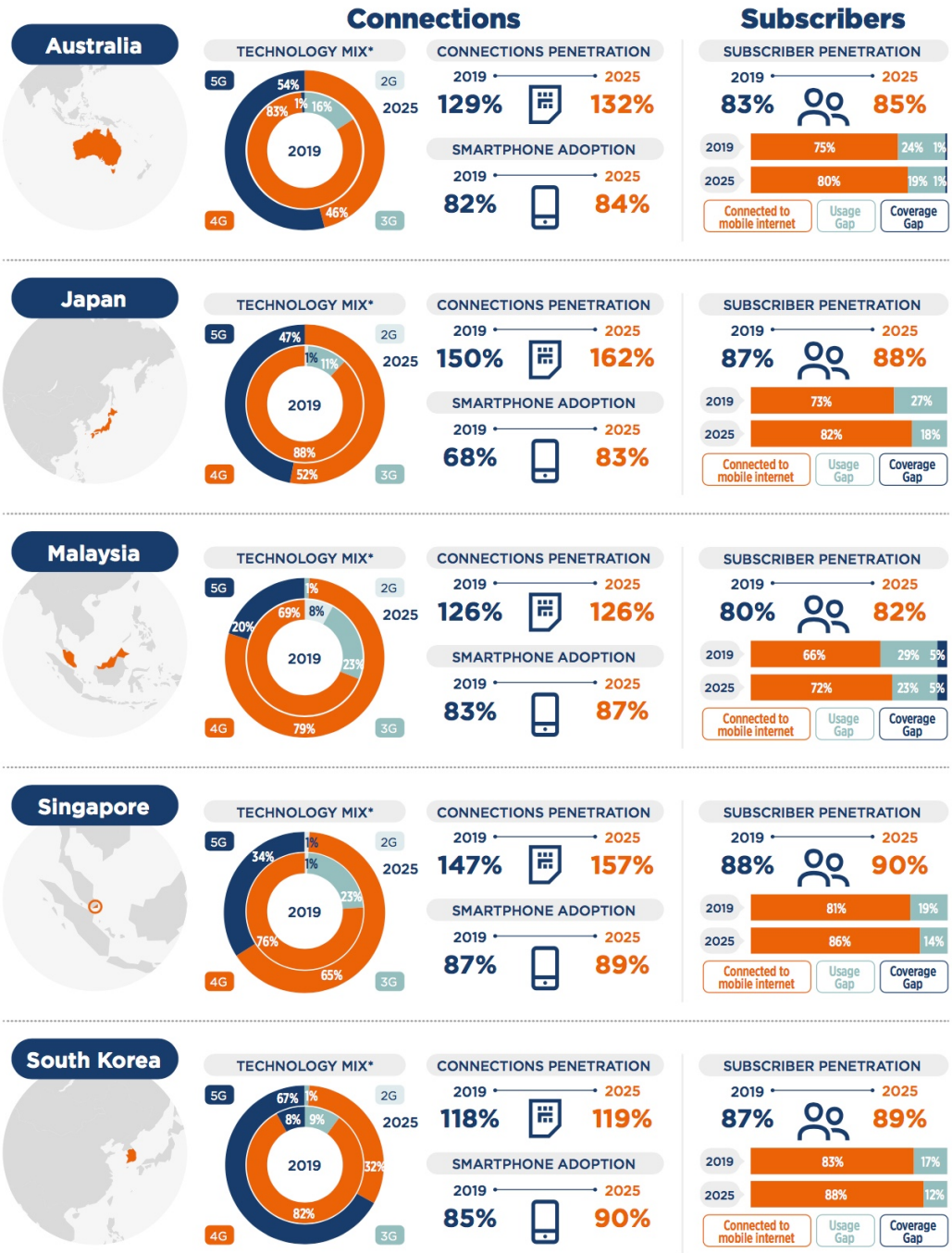
4.4.1 Comparison of 4G broadband penetration

One of the key questions is whether there is a desired or recommended 4G broadband penetration needed for 5G deployment. In short, what are the necessary preconditions to make 5G a success for emerging markets. Using GSMA data, we take a small sample of Asia-Pacific countries which have or are about to launch 5G services (see Exhibit 23) focusing on country penetration, technology mix and smartphone adoption.

[49] Refer to www.fcc.gov/general/incentive-auctions-0

[50] This is approximately USD 50 to 60 per customer. Given 300,000 existing WLL customers the maximum cost of such vouchers would be between USD15 to 20 million.

Exhibit 23: Selected country penetration, technology mix and smartphone adoption



Source: GSMA, December 2020

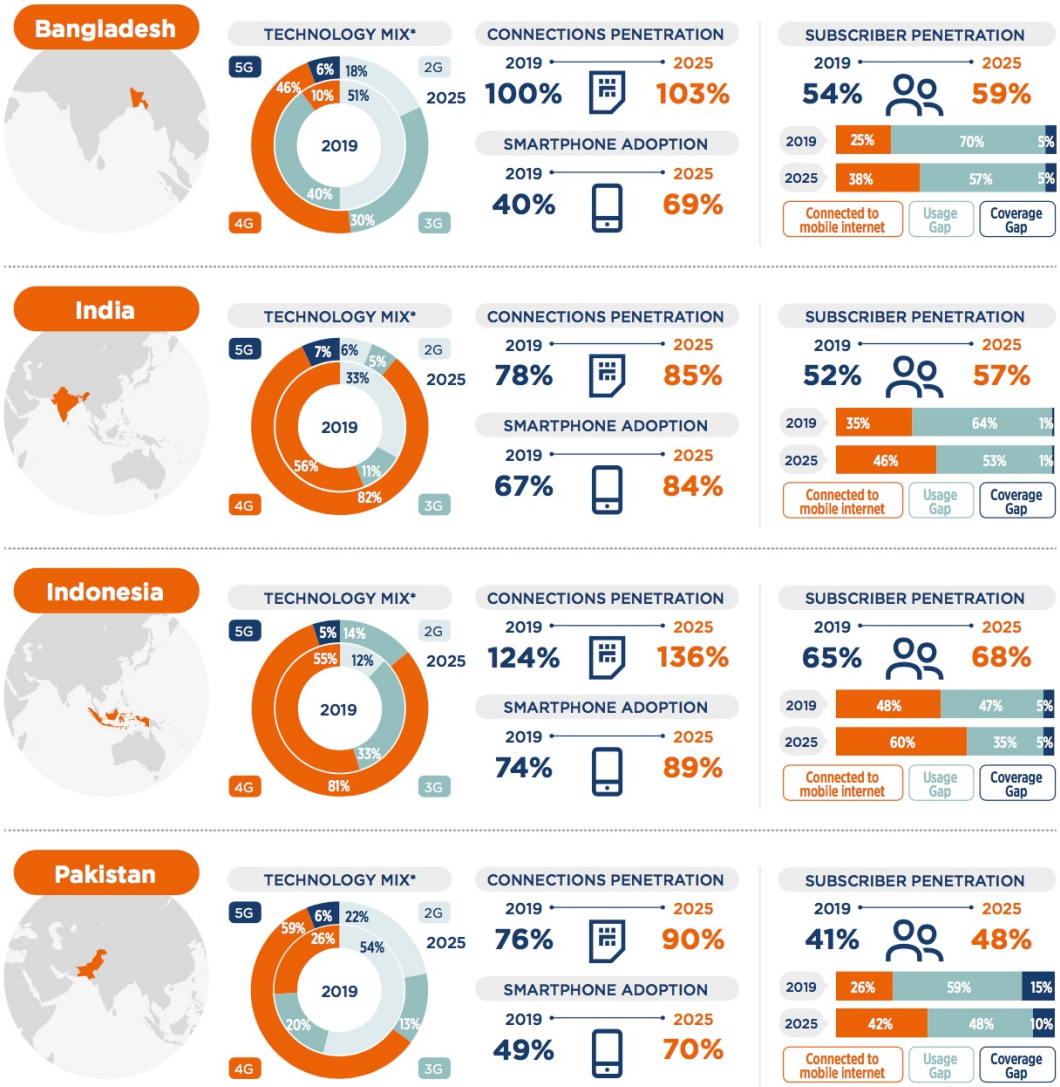
The common feature of these markets is that have strong smartphone adoption, connections penetration and the technology mix is over 75 percent towards 4G/5G except Malaysia which is at 69 percent.[51] In fact the majority are above 80 percent. Malaysia is also the only country with 2G services although it is planning to switchoff 3G at end of 2021.[52]

[51] Malaysia is the only country of the group where 5G has not been launched – it is scheduled for 2022.

[52] https://malaysia.news.yahoo.com/malaysia-switch-off-3g-2021-053835789.html

In contrast, looking at the largest emerging Asian markets outside of China, in Exhibit 24, we find that Indonesia is best placed based on the connect penetrations, smartphone adoption and the technology mix.[53] They are followed by India, Pakistan and Bangladesh.

Exhibit 24: Large emerging Asia country penetration, technology mix and smartphone adoption



Source: GSMA, 2020

Importantly, all three large Asian emerging markets have made strong announcements and commitments in relation to 5G. Specifically, Indonesia has announced 5G roadmap and made regulatory changes to infrastructure sharing etc, India has had many discussions on 5G and 5G spectrum is scheduled for release later in 2021/2022, and Bangladesh is currently in the middle of reviewing draft 5G Guidelines released (discussed in more detail below).

[53] Indonesia has strong 5G plans but is struggling to release IMT spectrum to support such plans. See MoICT, *Indonesia's 5G Initial Roadmap, Conference on Indonesia 5G Roadmap and Digital Transformation,* 10 December 2020.

4.4.2 Detailed Comparison with Bangladesh and Vietnam

It is also instructive to undertake a more detailed analysis of 5G approach being undertaken in two comparable large emerging Asian markets. For this purpose, Bangladesh (8th largest country by population) and Vietnam (15th largest country by population) have been selected.

Vietnam has a population is 96.4 million, compared with Bangladesh's 163 million and Pakistan's 216.5 million. The GDP per capita is higher Vietnam (USD2,715), and Bangladesh (USD1,940) than in Pakistan (USD1,284),[54] however the countries share several similarities. Approximately, 63% of the population is rural in all three countries,[55] and all countries also have a similar urban population growth rate.[56] There are approximately 165 million mobile cellular subscriptions in Pakistan and Bangladesh, and 136 million in Vietnam.[57] The World Bank records significant divergence in relation to the use of the internet with 68.7% of individuals using the internet in Vietnam, versus 13% and 17% in Bangladesh and Pakistan respectively. See the summary of Pakistan versus Bangladesh and Vietnam in Exhibit 25 below.

Importantly, while English is widely spoken in each country, each country has a particular language and script somewhat unique to the country which means content and applications are likely to need to be translated or customised for the market.

Exhibit 25 Comparison of key country indicators

Indicators	Bangladesh	Vietnam	Pakistan
Population (million)	163.0	96.4	216.5
GDP/capita (USD)	1,940	2,715	1,285
Rural population	62.6	63.0	63.3
Urban growth rate(%)	3.1	2.9	2.6
Mobile subscriptions	165.5	136.2	165.4
Total IMT spectrum allocated (MHz)	398.8	339.6	269.2
Internet usage (%)	12.9	68.7	17.0
Official languages (total speakers)	Bengali (230 m)	Vietnamese (76 m)	Urdu (170m) English (~2 billion)

Source: World Bank, 2020

4.4.3 Comparison with Bangladesh's Approach to 5G

In Bangladesh, the BTRC has released a draft *Regulatory and Licensing Guidelines 2021 for Establishing, Operating and Maintaining Cellular Mobile Services in Bangladesh* (draft 2021 Guidelines). The deadlines for responses which were originally due by the end of January were extended to the end of February 2021.[58]

[54] https://databank.worldbank.org/reports.aspx?source=world-development-indicators
[55] https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=VN-PK-BD
[56] https://data.worldbank.org/indicator/SP.URB.GROW?locations=VN-PK-BD
[57] https://data.worldbank.org/indicator/IT.CEL.SETS?locations=VN-PK-BD
[58] www.btrc.gov.bd/sites/default/files/notice_files/Time%20Extension%20Notice%20Regarding%20Public%20Opinion%20On%20Draft%20Regulatory%20And%20Licensing%20Guidelines%20-%202021.pdf

These draft 2021 Guidelines aim to create a single unifying licence including 2G,3G,4G|LTE and 5G as "Cellular Mobile Services Operator License". The Guidelines are "… *in line with the Government's spirit and plan to introduce 5G to promote high speed mobile broadband and multimedia communications, upscale usage of smart devices at the smart homes/ cities throughout the country and make it affordable for all and also to promote the 4th Industrial Revolution. The overall objective of these guideline is to contribute to a sustainable development towards better and affordable Cellular Mobile Phone technology neutral telecommunication services for all and to ensure efficient usage of resources through effective and healthy competition through 5G applications*". Further "*Existing Cellular Mobile Phone Operator(s) in Bangladesh who will obtain 5G service technology neutral spectrum from the Commission will be eligible to apply for the license*."[59]

Importantly, in relation to spectrum the BTRC has primarily designated 2.6 GHz and 3.5 GHz bands frequencies for the 5G service – however, no new spectrum has yet been released. The BTRC requires that the licensee is required to take prior permission and/or License from the Commission for usage of spectrum in evolution of 5G technology in addition to other generations of cellular mobile phone services.[60]

The other key requirement to be able to move to the draft 2021 Guidelines is a set of Rollout obligations detailed in Clause 14, is to launch 5G in 2021 and provide 5G in 50 percent of the district headquarters in 2023, to every district headquarter by 2024 and the entire country to have access to 5G services (at upazila level) by 2026. More specifically Clause 14 states:

"14. ROLLOUT OBLIGATIONS

14.01 First Phase: Service in all Divisional Headquarters

Operators who will receive the Cellular Mobile Services Operator License are required to provide 5G Services in all divisional headquarters within 12 (twelve) months from the date of issuance of the said license.

14.02 Second Phase: Service in another 507o of District Headquarters

Operators who will receive the Cellular Mobile Services Operator License shall have to provide 5G Services in 50% of the district headquarters within 24 (twenty four) months from the date of issuance of the said license.

14.03 Third Phase: Service in all District Headquarters

Operators who will receive the Cellular Mobile Services Operator License shall have to provide the 5G Services in all district headquarters within 36 (thirty six) months from the date of issuance of the said license.

14.04 Other Obligation:

14.04.1 The Commission may direct the Licensee to extend their services to other major cities/ locations of Bangladesh. The decision of the Commission shall be binding on the Licensee.

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[59] Refer to Clause 1 and 2 of the New 2021 Guidelines. Available at www.btrc.gov.bd/sites/default/files/notice_files/DRAFT%20REGULATORY%20AND%20LICENSING%20GUIDELINES%20-%202021%20FOR%20ESTABLISHING%2C%20OPERATING%20AND%20MAINTAING%20CELLULAR%20MOBILE%20SERVICES%20IN%20BANGLADESH.pdf

[60] Ibid. Refer to clause 15.

14.04.2 Upon fulfillment of the rollout obligation, the Licensee shall have the obligation to extend their services in all Upazillas, National Highway and Railway tracks of the country within 5 (five) years from the date of issuance of the License.
14.04.3 Upon fulfillment of the rollout obligation, the Licensee shall have the obligation to extend their 5G services all over the country during the licensing tenure as directed by the Commission."

On 11 August 2021, the Government announced that it would invest TK 200 crore (USD23.5 million) to roll out 5G mobile network infrastructure on a limited scale (a pilot project) in Dhaka by the end of 2021. The 5G network will be set up in 200 points across the city under the project. The proposal for the project, which will be implemented by state-owned telecom network operator Teletalk, has already been sent to the planning ministry for review.[61]

Industry response to the draft New 2021 Guidelines

In response to the release of the BTRC's draft 2021 Guidelines, the response from Bangladesh MNOs has been described in the media as 'lukewarm'[62] and can be summarised as:

- At least 70 per cent of the country should have 4G connectivity before moving to 5G. 4G is only available in Bangladesh divisional cities, with fluctuating network quality and broadband speeds;
- As less than 30 per cent of the country's registered handsets are 4G compatible, gearing for 5G in in February 2021 should be discussed extensively. Importantly, in Bangladesh the earlier slow uptake of 3G and 4G was due to low penetration of compatible handsets when those technologies were deployed in Bangladesh.
- Transitioning to 5G would be challenging as the necessary telecommunications infrastructure for 5G such as a robust optical fibre network, spectrum bandwidth and other factors have not been fully addressed in Bangladesh like in other countries. There are also concerns that given the current weakened state of the MNOs from the effects of the COVID-19 pandemic this made additional investments more difficult.[63]

The MNOs have also expressed the view that given low current 5G handset penetration (estimated at less than 0.1 percent in Bangladesh), there was not yet a compelling business case for them to undertake the massive investment needed for the service. This is not surprising given the ambitious 5G network coverage using only mid-band IMT spectrum (ie 2.6 and 3.5 GHz) rather than low band (ie 700 MHz) spectrum. Nominating only mid-band spectrum for 5G would make the cost of deployment prohibitive.

Lastly, senior officials from Robi Axiata, the second largest MNO has stated that "there were three challenges -- getting spectrum allocation with affordable price, availability of 5G devices and access to fiber -- to implement the high speed [5G] technology." [64]

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[61] Refer to www.thedailystar.net/business/telecom/news/govt-plans-5g-dhaka-year-2149621
[62] Refer to *inter alia* www.dhakatribune.com/business/2021/01/21/mobile-operators-lukewarm-on-5g-after-btrc-s-guideline
[63] *Ibid.*
[64] www.dhakatribune.com/business/2020/10/15/mobile-operators-not-prepared-to-launch-5g-in-2021

A good assessment of Bangladesh's current service offerings can be found in Opensignal's Mobile Network Experience Report July 2021.[65] All of the four MNOs had similar download speed experience ranging from 6.9 to 13.0 Mbps and upload speed experience of 3.4 to 4.8 Mbps. The download speed experience metrics showing the split between 3G and 4G download speeds in shown in Exhibit 26 below. 4G Availability in terms of percentage of time ranged from a low of 75.2 percent to 80.6 percent.

Exhibit 26: Bangladesh's Download Speed Experience Supporting Metrics, July 2021

Download Speed Experience Additional Metrics	A Airtel	B Banglalink	G Grameenphone	R Robi
in Mbps				
4G Download Speed	8.5 (± 0.44)	13.0 (± 0.54)	8.9 (± 0.25)	6.9 (± 0.35)
3G Download Speed	4.8 (± 0.33)	4.7 (± 0.29)	4.2 (± 0.22)	3.4 (± 0.21)

Mobile Network Experience Report | July 2021 | © Opensignal Limited

+/- numeric values represent confidence intervals. Read why confidence intervals are important.

4.4.4 Comparison with Vietnam's 5G Strategy

The Vietnamese Government sees digital transformation as the key to boosting its economy, and has been pursuing a national Industry 4.0 strategy since 2019.[66] 5G access is crucial to this policy, and the number of 5G subscriptions in Vietnam is forecast to reach 6.3 million in 2025, according to Cisco.[67] Vietnam has committed to have 80 percent of households have fibre broadband coverage by 2025, and 100% by 2030. The Government is also looking to promote smartphone penetration and facilitate infrastructure sharing to pursue the transformation benefits of Industry 4.0.

It is the Government's aim that 5G services will be 'common' in Vietnam by 2025, and 'ubiquitous' in 2030.[68] In furtherance of this aim, in Q4, 2020, Vietnam began commercial testing of 5G with Viettel, Mobifone, and VNPT using both mid-band and mmWave spectrum.[69] The purpose of this pilot scheme is to evaluate the potential of the market and stability of 5G equipment before formal commercialisation. When the rollout begins, urban areas will be the first to have 5G, followed by industrial zones and universities to aid innovation, before the rollout extends to the rest of the country.

The Ministry of Information and Communications of Vietnam plans to allocate the following spectrum for deployment:

- 2 x 30 MHz in 700 MHz band (ie a total of 60 MHz);
- 550 MHz in mid- bands (in large 80/90/100 MHz blocks) and
- 3200 MHz in mmWave (400MHz per block). [70]

[65] www.opensignal.com/reports/2021/07/bangladesh/mobile-network-experience
[66] https://opengovasia.com/vietnam-creates-policies-for-industry-4-0/
[67] https://vietnamnews.vn/economy/570671/5g-key-for-viet-nam-in-industry-40.html
[68] Luong Pham Nam Hoa, VNTA, MIC, Viet Nam Telecommunications Authority, *Viet Nam: A Proactive Approach to 5G*, November 2020.
[69] Dashveenjit Kaur, *Vietnam is Ahead of the Game With Commercial 5G,* Techwire Asia, 1 December 2020.
[70] Luong Pham Nam Hoa, *op cit*

Spectrum is a key challenge – especially on how to value the spectrum – as Vietnam currently has a relatively low total of IMT spectrum allocated as shown in Exhibit 27 below. This is currently the topic of discussions between MNOs and the Ministry of Information and Communication (MIC).

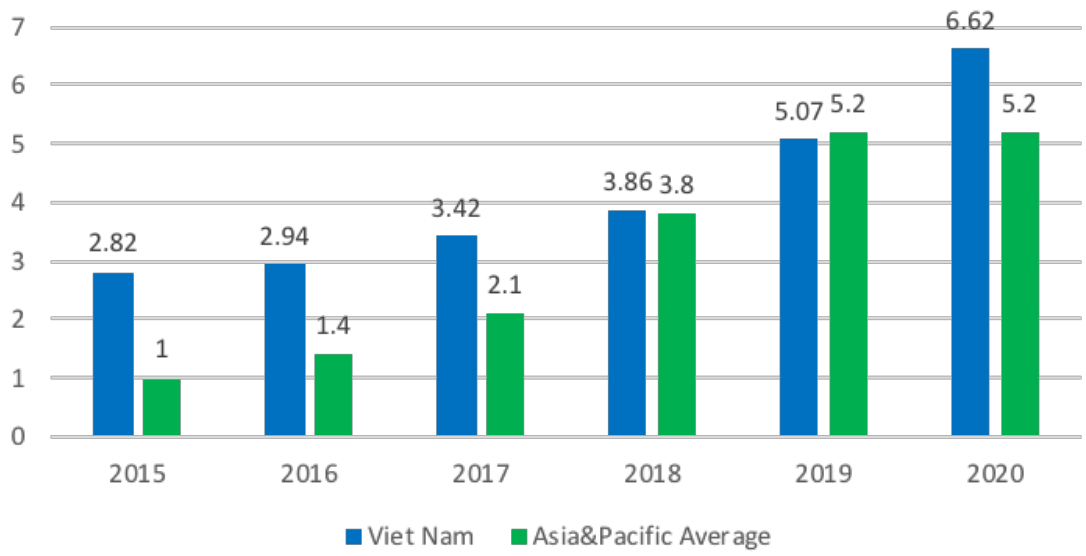
Exhibit 27: Current Vietnam MNO IMT spectrum allocations

MNO	900 MHz	1800 MHz	2100 MHz	Total MHz
Viettel	16.4	40	45	**101.4**
Vinaphone	16.8	40	30	**86.8**
Mobifone	16.4	40	30	**86.4**
GTel	0	30	0	**30**
Vietnamobile	20	0	15	**35**
TOTAL	**69.6**	**150**	**120**	**339.6**

Source: ARFM, 2019

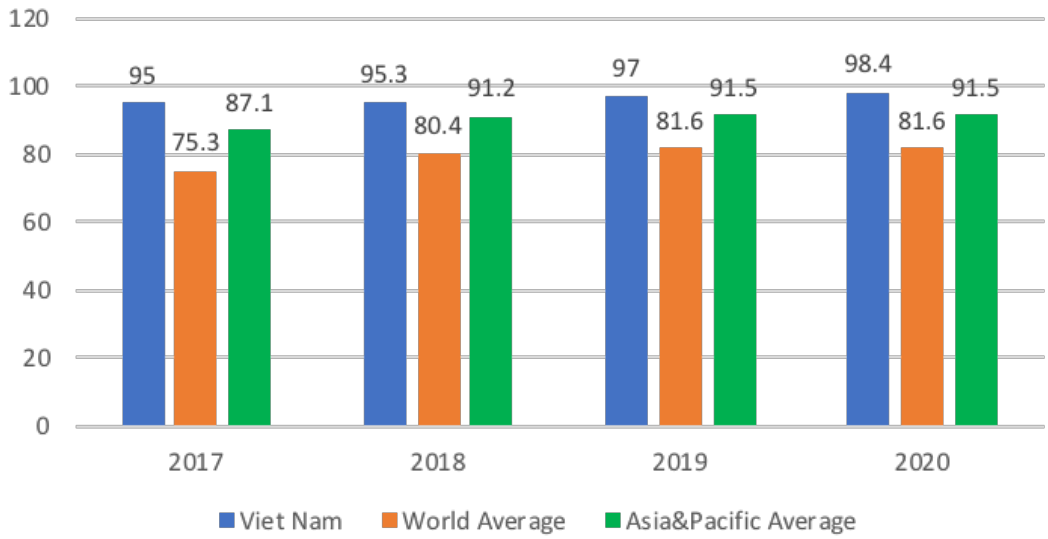
From an industry perspective it should be noted that Vietnam is seeing strong continuing growth of mobile data consumption and broadband penetration rate. Vietnamese smartphone penetration per mobile subscriber is almost 70% and the nationwide 4G coverage is almost complete as shown in Exhibit 28 and Exhibit 29 below.

Exhibit 28: Data usage (GB)/mobile subscriber/month



Source: MIC, 2020

Exhibit 29: Vietnam's 4G coverage



Source: MIC 2020

A good assessment of Vietnam's current service offerings can be found in Opensignal's Mobile Network Experience Report March 2021.[71] All of the three major MNOs had similar download speed experience ranging from 27.8 Mbps to a high of 31.7 Mbps and upload speed experience of 8.0 to 10.8 Mbps.[72] The download speed experience metrics showing the split between 3G and 4G download speeds in shown in Exhibit 30 below. 4G Availability in terms of percentage of time ranged from a low of 87.0 percent to a high 91.2 percent (Viettel).

Exhibit 30: Vietnam's Download Speed Experience Supporting Metrics, March 2021

Download Speed Experience Additional Metrics	MobiFone	Vietnamobile	Viettel Mobile	Vinaphone
in Mbps				
4G Download Speed	27.8 (± 0.52)	4.7 (± 0.20)	31.1 (± 0.36)	31.7 (± 0.61)
3G Download Speed	8.6 (± 0.31)	4.2 (± 0.16)	7.9 (± 0.24)	6.4 (± 0.28)

Mobile Network Experience Report | March 2021 | © Opensignal Limited

+/- numeric values represent confidence intervals. Read why confidence intervals are important.

4.4.5 Broader Opensignal comparative assessment of 4G availability

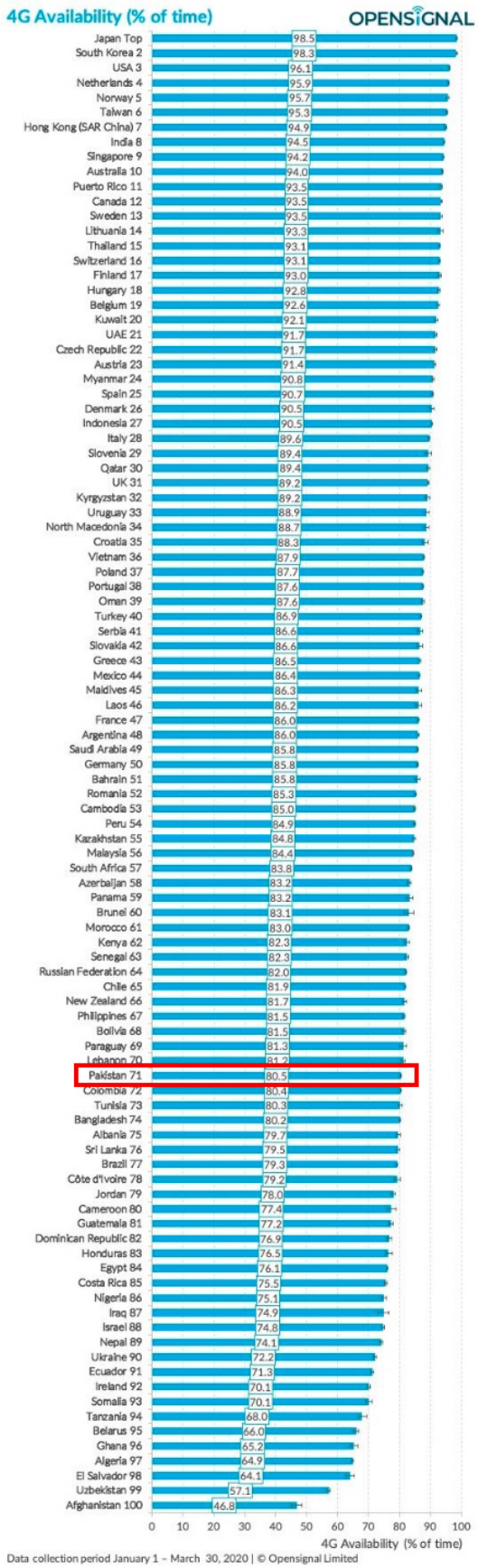
In relation to Pakistan, Opensignal's recent reports on 4G speeds and availability are a good proxy for the LTE market characteristics of the local market. In Opensignal's *State of the Mobile Network Experience 2020:One Year into the 5G Era*, May 2020,[73] Pakistan was ranked 71 out of 100 countries (see Exhibit 31 below) with a score of 80.5. By February 2021, when Opensignal again reviewed Pakistan the score had somewhat increased (the MNOs scores ranged from 64.9 to 88.1 percent). So there are positive signs of improving 4G performance albeit there is a long way to go for such 4G coverage to be ubiquitous.

[71] www.opensignal.com/reports/2020/09/vietnam/mobile-network-experience

[72] Vietnamobile which has significantly less IMT spectrum assigned to it a small customer base has been excluded from the analysis.

[73] Refer to www.opensignal.com/sites/opensignal-com/files/data/reports/pdf-only/data-2020-05/state_of_mobile_experience_may_2020_opensignal_3_0.pdf

Exhibit 31: Global comparison of 4G availability, May 2020



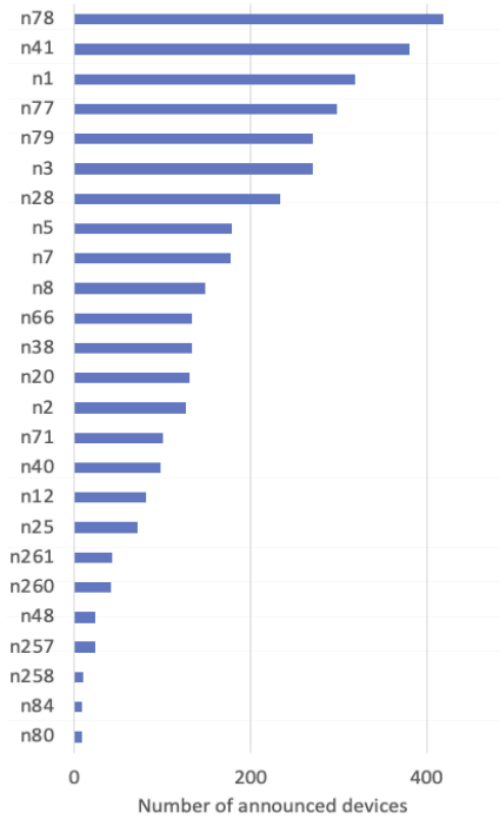
In terms of download speeds, Pakistan was in 85th position on the same study, suggesting that IMT spectrum allocations and probably backhaul transmission was holding the country back from achieving better results.[74] While the majority of early 5G adopters are advanced rather than emerging markets there are an increasing number of emerging markets are looking to facilitate the deployment of 4G/5G services. Certainly adopting a technology neutral approach allowing MNOs to make forward thinking decisions in relation to their investments.

4.5 Assessment of 5G device availability and affordability

4.5.1 Rapid growth of the 5G device ecosystem

The 5G device ecosystem has grown rapidly and it can be expected to continue to do so. As at July 2021, the GSA stated 873 5G devices has been announced, of which 63.8 percent are understood to be commercially available. These devices include 22 form factors (including phones, head-mounted display, hotspots, indoor and outdoor CPE, laptops, modules, snap-on dongles/adapters, enterprise routers, IoT routers, drones, robots, TVs, cameras, USBs terminals, heads-up displays, and a vending machine) from 131 vendors.[75] This includes 431 phones including at least 381 phones which are commercially available. In terms of the 5G supported spectrum bands, details can be found in Exhibit 32.

Exhibit 32: 5G device ecosystem – Supported bands as at end March 2021



Source: GSA, 5G Market: Snapshot, April 2021

[74] *Ibid*, page 9

[75] GSA, *5G Ecosystem Report Executive Summary July 2021*, available at https://gsacom.com/technology/5g/

The majority of devices support the n77/79 band (including the 3.5 GHz band) with the n41 (2.6 GHz TDD), n78 (4.9 GHz) and n28 (700 MHz) being well supported. Of the legacy in use bands, 2100 MHz (n1) and 1800 MHz (n3) are the best supported. About 20 percent of devices support mmWave 5G services. A range of cheaper priced 5G handsets are expected given the growth in demand in China and many other global markets.

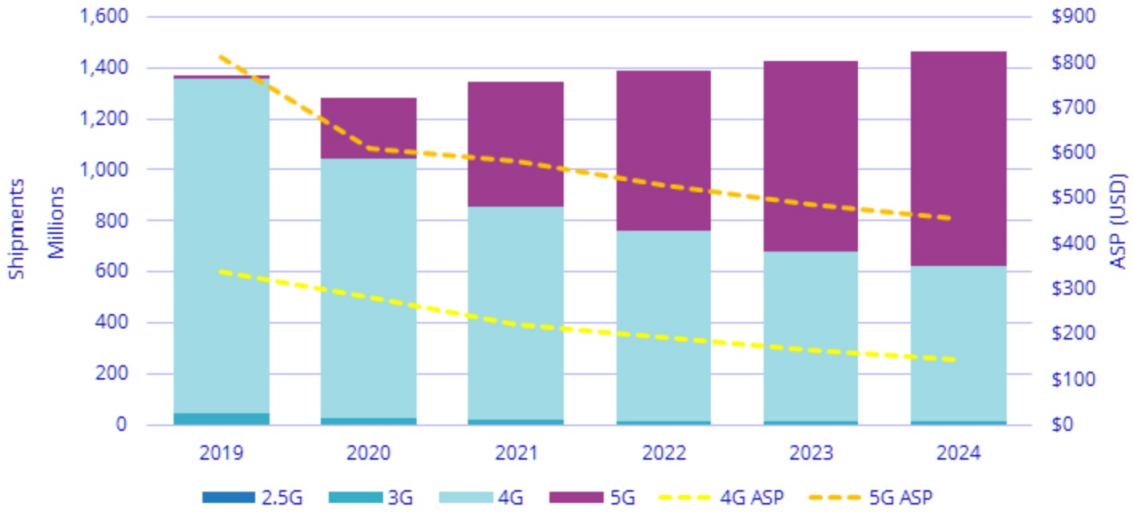
In our view, while Band n78 (3.5 GHz) and Band n41 (2.6 GHz TDD) are the most supported bands from an ecosystem perspective, we consider that Band n28 (700 MHz) and Band n40 (2.3 GHz) will grow proportionally faster. This is because of the deployment of 5G in the 700 MHz in Asia (eg China, India, Thailand, Philippines) and in Europe (mandatory for all EU members). The 2.3 GHz band which is already a TDD band is well placed to grow fast as a 5G band given the interest in the band following its first launch by Singtel Optus in Australia[76] and subsequent use of this band for 5G in markets like Indonesia (Telkomsel).

4.5.2 Increasing affordability of 5G smartphones and devices

From an affordability perspective there is much to do in order to make 5G smartphones and other devices more affordable in the Pakistani context. However, the trend is strongly in that direction.

As indicated recently by the IDC, from a technology standpoint, 5G is the driving force for the industry. IDC expects "*5G smartphone shipments to reach close to 19 percent of global volume in 2020 and grow to 58 percent in 2024. A key factor to accomplish this will be getting the cost of 5G hardware close to or on par with 4G phones. This is something the industry is focusing on and IDC expects worldwide 5G ASPs to drop 25% year over year in 2020 to USD611 and then to USD453 in 2024.*" This is shown in Exhibit 33 below.

Exhibit 33: Worldwide Smartphone Forecast Q3,2020



Source: IDC, 25 November 2020[77]

[76] For more information see www.gtigroup.org/news/ind/2020-07-30/15373.html and www.optus.com.au/about/media-centre/media-releases/2020/02/optus-launches-worlds-first-2300mhz-and-3500mhz-dual-band-5g-production-network

[77] See www.idc.com/getdoc.jsp?containerId=prUS47036220

IDC states that "*Competitive pricing will play an integral role in shaping 5G development. The COVID-19 crisis has influenced consumer behavior by tilting it toward more budget-friendly devices and narrowing the spend for essentials only. Aggressive promotions and more affordable 5G devices from major smartphone vendors are expected to partially offset the impact in the near term."* For its part Qualcomm, in early January 2021, it announced the inclusion of 5G on a 5G to Snapdragon 480, an affordable platform for lower-end smartphones.[78]

While the 5G average selling price (ASP) above is high as it includes high end Apple iPhones etc, already low cost vendors such as RealME have released much cheaper 5G devices. In September 2020, it launched the V11, which has been described as the cheapest 5G smartphone in the world at below USD150 (or PKR23,500 subject to taxes).[79] In overall terms, the prices of 5G smartphones are coming down swiftly as more choices enter the market. It is expected that globally 5G entry levels smartphones will be sub-USD100 later in 2021. Such reductions is assisted by the fact that 5G smartphone shipments exceeded 167 million in 2020.[80]

As indicated by the Pakistan MNOs in their joint submission of 22 February 2021, handset taxes could also be removed which would result in lower consumer prices and this would allow the rapid adoption of 5G devices.[81]

4.6 Analysis of 5G market readiness

Based on the above analysis, and comparisons with other comparable markets it is possible to conclude that the Pakistan market as at August 2021 is not yet 5G ready. There exists a considerable number of factors to address in facilitating Pakistan's market readiness especially the lack of large contiguous blocks of affordable spectrum, broader access to fibre backhaul and widespread availability of affordable 5G smartphones and other devices which are necessary preconditions in order to make 5G a success.

The above view is shared by the Pakistani MNOs who have jointly stated that "*The state of readiness of any project is fundamentally intertwined with both demand and supply side factors and the enabling framework (often a collaboration between public and private sector initiatives) and commercial viability.*"[82] Their joint submission went on to highlight the need for *inter alia*:

- Spectrum in the prime 5G bands including 700 MHz, 2.6 and 3.5 GHz and mmWave bands at significantly reduced prices in order to allow the MNOs to concentrate on service rollout and 5G ecosystem development in Pakistan;
- Mandated 5G Coverage and QoS levels to be kept at reasonable levels;

[78] Refer to www.itwire.com/home-it/qualcomm-brings-5g-to-snapdragon-480,-an-affordable-platform-for-lower-end-smartphones.html

[79] www.scmp.com/abacus/tech/article/3099730/oppo-spin-realme-unveils-sub-us150-5g-smartphone-china-thats-cheaper

[80] Refer to www.globaltimes.cn/page/202102/1215151.shtml

[81] PTCL, Jazz, Ufone, Telenor Pakistan, and Zong, *Consultation on 5G Readiness,* 22 February 2021.

[82] PTCL, Jazz, Ufone, Telenor Pakistan, and Zong, *Consultation on 5G Readiness,* 22 February 2021. Page 1

- Handset and data taxes to be removed to facilitate the rapid adoption and uptake of services; and
- Fibre proliferation to be done urgently along with a plan to enhance wireless backhaul frequencies.[83]

Does this mean that Pakistan Government should not announce its strong support for 5G and include it within its broader revised telecommunications sector policy? No. Far from it. This is because as the GSMA has noted "*5G is not necessarily a race, but countries that move more quickly will deliver greater benefits to consumers, businesses, and their own economies sooner*."[84]

Readiness for 5G in Pakistan or in any country does not occur at a single point of time or as the result of a binary decision. Building a country's digital economy and support for 5G and other service innovations is a journey. Built on the Government's sector policy and regulation, successive deployments of technology – 2G, 3G and 4G – combine to create the environment where future 5G and in the 2030 timeframe future 6G services, will see investments from industry stakeholders, new services and applications and increased customer and enterprise demand.

In this context, unfortunately, it is arguable that Pakistan's IMT spectrum management policy has been the key factor which has held back the sector. By creating artificial spectrum scarcity and releasing only minimum levels of new IMT spectrum without the requisite levels of regulatory certainty (and not in accordance with a long term spectrum roadmap), the industry has been unable to fully invest in 4G deployment. Had it done so, additional investment in backhaul and other transmission capacity to support 4G data traffic would have been necessary. Further, consumers have not seen fundamentally higher wireless broadband speeds in respect of which 3G and later 4G technology should have delivered. As shown by Opensignal, today's 4G wireless broadband speeds in Pakistan while slightly higher to Bangladesh but are half that Vietnam and closer to 3G speeds.[85] On the metric of 4G availability, 4G availability in Pakistan is similar to that in Bangladesh (except that offered by Ufone and Telenor Pakistan) and in Vietnam.

As a result, of lower wireless broadband speeds it is possible to argue that Pakistani consumers have not enjoyed in economic terms, consumer surpluses. If Pakistani consumers had enjoyed high consumer surpluses from the that, subject to economic conditions, would have made them more inclined to invest in newer more capable smartphones and other access devices.

The low total amount of IMT spectrum in Pakistan has also had a material effect on sector competition. Again referring to the Opensignal report from July 2021, extracted in Exhibit 34 below, we find that the 4G wireless broadband offering from Ufone and Telenor Pakistan are only marginally higher than their 3G offerings.

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[83] *Ibid,* pages 3 and 4

[84] GSMA, *Realising 5G's full potential: Setting policies for success*, March 2020, page 33

[85] Refer to www.opensignal.com/reports/2021/07/pakistan/mobile-network-experience www.opensignal.com/reports/2021/02/bangladesh/mobile-network-experience and www.opensignal.com/reports/2020/09/vietnam/mobile-network-experience

Exhibit 34: Pakistan Download Speed Experience Supporting Metrics, July 2021

Download Speed Experience Additional Metrics	Jazz	Telenor	Ufone	Zong
in Mbps				
4G Download Speed	12.9 (± 0.29)	4.6 (± 0.16)	5.6 (± 0.22)	13.5 (± 0.29)
3G Download Speed	3.7 (± 0.15)	2.9 (± 0.16)	4.0 (± 0.14)	4.0 (± 0.29)

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+/- numeric values represent confidence intervals. Read why confidence intervals are important.

This is an result of *inter alia* not having sufficient IMT spectrum in order for the 3rd and 4th players in the market to provision competitive 4G service offerings even if they wished to invest more capital in their businesses. The lack of vigorous sector competition as a result of IMT spectrum shortages means that Pakistan faces the possibility of the market becoming a duopoly (with a range of attendant social welfare losses). It also means that Pakistan is less 5G ready than it would have been if vigorous sector competition had delivered higher wireless broadband speeds, improved quality of services and innovative service offerings and tariffs.

Importantly, in accordance with economic theory and exemplar regulatory practice, spectrum allocations processes especially auctions, should be designed in such a way that the weakest market participant is able to acquire necessary IMT spectrum. IMT Spectrum pricing should not be priced such that only the market leaders can afford to participate.

The corollary is that while a range of other countries with competitive mobile markets – both developed and emerging – have seen 75 percent of smartphone/4G penetration as trigger point for MNOs to strongly invest in and launch 5G services, Pakistan requires a more bespoke approach. Such an approach should announce strong support for Pakistan to deploy 5G services by 2022, and concurrently address the three key necessary conditions for this to successfully take place namely – (i) larger contiguous blocks of reasonably priced spectrum in accordance with a spectrum roadmap so that by 2024 more than 840 MHz (plus mmWave spectrum) has been assigned in Pakistan, (ii) fiberisation/transmission capacity upgrades of backhaul capacity and (iii) policy support for consumers to gain access to more affordable 4G and 5G capable smartphones and other devices. As discussed in Section 8 of this report there is also a need to facilitate local content and applications in order for the country to get full value for its investment in 4G and 5G technology.

Importantly, taking such steps now will also advantage existing 3G and 4G customers in Pakistan. As stated by Opensignal late last year: *"Globally, there are many operators still to launch 5G that will unveil their fifth generation service during 2021. Opensignal predicts that these upcoming 5G operators will invest in network infrastructure that is shared by 5G and older mobile technologies, such as improved cell base station backhaul, ahead of 5G launches. This better onward connectivity will boost the experience for 4G users too. We have seen tremendous improvements on 4G in many countries in 2020, such as in the Philippines."*[86]

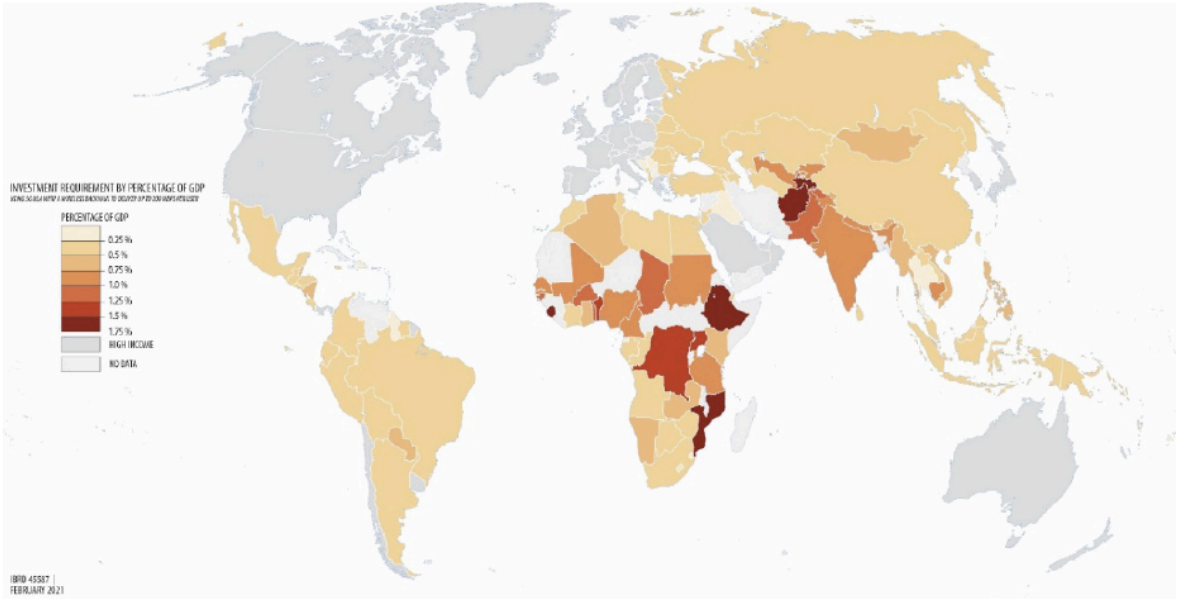
[86] Opensignal, *The Mobile Future: Predictions for 2021 and Beyond*, 21 December 2020

Concurrently, with the above, there is a need to remove any regulatory and other obstacles for Pakistani MNOs, should they wish to, to switch off legacy 2G or 3G networks. This is because it is simply too expensive for an MNO to deploy and operate 2G, 3G, 4G and 5G networks together.[87] Some rationalization is required.

4.7 Policy Choices Can Help Keep 4G and 5G Universal Broadband Affordable

In March 2021, the World Bank published a scenario analysis to determine the global cost-effectiveness of different infrastructure strategies for the developing world to achieve universal mobile broadband. The report estimated that for Pakistan which was specifically a focus of the study, the investment required for 5G is 1.0 to 1.25 percent of GDP (see Exhibit 35).

Exhibit 35: Country by country investment for 5G NSA (Wireless) as a percentage of GDP



Source: Edward J Oughton et al, Policy Choices Can Help Keep 4G and 5G Universal Broadband Affordable, World Bank Group Policy Research Working Paper p 33

Considering that aggregate spending on all aspects of infrastructure in emerging markets — including transport, energy and water as well as telecommunications — has been estimated at around 3% of GDP, the investment for 5G is considerable. However, if the government adopts a favourable regulatory strategy, the cost could be reduced by as much as three quarters.[88] The World Bank Report advised that governments should undertake the following:

[87] Refer to Scott Minehane, *The case for early downbanding to ensure affordable and sustainable 5G services in Vietnam and ASEAN,* ASEAN Conference on 5G, 21 March 2019 and GSMA, *Legacy mobile network rationalisation, Experiences of 2G and 3G migrations in Asia-Pacific,* May 2020

[88] Edward J Oughton et al, *Policy Choices Can Help Keep 4G and 5G Universal Broadband Affordable,* World Bank Group Policy Research Working Paper, March 2021 p 31

- Consider the range of mobile technologies MNOs could utilize to meet universal coverage objectives, in particular whether to complete (or even commence) 4G deployments, or 'leapfrog' straight to 5G;
- Decide on the desired balance between competition and consolidation in broadband infrastructure development. In remote areas, demand may not be high enough to support more than one infrastructure provider, and network sharing should be facilitated by government regulations; and
- Design a fiscal regime that establishes a policy for pricing access to radio spectrum, as it may constitute a significant part of the cost of providing broadband infrastructure.[89]

Key points and recommendations

Key points

- Based on analysis, and comparisons with other comparable markets it is possible to conclude that the Pakistan market as at August 2021 is not yet 5G ready. There exists a considerable number of factors to address in facilitating Pakistan's market readiness especially the lack of large contiguous blocks of affordable spectrum, broader access to fibre backhaul and widespread availability of affordable 5G smartphones and other devices which are necessary preconditions in order to make 5G a success.
- To increase long-term MNO investment, it is important that MNOs are confident that there will be sufficient spectrum made available. The investment required for 5G is considerable (ie estimated to be 1.0-1.25% of GDP).
- Currently in Pakistan there is a total of 279.2 MHz of IMT spectrum in use. MNOs are each likely need more than 1000 MHz of spectrum (including 3.5 GHz and mmWave spectrum) and prices cannot increase by that same factor. The consequence of not having sufficient IMT spectrum has been a lessening of competition for mobile services in Pakistan.

Recommendations

- Pakistan needs to substantially increase IMT spectrum allocations in order to deploy a compelling 5G network service offering. Such spectrum should be allocated on a technology neutral basis
- The following bands should be refarmed and then allocated for IMT use:
    - 1800 MHz: would require some rearranging to create contiguous spectrum allocations of an optimal size for 4G and 5G services
    - 2100 MHz: DECT 6.0 Equipment is currently causing interference in this band and the PTA should undertake a campaign to educate the public that the use of such devices are illegal in order to make more of the band available in order to reduce harnful interference and be in a position to auction the remaining blocks of spectrum in this band in the future
    - 3.5 GHz: Part of this band is currently allocated for WLL licences. The PTA could encourage the early return of the spectrum, perhaps by providing compensation for early handback or allowing WLL players to become MVNOs in order to make this spectrum band available before 2024

[89] *Ibid* pages 2–3.

- The availability of affordable 5G-compatible devices is critical to make 5G a success in Pakistan. The Pakistan Government should consider reducing or removing handset taxes to lower consumer prices

5 Spectrum Management and Availability

5.1 Regulation of Spectrum in Pakistan

The Pakistan Telecommunication Authority (PTA) is tasked with regulating ICT services. This involves promoting investment, encouraging competition, protecting consumer interests and ensuring high quality services.[90] The PTA was established by The *Pakistan Telecommunication (Re-Organization) Act 1996*.

The PTA's functions include receiving and expeditiously disposing of applications for the use of radio-frequency spectrum.[91] The PTA is deals with applications relating to the use of radio-spectrum frequency through Frequency Allocation Board (FAB). The FAB was established by section 4-2 of the PTR Act 1996, and is given the exclusive authority to allocate and assign portions of spectrum to Government, providers of telecommunication services and systems, radio and television broadcasting operations, public and private wireless operators and others.[92]

Every application for allocation and assignment of radio frequency spectrum has to be made to the PTA. The PTA is required to refer the application to the FAB within 30 days from the receipt of such application. PTA is also responsible for spectrum auctions.

5.2 Overview of 5G Spectrum Bands

The 3GPP has frozen the specification for 5G NR (New Radio). TS 38.104 Section 5.2 provides the list of bands for 5G NR utilization (see Exhibit 36 and Exhibit 37 below). According to 3GPP Release 16, these frequency bands are designated for different frequency ranges (FR) and current specification (Release) defines them as FR1 (450 to 6000 MHz) and FR2 (24,250 to 52,600 MHz). Apart from FR, NR bands can be classified into three into categories: [93]

- Frequency Division Duplex Bands (FDD);
- Time Division Duplex Bands (TDD); and
- Supplementary Bands: Downlink Supplement Bands and Uplink Supplement Bands.

It should also be noted NR has introduced a new notation for band which starts with "n" e.g. Band 20 is noted as n20 where in LTE it was termed as B20. The 3GPP has also agreed upon a number of LTE-NR sharing combinations where the UL direction of some low frequency bands (e.g. 700, 800, 900, 1800 and 2100 MHz) is paired with the 3300-3800 MHz band.

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[90] Pakistan Telecommunication Authority, Vision. Available at: www.pta.gov.pk/en/vision.
[91] *Pakistan Telecommunications (Re-organization) Act* , section 4.
[92] *Pakistan Telecommunications (Re-organization) Act* Act s 43.
[93] Furthermore, it should be noted that depending on the Subcarrier Spacing (SCS) in use, the typical supported channel bandwidths are up to a maximum of 40 MHz for FDD configurations in 5 MHz increments (including the 1800 MHz band (n3)) and 2100 MHz (n1) and 2600 MHz DSS (n7) which have a maximum of 50 MHz) while TDD configurations are up to 100 MHz which is more usable for 5G services. For example, the maximum channel bandwidth for 2.3 GHz (n40), 2.6 GHz (n41) and 3.5 GHz (n78) is 100 MHz. For the 1.5 GHz (n50) band the maximum is 80 MHz.

Exhibit 36: 5G NR Frequency Range below 6 GHz (bands in red are currently in use in Pakistan)

NR FR1 Band	Band Alias	Uplink (UL) Operating Band BS Receive / UE Transmit F_{UL_low} – F_{UL_high}	Downlink (DL) Operating Band BS Transmit / UE Receive F_{DL_low} – F_{DL_high}	Bandwidth	Duplex Mode
n1	2100	1920– 1980 MHz	2110– 2170 MHz	60 MHz	FDD
n2	1900 PCS	1850– 1910 MHz	1930– 1990 MHz	60 MHz	FDD
n3	1800	1710– 1785 MHz	1805– 1880 MHz	75 MHz	FDD
n5	850	824– 849 MHz	869– 894 MHz	25 MHz	FDD
n7	2600	2500– 2570 MHz	2620– 2690 MHz	70 MHz	FDD
n8	900	880– 915 MHz	925– 960 MHz	35 MHz	FDD
n12	700a	699 - 716 MHz	729 -746 MHz	17 MHz	FDD
n13	700c	777 – 787 MHz	746 -756 MHz	10 MHz	FDD
n14	700 PS	788 - 798 MHz	758 - 768 MHz	10 MHz	FDD
n18	800 Lower	815 – 830 MHz	860 - 875 MHz	15 MHz	FDD
n20	800	832– 862 MHz	791– 821 MHz	30 MHz	FDD
n24	1600 L	1626.5 – 1660.5 MHz	1525 -1559 MHz	34 MHz	FDD
n25	1900+	1850 - 1915 MHz	1930 -1995 MHz	65 MHz	FDD
n26	850+	814 – 849 MHz	859 – 894 MHz	35 MHz	FDD
n28	700 APT	703– 748 MHz	758– 803 MHz	45 MHz	FDD
n29	700 d	N/A	717 – 728 MHz	11 MHz	SDL
n30	2600 WCS	2305 – 2315 MHz	2350 – 2360 MHz	10 MHz	FDD
n34	TD 2000	N/A	2010 - 2025 MHz	15 MHz	TDD
n38	TD 2600	N/A	2570– 2620 MHz	50 MHz	TDD
n39	TD 1900+	N/A	1880 – 1920 MHz	40 MHz	TDD
n40	TD 2300	N/A	2300 – 2400 MHz	100 MHz	TDD
n41	TD 2600+	N/a	2496– 2690 MHz	194 MHz	TDD
n46	TD unlicensed	N/A	5150 – 5925 MHz	775 MHz	TDD
n48	TD 3600	N/A	3550 – 3700 MHz	150 MHz	TDD
n50	TD 1500+	N/A	1432– 1517 MHz	85 MHz	TDD
n51	TD 1500-	N/A	1427– 1432 MHz	5 MHz	TDD
n53	TD 2500	N/A	2483.5 – 2495 MHz	11.5 MHz	TDD
n65	2100+	1920-2010 MHz	2110-2200 MHz	90 MHz	FDD
n66	AWS-3	1710– 1780 MHz	2110– 2200 MHz	70/90 MHz	FDD
n67	700 EU	N/A	738 – 758 MHz	20 MHz	SDL
n70	AWS-4	1695– 1710 MHz	1995– 2020 MHz	15/25 MHz	FDD
n71	600	663– 698 MHz	617– 652 MHz	35 MHz	FDD
n74	L-Band	1427– 1470 MHz	1475– 1518 MHz	43 MHz	FDD
n75	DL 1500+	N/A	1432– 1517 MHz	85 MHz	SDL
n76	DL 1500-	N/A	1427– 1432 MHz	5 MHz	SDL
n77	TD 3700	N/A	3300– 4200 MHz	900 MHz	TDD
n78	TD 3500	N/A	3300– 3800 MHz	500 MHz	TDD
n79	TD 4500	N/A	4400– 5000 MHz	600 MHz	TDD
n80	UL 1800	1710– 1785 MHz	N/A	75 MHz	SUL
n81	UL 900	880– 915 MHz	N/A	35 MHz	SUL
n82	UL 800	832– 862 MHz	N/A	30 MHz	SUL
n83	UL 700	703– 748 MHz	N/A	45 MHz	SUL
n84	UL 2100	1920– 1980 MHz	N/A	60 MHz	SUL
n85	700 a+	698 – 716 MHz	728 – 746 MHz	18 MHz	FDD
n86	UL 1800	1710 – 1780 MHz	N/A	70 MHz	SUL
n89	UL 850	824 – 849 MHz	N/A	25 MHz	SUL
n90	TD 2600+	N/A	2496 – 2690 MHz	194 MHz	TDD
n91	FD1500-	832 – 862 MHz	1427 – 1432 MHz	20/5 MHz	FDD
n92	FD 1500+	832 – 862 MHz	1432 – 1517 MHz	30/85 MHz	FDD

NR FR1 Band	Band Alias	Uplink (UL) Operating Band BS Receive / UE Transmit F_{UL_low} – F_{UL_high}	Downlink (DL) Operating Band BS Transmit / UE Receive F_{DL_low} – F_{DL_high}	Bandwidth	Duplex Mode
n93	FD1500-	880 – 915 MHz	1427 – 1432 MHz	5/35 MHz	FDD
n94	FD 1500+	880 – 915 MHz	1432 – 1517 MHz	85/35 MHz	FDD
n95	UL 2000	2010 - 2025 MHz	N/A	15 MHz	SUL
n96	TD 6500	N/A	5925 – 7125 MHz	1200 MHz	TDD
n97	UL n40	2300 – 2400 MHz	N/A	100 MHz	SUL
n98	UL n39	1880- 1920 MHz	N/A	40 MHz	SUL
n99	UL n24	1626.5 – 1660.5 MHz	N/A	34 MHz	SUL

Source: 3GPP and www.sqimway.com/nr_band.php . Updated to June 2021.

Exhibit 37: 5G NR Frequency Range above 24 GHz (no bands are currently in use in Pakistan)

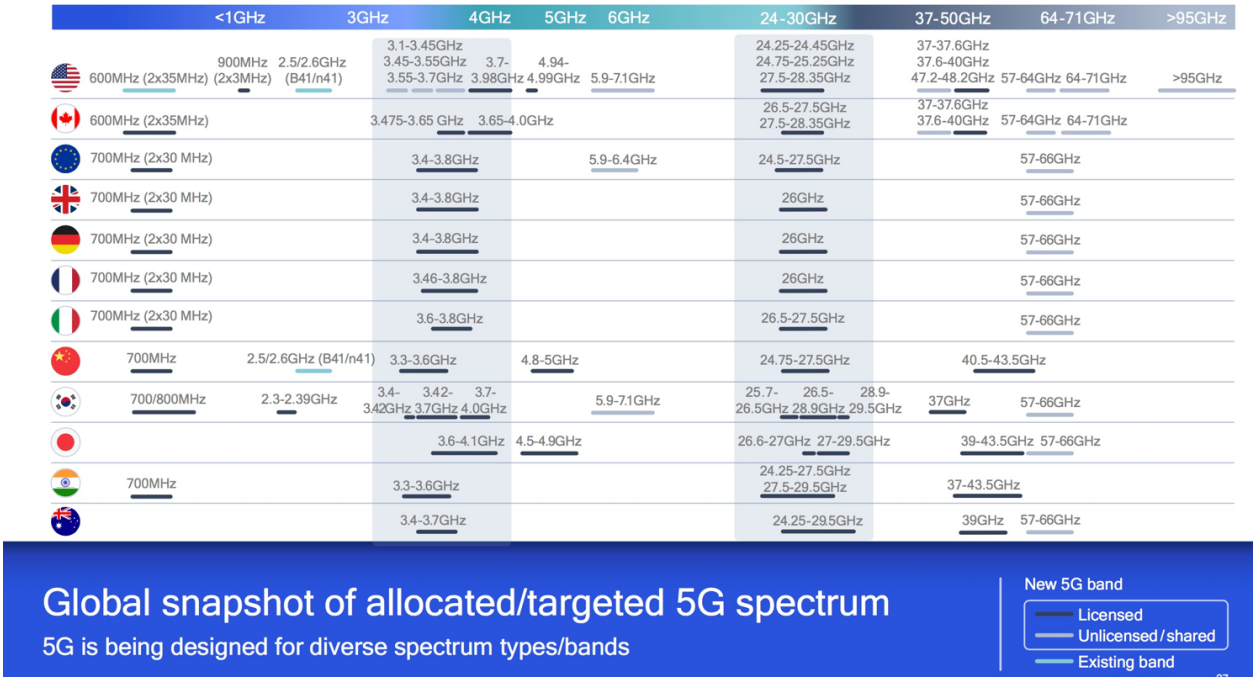
NR FR2 Band	Band Alias	Uplink (UL) Operating Band BS Receive / UE Transmit F_{UL_low} – F_{UL_high}	Downlink (DL) Operating Band BS Transmit / UE Receive F_{DL_low} – F_{DL_high}	Bandwidth	Duplex Mode
n257	28 GHz	N/A	26500 – 29500 MHz	3000 MHz	TDD
n258	26 GHz	N/A	24250 – 27500 MHz	3250 MHz	TDD
n259	41 GHz	N/A	39500 – 43500 MHz	4000 MHz	TDD
n260	39 GHz	N/A	37000 – 40000 MHz	3000 MHz	TDD
n261	28 GHz	N/A	27500 – 28350 MHz	850 MHz	TDD
n262	48 GHz	N/A	47200 – 48200 MHz	1000 MHz	TDD

Source: 3GPP and www.sqimway.com/nr_band.php. Updated to June 2021

The key global 5G spectrum bands are summarized in Exhibit 38 below. The key pioneer 5G bands are in 3.4 to 3.8 GHz band and 24 to 28 GHz for the mmWave. In time, many legacy IMT bands will be converted to 5G use. It should be noted that in addition to these global spectrum bands, the following apply in regional terms:

- the USA is supporting 600 MHz, 2.6 GHz and 3.5 GHz bands for 5G;
- the EU supports the lower APT700 duplex, 3.5 GHz and 26 GHz band for 5G;
- globally the 4.4 GHz band (n79) is gaining considerable support following their allocation in China and Japan; and
- while China has endorsed 2.6 GHz with large allocation to China Mobile of 160 MHz, and it's new fourth 5G licensee, China Broadcasting Networks will deploy 5G in the 700 MHz and 4.4 GHz bands.

Exhibit 38: Key Global 5G Bands



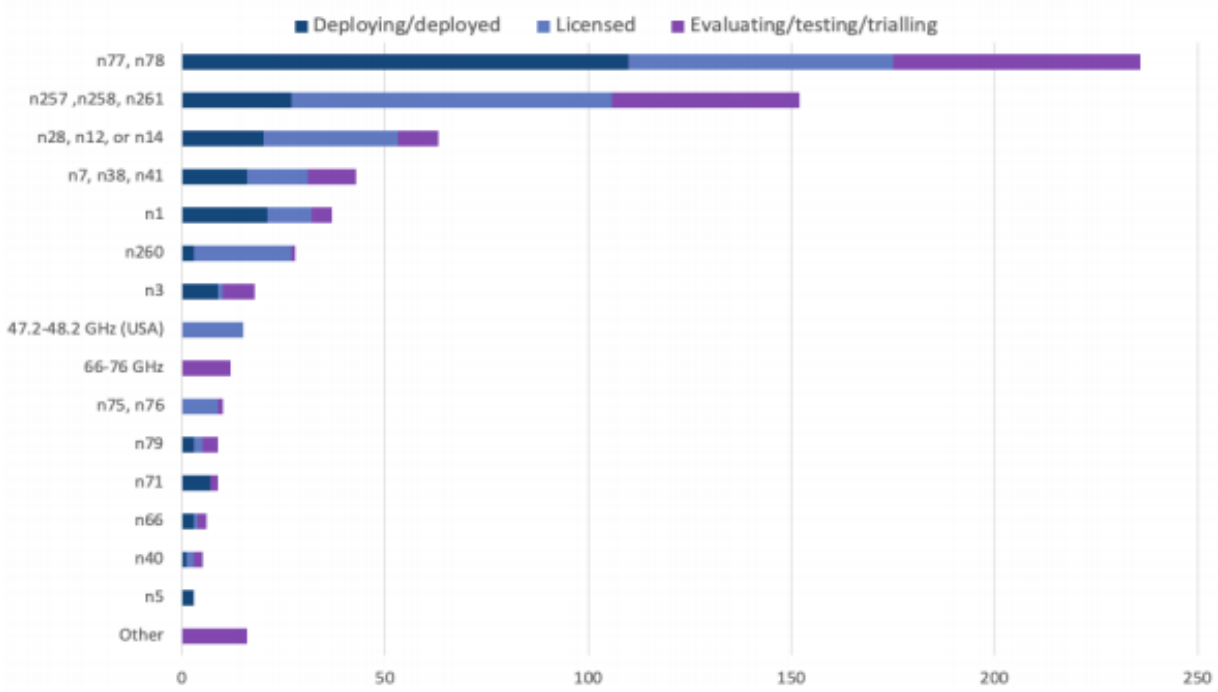
Source: Qualcomm, *5G spectrum innovation and global update*, 8 December 2020, page 27

5.3 Overall assessment of key 5G bands for Pakistan

Presently, global 5G deployments are mainly occurring in a limited number of key spectrum bands. As at mid-April 2021, the GSA had identified nearly 250 operators investing in the C-Band (specifically the overlapping bands n77 and n78).[94] Approximately 120 of those operators are identified as have deployed or are deploying networks in the 3.5 GHz band (ie Bands n77 or n78). Over 150 operators have been identified by the GSA as investing in mmWave 5G deployments within 24.25-29.5 GHz (Bands n257, n258 or n261). The most popular 5G spectrum bands for 5G network deployments are shown in Exhibit 39 below.

[94] GSA, *5G Market: Snapshot,* April 2021

Exhibit 39: Global 5G deployments by spectrum band (mid-April 2021)



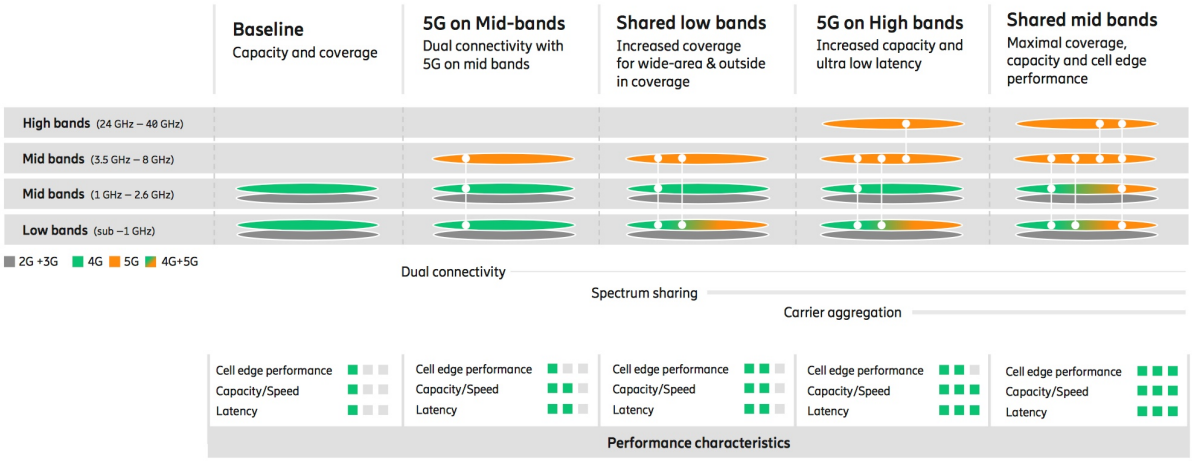
Source: GSA, 5G Market: Snapshot, April 2021, Page 4

Any assessment of the key bands for 5G in Pakistan also needs to acknowledge the following:

- that ideally, an MNO will require low band (up to 1 GHz) spectrum, mid-band spectrum (1-6 GHz) and high-band (>6 GHz) IMT spectrum as part of its spectrum portfolio and;
- that over time, legacy IMT bands including *inter alia* 1800 MHz (n3), and 2100 MHz (n1) would be used for 5G services subject to any technical and regulatory considerations.

As shown in Exhibit 40, there are a number of different strategies which can be adopted by MNOs depending on their view on demand, current traffic patterns, current IMT spectrum holdings etc. Global spectrum harmonization and the development of the device and equipment eco-system are important external factors. Considering how 5G coverage and capacity can be provided to Pakistan consumers should be a key factor in the PTA/FAB's release of additional spectrum bands.

Exhibit 40: 5G Spectrum strategy



Source: Ericsson, 2018[95]

With these considerations, this study will assess the following spectrum bands for 5G services in Pakistan, namely:

- 3.5 GHz band (n77/78);
- mmWave (26/28 GHz) (n257/258/261);
- 700 MHz (n28);
- 2.3 GHz (n40);
- 2.6 GHz (n41);
- L-band (1.5 GHz namely n75/76);
- 6 GHz band; and
- Others.

Given the possibility of utilising dynamic spectrum sharing (DSS) the following legacy bands will also be assessed:

- 1800 MHz (n3); and
- 2.1 GHz (n1).

In relation to the bands in consideration in Pakistan we would make the following 3 points:

(i) While 3.5 GHz (n78) is preferred in global terms, given as it is only currently vacant from 3.3 to 3.4 GHz then the easiest next band to release is n40 (2.3 GHz TDD) as it is vacant. As soon as clearance issues in n41 (2.6 GHz) band are resolved it should be auctioned and assigned;

[95] Ericsson, *5G Deployment considerations*, 2018. Available at www.ericsson.com/4a5daa/assets/local/networks/documents/5g-deployment-considerations.pdf

(ii) Given the overlap between n28 (APT700) and n20 (800 MHz), it is not possible to fully allocate both bands for 5G unless only the lower duplexer of band n28 (2 x 30 MHz) was to be utilised (like in the EU). While this approach would provide two lots of 2 x 30 MHz of spectrum to be allocated, given cost considerations it would be more optimal for Pakistan to adopt the APT700 band plan and have 2 x 45 MHz to allocate in one block. Later on, depending on ASO and securing the second digital dividend, the 600 MHz band (n71) could be made available; and

(iii) It should be noted that there are recent studies in the SAARC region suggesting significant economic and societal benefits from the release of mmWave spectrum.[96] On that basis, while it is unlikely to the IMT spectrum band which is first preferred by MNOs, the release of such spectrum need not be delayed in Pakistan.

The challenge is to release IMT spectrum at reasonable prices in a way which reflects the new spectrum paradigm that (i) larger contiguous blocks of IMT spectrum are needed and (ii) in overall terms with release of 5G NR, especially post WRC-19, the total of IMT spectrum needed by an individual MNOs and the market overall will significantly rise. Pakistan can avoid the challenges that other countries are facing in relation to legacy spectrum management decisions (ie like small fragmented spectrum blocks) if the country takes good decisions now in relation to the release of future IMT spectrum. Being later to allocating key IMT spectrum capacity bands such as the 2.3, 2.6 and 3.5 GHz bands has its advantages!

5.4 Individual assessment of 5G Bands for Pakistan

5.4.1 3.5 GHz Band

As detailed in section 5.1, the 3.5 GHz band (3.3 – 3.8 GHz)[97] is a pioneer 5G band globally . Due to its propagation characteristics and the potential for large contiguous bandwidths, the 3.5 GHz band is an ideal frequency band for 5G as it is able to provide both capacity (data bandwidth) and coverage (propagation distance). High-speed wireless broadband services need to be capable of delivering peak download speeds of at least 20 Gbps, a reliable 100 Mbps user experience data rate in urban areas, and 4 ms latency. The 3.5 GHz band is therefore key for delivering eMBB and FWA, and to enable good 5G service performance. It should be a core spectrum band for 5G deployment in Pakistan.

In the Pakistan context, it is important to highlight that 3.6 to 3.8 GHz is not available as it is use by the Pakistan Satellite Agency.

It is also important to highlight that the 3GPP has also agreed upon a number of LTE-NR sharing combinations where the upload direction of some low frequency legacy bands (e.g. 700, 800, 900, 1800 and 2100 MHz) are paired with the 3.3 – 3.8 GHz band. Deployment of such sharing combinations would be useful in the Pakistani context if existing MNO licensees were able to secure 3.5 GHz spectrum. Over the past three years, many national regulators globally have either assigned the 3.5 GHz band spectrum for mobile (IMT) services or have started preparations to do so see Exhibit 41 below). There is also a rapidly growing ecosystem of 5G devices, setting the stage for successful network deployments and consumer adoption.

[96] Refer to www.gsma.com/spectrum/resources/mmwave-5g-a-digital-india-cornerstone/
[97] In 3GPP terms it is n77/78.

Exhibit 41: Global Status of 3.5 GHz band allocations (as at August 2021)

Assignment Completed	Planned/Under consultation
Ireland (May 2017)	Poland (August 2021)
Czechia (July 2017)	Brazil (August 2021)
Slovakia (October 2017)	Macedonia (H2 2021)
UK 3.4 GHz (April 2018)	Norway 3.6 GHz (September 2021)
South Korea (June 2018)	Mexico (September 2021)
Spain (July 2018; February 2021)	Romania (Q3, 2021)
Latvia (September 2018)	Lithuania (2021)
Lesotho (October 2018)	Ukraine (late 2021)
Finland (October 2018)	Nigeria (Q4 2021)
Italy (October 2018)	Colombia (Q4 2021)
UAE (November 2018)	Uzbekistan (2021)
Oman (December 2018)	Slovakia (2021)
Australia (December 2018)	Estonia (2021)
Qatar (January 2019)	India (late 2021)
Switzerland (February 2019)	South Africa (Auction delayed - 2021)
Saudi Arabia (March 2019)	Ecuador (2021)
Austria (March 2019)	Netherlands (2022)
Japan (April 2019)	Thailand (2022)
Germany (June 2019)	Bangladesh (2022)
Mexico 3.5 GHz (October 2019)	New Zealand (2022)
Hong Kong (October 2019)	
Taiwan (December 2019)	
China (February 2020)	
Singapore (April 2020)	
South Africa (April 2020 - temporary)	
New Zealand (May 2020)	
Hungary (March 2020)	
Luxembourg (3.6 GHz only) (July 2020)	
United States (August 2020)	
France (October 2020)	
Croatia (November 2020)	
Greece (December 2020)	
Sweden (January 2021)	
Chile (February 2021)	
Slovenia (April 2021)	
Bulgaria (April 2021)	
UK 3.6-3.8 GHz (April 2021)	
Denmark (April 2021)	
Belgium (provisional licences May 2021)	
Malaysia (to SWN July 2021)	
Croatia (August 2021)	
Canada (August 2021)	
Portugal (Auction ongoing)	

Source: GSMA, August 2019 as updated by WPC, August 2021 and GSA, Spectrum Auctions Calendar, June 2021

The minimum block size to take advantage of 5G NR, support competition and allow MNOs (in relation to the 3.5 and 2.3/2.6 GHz band) to utilize 4G or 5G should be 50 to 60 MHz,[98] with lot sizes being 10 MHz.[99]

While 80 to 100 MHz of mid-band spectrum for 3.5 GHz spectrum is ideal, a similar minimum block size applies in relation to this band in order to get the benefits of 5G in this 5G only band. For competition reasons, a single MNO should not be able to monopolise the entire 100 MHz which is available initially in this band. The spectrum licences should contain a requirement to refarm the 3.5 GHz band into larger contiguous spectrum blocks post the availability of additional spectrum in that band (ie post 2024 or earlier if WLL licensees hand back spectrum).

Ideally 110 MHz (ie 3.3 to 3.410 GHz) could be made available initially in 2022 (which could be offered in two lots of 50 and 60 MHz respectively), then post 2024 the available spectrum in the band could be extended to say 3560 MHz (if a guard band is needed to the Government use which starts at 3585 MHz). This would free up another 150 MHz of the 3.5 GHz band in 2024 which is excellent from a 5G deployment and broadband speed perspective. Thus a total of 260 MHz of this band could be made by 2024.

Recently, all of the Pakistani MNOs have recommended to the Government that the availability of spectrum in this band (including 3.3 to 3.4 GHz) should be accelerated.[100]

5.4.2 mmWave - 26 and 28 GHz bands

The 26 GHz (n258) and the 28 GHz bands (n257), being 24.25–27.5 GHz, and 26.6 – 29.5 GHz respectively and known as mmWave[101] are the second most popular bands for the delivery of 5G wireless broadband services globally. Importantly the 26 GHz is preferred for any IMT allocations in Pakistan given the ecosystem and regional satellite use in the 28 GHz band.

It should be noted in markets with significant rainfall, there are concerns about the impact of rain attenuation even for 5G small cell sizes using mmWave spectrum given recent operator experiences and technical studies. In Pakistan, some northern parts of the country receive more than 1,400 mm of rain a year. More specifically, in certain urban markets where mmWave would be most useful, mmWave service would be materially affected in the monsoon season which generally lasts from mid-June through September (see Exhibit 42 below). Some other parts of the country do have low average rainfall below an average of 400 mm per year which would make them more suitable for year round mmWave use.

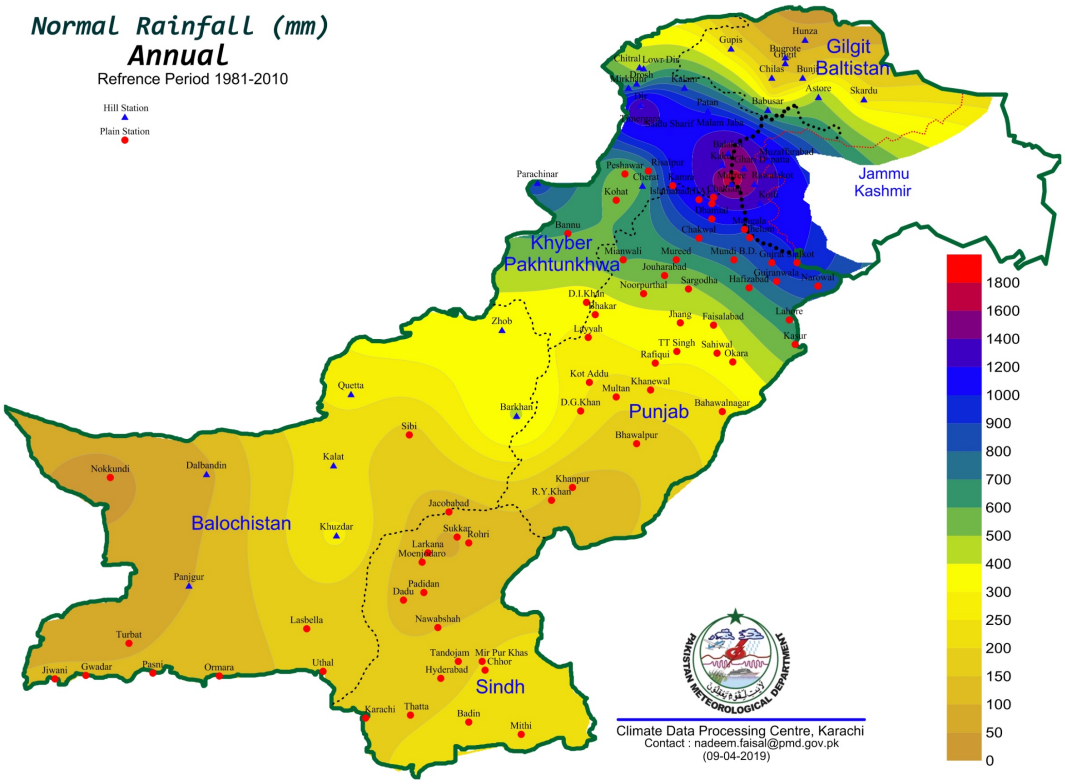
[98] GSMA, *Roadmap for C-Band spectrum in ASEAN*, August 2019, page31

[99] Ideally the 2.6 GHz band would be sold into 2 lots of 100 and 90 MHz respectively to support high speed broadband while the 2.3 GHz band should be sold in 2 lots of 50 and 40 MHz.

[100] Jazz, Telenor, Zong and PTCL & Ufone, *5G Readiness Plan for Pakistan* letter, 19 July 2021, page 2

[101] mmWaves span 30 to 300 GHz (i.e. a wavelength of 1 cm to 1 mm), however, in the current 5G context, mmWave bands in consideration span from around 24 GHz up to 86 GHz.

Exhibit 42: Mean Annual Rainfall in Pakistan



Source: www.pmd.gov.pk/cdpc/home.htm

Given what we understand the availability of mmWave spectrum in the 26 and 28 GHz bands in Pakistan, there may be a case for making certain mmWave spectrum available for current WLL licensees. Likewise, mmWave spectrum should be made available for enterprise customers – see the discussion in section 5.6.

5.4.3 2.3 GHz band

The 2.3 GHz band has recently become a 5G spectrum band and is only the 13th most popular band for 5G network deployments. It is however, the most popular TDD band for 4G deployments globally and industry sources in Pakistan[102] have indicated that smartphones supporting band are some of the most popular already in Pakistan. Pakistani MNO have recently argued that the 2.3 GHz band should be the first band allocated to the MNOs to test the consumer appetite for high bitrate wireless broadband services.[103] One of MNOs has indicated that 67% of LTE handsets on their network supported Band 40.

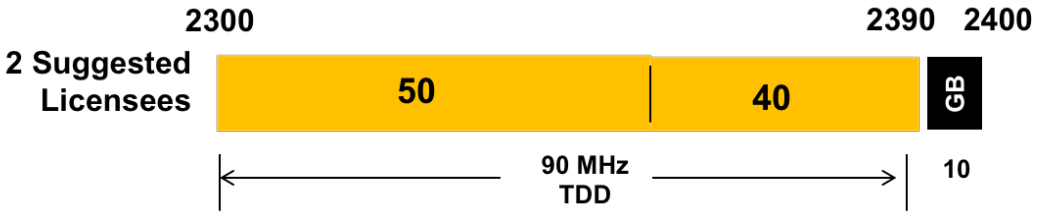
In relation to 5G, this is likely to change quickly going forward because it is a large TDD band of 90 MHz, good propagation characteristics and can be re-farmed in number of global markets for 5G. Early MNOs deploying 5G in this band include Telkomsel in Indonesia, STC in Saudi Arabia and Singtel Optus in Australia. Device support for 5G services in n40 is also increasing.

[102] GSA, *LTE Ecosystem Report Status Update*, October 2020, page 3. Note the Rolling Spectrum Strategy report on page 17 is incorrect/outdated when it states "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."
[103] Jazz, Telenor, Zong and PTCL & Ufone, *5G Readiness Plan for Pakistan* letter, 19 July 2021, page 2

In Pakistan, this band is currently vacant and the PTA/FAB confirm it is available for assignment in the near term.

The key challenge with the typical allocations is that they are too small for a 5G deployment and integrated 4G/5G networks. Consideration should be how the band could be re-farmed so that at a maximum, there will be two licensees who would have 50 and 40 MHz respectively (see Exhibit 43 below). Though this is not optimal from a spectrum perspective, a larger spectrum allocation will permit higher bandwidth 5G services than trying to deploy 5G say, in a 20 MHz spectrum block.

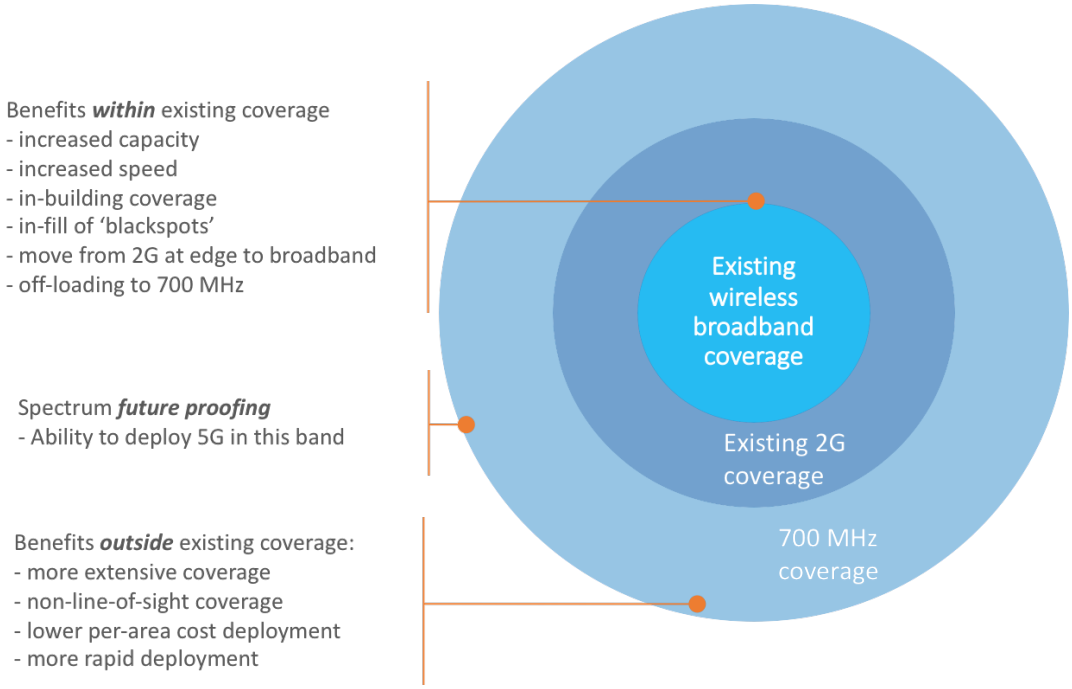
Exhibit 43: Suggested 2.3 GHz Band plan for 5G services



5.4.4 700 MHz band

Harmonized spectrum below 1 GHz, particularly 700 MHz frequency band, is very useful. This is because the propagation characteristics of this band provide greater geographic reach or coverage and better in-building penetration relative to higher IMT bands. With greater reach, the number of cell sites needed to serve an area is significantly less compared to higher frequencies such as 1.8, 2.1 and 3.5 GHz or mmWave spectrum are used (see Exhibit 44 below).

Exhibit 44: Benefits of 700 MHz deployment over existing IMT spectrum bands



Source: GSMA, 2018 with updating modifications by the WPC, April 2020

This fact, which has been well analysed and modelled, translates to lower deployment (both capital expenditures and operating expenditures) costs for mobile operators, and hence more affordable services to Pakistani consumers. 700 MHz spectrum is particularly attractive in this role because it means that services can be provided to rural and remote communities at significantly lower capital cost, and therefore at lower ongoing operating costs.

The other advantage is that the 700 MHz band is becoming the affordable coverage layer for future 5G services globally. This follows the December 2016 designation by the European Union (EU) of the 700 MHz as a 5G band.[104] The view from the European Commission's Radio Spectrum Policy Group in Europe in relation to 5G services in 2018 was that:

> *"The 700 MHz band can be used to provide wide area coverage, the 3.6 GHz band can be used to provide high capacity and coverage, using both existing macro cells and small cells. The 26 GHz band is likely to be deployed in areas with very high demand, for example transport hubs, entertainment venues, industrial or retail sites and similar."*[105]

While the original plan was for all EU member states to release the 700 MHz for 5G by June 2020, this deadline is being postponed in some markets. While delays were already occurring in certain markets, the current COVID-19 pandemic and associated lockdowns which has made planning and carrying out spectrum auctions difficult.[106] In addition to Europe, a range of other markets including China,[107] India, Thailand, and South American markets will utilize the 700 MHz band for 5G as well as 4G services.

It should also be noted that based on information from the GSA, the 5G device ecosystem support for the 700 MHz band (APT700) is strong as it is the fourth most popular band overall.[108] It is also the most supported sub-1 GHz band; suggesting that it is currently the preferred global 5G coverage band.

This emphasizes that allowing 700 MHz spectrum to be used for 5G services in Pakistan is a forward looking approach. The Rolling Spectrum Strategy notes that band is currently used by government systems and there is a need to refarm this band.[109] Pakistani MNOs have recently argued that the 700 MHz band should be made available in order to allow for the rural penetration of 5G services.[110]

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[104] See http://europa.eu/rapid/press-release_IP-16-4405_en.htm

[105] EC, Radio Spectrum Policy Group, *Strategic Spectrum Roadmap towards 5G for Europe: RSPG Second Opinion on 5G networks, RSPG18-005 FINAL*, 30 January 2018.

[106] See https://5gobservatory.eu/observatory-overview/5g-scoreboards/

[107] 2 x 40 MHz of 700 MHz spectrum was allocated by MIIT on 2 April 2020 to China Broadcasting Network (SBN) for 5G services subject to the spectrum clearance. See www.commsupdate.com/articles/2020/04/02/miit-clears-the-way-for-5g-on-700mhz-band/

[108] GSA, *5G Ecosystem Report, Member Report, December 2020*

[109] Refer to Rolling Spectrum Strategy report, page 17

[110] Jazz, Telenor, Zong and PTCL & Ufone, *5G Readiness Plan for Pakistan* letter, 19 July 2021, page 2

5.4.5 2.6 GHz Band

The reference in the Rolling Spectrum Strategy to the 2500MHz band is noted. It refers to the 2500 MHz band as "…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)."[111]

For Pakistan, the adoption of Band 41 TDD is strongly supported as exemplar spectrum management practice especially in 2021.[112] Such an approach is also consistent with the global and regional growth of 5G services and with Pakistan's 5G aspirations as the 2.6 GHz is a more affordable band to deploy services. Deploying TDD in this band is sensible and prudent given strong demand for 4G wireless broadband and future 5G services in the country's key domestic urban markets of Lahore, Karachi etc.

It should be noted that other key global markets have also endorsed TDD Band 41 for the 2.6 GHz band and licensed spectrum accordingly. In particular, it is critical to highlight that the USA, China, India, Japan, Philippines, and Thailand have also supported Band 41 TDD band plan and licensed spectrum in this band. This means that markets representing significantly more than half of the world's population support TDD Band 41. In addition in the past three years, Indonesia, Vietnam, Bahrain, Jordan, South Africa and Myanmar have all transitioned from the old legacy hybrid FDD/TDD bandplan (b7/38) to band 41.

It should also be noted that in relation to ASEAN, countries representing more than more than 90 percent of ASEAN's 667 million consumers will use band 41.

The Rolling Spectrum Strategy states that in Pakistan, the 2500MHz band (note this should be a reference to the 2600 MHz as this is the reference for this band globally except for the USA) "… is currently occupied by Southern Network Limited (SunTV) for operating its MMDS system that is used to deliver Pay-TV services.[113] 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. The Government in its Policy Directive for Test & Trials of Future Technologies has also identified it as potential band for IMT deployment in Pakistan."[114] Pakistani MNOs have recently argued that the part of the 2.6 GHz band which is not subject to litigation should be made available.[115]

While we would assume that the 2.6 GHz spectrum band once cleared would be auctioned (preferably in 10 MHz blocks), there would also be considerable value from a spectrum management and economy perspective if the allocations to the MNOs were sufficiently large enough to support 4G and 5G services. If the 2.6 GHz band was unable to be allocated to two MNOs (if, for example, it was offered concurrently with the 2.3 and/or 3.5 GHz bands) then the following band plan would be a good balance between deploying 5G and ensuring sector competition (see Exhibit 45 below).

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[111] Ibid.

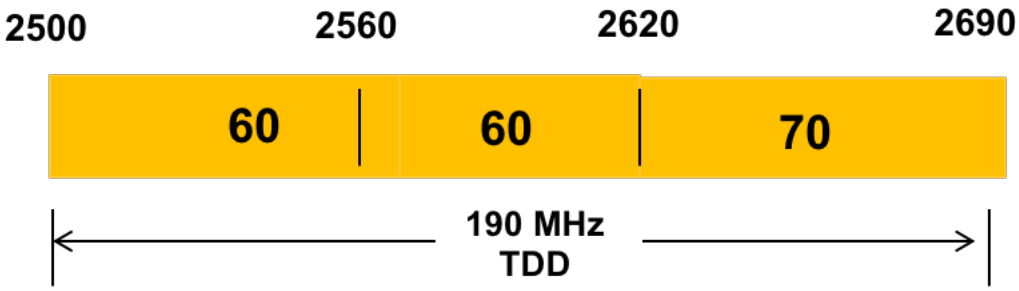
[112] For a more detailed analysis of the benefits of endorsing Band 41 refer to WPC, *Powered Evolution to 5G: The compelling case to adopt and/or transition to LTE Band 41 in the 2.6 GHz spectrum band in Asia and globally*, October 2018.

[113] 2550-2690 MHz is under litigation but court has granted a stay in the case since 2008. There is a need to accelerate the resolution of this court case.

[114] Refer to Rolling Spectrum Strategy report, page 17

[115] Jazz, Telenor, Zong and PTCL & Ufone, *5G Readiness Plan for Pakistan* letter, 19 July 2021, page 2

Exhibit 45: Possible allocations in the 2.6 GHz band (n41)



5.4.6 L-Band (1.5 GHz)

At WRC-15, the entire 1.5 GHz band (1427–1518 MHz) (n50/51) was harmonized for IMT within ITU Regions 2 and 3. WRC-19 agenda item 9.1.1 considered the compatibility of IMT and broadcasting-satellite service (sound) in the frequency band 1452–1492 MHz in Regions 1 and 3 as detailed in Resolution 761 (WRC-15).

At WRC-19, it was decided to retain and modify Resolution 761 (WRC-19) to define restrictions and coordination triggers on BSS (sound) in order to protect IMT. Limits on IMT emissions from IMT near country borders were also introduced. Recommendation ITU-R M.1036 was updated to include frequency arrangements for implementation of the terrestrial component of IMT in the 1.5 GHz band. This includes a footnote to indicate studies are still being conducted in accordance with Resolution 223 (Rev.WRC-15) to provide possible technical measures to facilitate adjacent band compatibility. This work is underway in Working Party 5D and may result in a revision to the frequency arrangements contained in Recommendation ITU-R M.1036.

The Rolling Spectrum Strategy states that the "PTA/FAB is prepared to make this band available in the longer term when deployment begins in other markets and equipment becomes available"[116] However, subsequent checking has found that the current use of this band nationwide by Pakistan Railways continues.[117] While Pakistan Railways was advised by FAB in 2015/16 to move to alternate frequencies no migration plans have been prepared and as such there is no availability of this band in the near future.

5.4.7 6 GHz Band

The 6 GHz band represents another opportunity for Pakistan to allocate spectrum for 5G use. The 6 GHz band is ideally suited to meet 5G future capacity needs as it has similar coverage possibilities as the 3.5 GHz band which can support 5G services. It also complements current mid-band spectrum for IMT.[118] Currently, the band has multiple uses in Pakistan including microwave links, so we understand that the band would first need to be cleared for alternative use.

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[116] Ibid, page 16
[117] Pakistan Railways has 235 fixed point to point links along the railway tracks using these frequencies.
[118] *6 GHz IMT for 5G Evolution in APAC*, May 2021.

However, globally there is a debate over the optimal use of the 6 GHz band. So far, countries have taken varying approaches. In the United States, the FCC voted in 2020 to use 1200 MHz in the band to create WiFi 6E.[119] Conversely, China intends to use the entire 1200 MHz in the 6 GHz band for 5G. The EU has partitioned the 6 GHz band releasing 480 MHz of 6 GHz spectrum for WiFi use (see Exhibit 35).[120] Each EU member state must update their national frequency allocation plans to reflect the above decision before 1 December 2021. The EU decision has already been implemented in Germany and the France has commenced industry consultations.[121] Africa and parts of the Middle East also intend to split the band, with the upper part for 5G/IMT and the bottom 500 MHz for WiFi.[122] Other countries including Australia and Malaysia are still studying the issue.

While the 6 GHz band can be used to quadruple the amount of spectrum available for WiFi and IoT devices,[123] there are compelling arguments that why the approach in Pakistan should be to partition the 6 GHz band between unlicensed (Wi-Fi etc) and licensed (IMT) uses. This is because of *inter alia*:

- Likely economic benefits of partitioned allocation of the 6 GHz band: The partitioned use of the band will short and long term economic benefits form the use of both improved IMT and enhanced Wifi; and
- A large allocation of 6 GHz spectrum to WiFi does not, of itself, address the digital divide: The allocation of the entire 6 GHz band for unlicensed use does not provide additional coverage and help bridge the region's digital divide which COVID-19 pandemic has highlighted is a key public policy issue. It merely results in excellent short range connectivity to users who have, for example fibre connectivity; and
- Strong regional FWA growth supports an IMT allocation in the 6 GHz band in Pakistan: Growth in 4G and 5G FWA in Asia-Pacific region (which has underdeveloped fixed network infrastructure especially fibre deployments) would be supported by reservation of additional mid-band spectrum in the 6 GHz band. It is expected that a key use for 5G in Pakistan will be FWA service offerings.

The optimal approach for Pakistan therefore would be to partition the 1200 MHz between IMT and WiFi to realise the benefits of both (see Exhibit 45).

[119] The Verge, *Wi-Fi is Getting Its Biggest Upgrade in 20 Years,* 23 April 2020

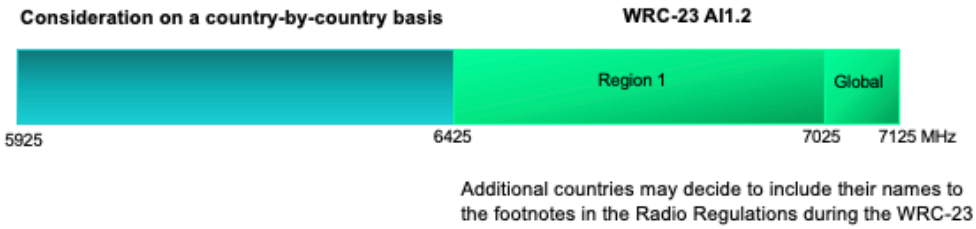
[120] Official Journal of the European Union: Legislation (Vol 64, 30 June 2021)

[121] Refer to: www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Allgemeines/Presse/Pressemitteilungen/2021/20210714_WLAN6GHz.pdf and www.arcep.fr/actualites/les-consultations-publiques/p/gp/detail/projet-decision-designant-frequences-bande-5945-6425-mhz-systemes-acces-sans-fil-incluant-reseaux-locaux-radioelectriques-300721.html

[122] GSMA, *GSMA Calls on Governments to License 6 GHz to Power 5G,* 17 May 2021.

[123] Renuka Rajaratnam, Facebook, *License Exempt Use of 6 GHz: Value and Progress,* May 2021

Exhibit 46: Suggested Optimal Spectrum Use of 6 GHz band in Pakistan



Source: APT, May 2021

WRC-23 will be a great opportunity to ensure spectrum harmonisation for IMT and help develop the ecosystem. Prior to this, Pakistan could still engage in preparatory work for the repurposing of the band and could allocate the lower part of the band to WiFi.

5.4.8 Other bands

Due to support from markets like China and Japan, the 4.4 GHz band (n79) (which goes from 4.4 to 5.0 GHz) has seen rising support. At the present time, this band is not available in Pakistan as it has been assigned to Government users including for PPDR with multiple deployments across Pakistan. As such, there is no possibility of its release in the near future.

We also note that other legacy IMT bands like 850 MHz (n5) and 900 MHz (n8) will also support 5G and maybe useful as a 5G coverage layer going forward.

5.4.9 Legacy spectrum bands – using Dynamic Spectrum Sharing (DSS)

Dynamic spectrum sharing (DSS) allows MNOs to use the same spectrum bands for different radio access technologies. From 2020, all the major vendors – Ericsson, Huawei and Nokia - support DSS with some variations. Announced in relation to 5G in late 2019, equipment vendors have positioned it primarily as a way to help MNOs evolve their 4G networks to support 5G in the face of finite or expensive spectrum in a market.

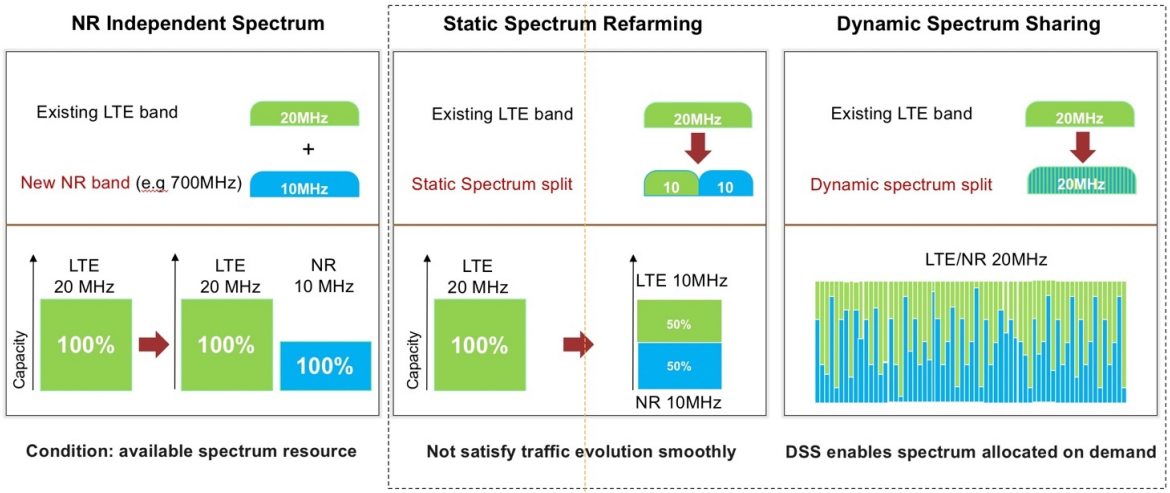
Though some MNOs will prefer from an engineering perspective to dedicate separate frequency bands to 4G and 5G (or have amble spectrum holdings which allows them to do this), DSS allows them to share the same spectrum assignment and to 'adjust' the amount of spectrum available to each technology based on user needs that are assessed in real time and rapidly changing. [124]

DSS has particular relevance for MNOs that are deploying 5G in existing low- or mid-band spectrum such as 1800 and 2100 MHz (see Exhibit 47 below) in order to achieve broad coverage with 5G services while making more efficient use of their existing spectrum holdings. Some vendors support DSS for both standalone and non-standalone networks

[124] Refer to www.mobileworldlive.com/huawei-updates/dynamic-spectrum-sharing-dss-an-update-on-recent-vendor-activity; www.fiercewireless.com/tech/ericsson-china-telecom-test-5g-standalone-dss-call-over-2-1-ghz and www.lightreading.com/5g/nokia-disses-dss-naysayers/d/d-id/758789

(SA/NSA) and others for triple mode operations (2G or 3G/4G/5G). At least Huawei will support non-standard bandwidth allocations.[125]

Exhibit 47: Options to deploy 5G NR (Indicative)



Source: Huawei 2020

For Pakistani MNOs, depending on age of the network equipment, there are options to utilize DSS in order to support the early launch of 5G services should their current spectrum not be fully utilized under current load conditions and the 5G devices are available. Note there are some disadvantages of DSS as well: primarily, if sub frames are used very frequently for 5G NR it takes away resources from LTE users, reducing LTE user throughput.[126] The biggest challenge in Pakistan is that the MNO allocations in bands which could be used for DSS are small and are being heavily used to support existing voice and data traffic.

The additional 2.1 GHz spectrum allocations which are soon to be auctioned could be used for both 4G and 5G services. Notably, in July 2021, the IMDA released a consultation paper enabling the potential use and allocation of the 2.1 GHz spectrum band for 5G in Singapore.[127] Currently, 2.1 GHz (n1) is the third most support band on 5G devices even though it is only the fifth most popular network currently being deployed. Ideally, any new assignments in this band to MNOs would be done on a contiguous basis (albeit this may result in a need to refarm the band).

5.4.10 Recommended Way Forward in relation to spectrum for 5G

In addition, given device availability and affordability and the focus on Pakistan's urban areas first (given available backhaul and higher income levels), the optimal 5G bands for

[125] Refer to https://finance.yahoo.com/news/huawei-releases-hybrid-dss-scenario-190000669.html

[126] Refer to https://blog.viavisolutions.com/2020/08/12/dss-the-5g-deployment-x-factor/

[127] Refer to https://www.imda.gov.sg/news-and-events/Media-Room/Media-Releases/2021/IMDA-To-Make-Available-New-5g-Spectrum-Bands-To-All-Mobile-Network-Operators

Pakistan are the 3.5 GHz (n78) and the 2.3 GHz (n40) bands. Both are TDD capacity bands and available now.

In the next phase, making the 2.6 GHz band (n41) available would add additional 4G/5G capacity spectrum in urban areas; while the 700 MHz (n28) band is optimal for coverage and would help to extend 4G/5G services outside Pakistan's cities/towns. The 2.6 GHz band could be concurrently released with the 2.3 GHz band if so desired.

While the 3.5 GHz band can only be used for 5G, the 2.3, 2.6 GHz and 700 MHz bands can be used for 4G and/or 5G as well. Thus the MNOs are able deploy 4G and then convert the band to 5G where possible based on device penetration, demand etc in Pakistan. mmWave could be made available to the market in 2022, if demand exists.

As only 110 MHz from 3.3-3.4 GHz band may be available until the WLL providers exit the band (2024 or if they can be enticed to leave earlier), the 2.3/2.6 GHz with 90 and 190 MHz respectively of available spectrum respectively maybe a preferred option for Pakistan.

The proposed phased timeline for the release of spectrum – which can be used for 5G is shown in Exhibit 48 below. Note Phase 1a and Phase 1b could be done simultaneously depending on the timing of the availability of 700 MHz spectrum. Exhibit 49 shows the annual releases of IMT Spectrum required to achieve the ITU's IMT Spectrum Target of 840 MHz (excluding mmWave spectrum).

Exhibit 48: Proposed Timeline for the release of IMT spectrum for 5G services

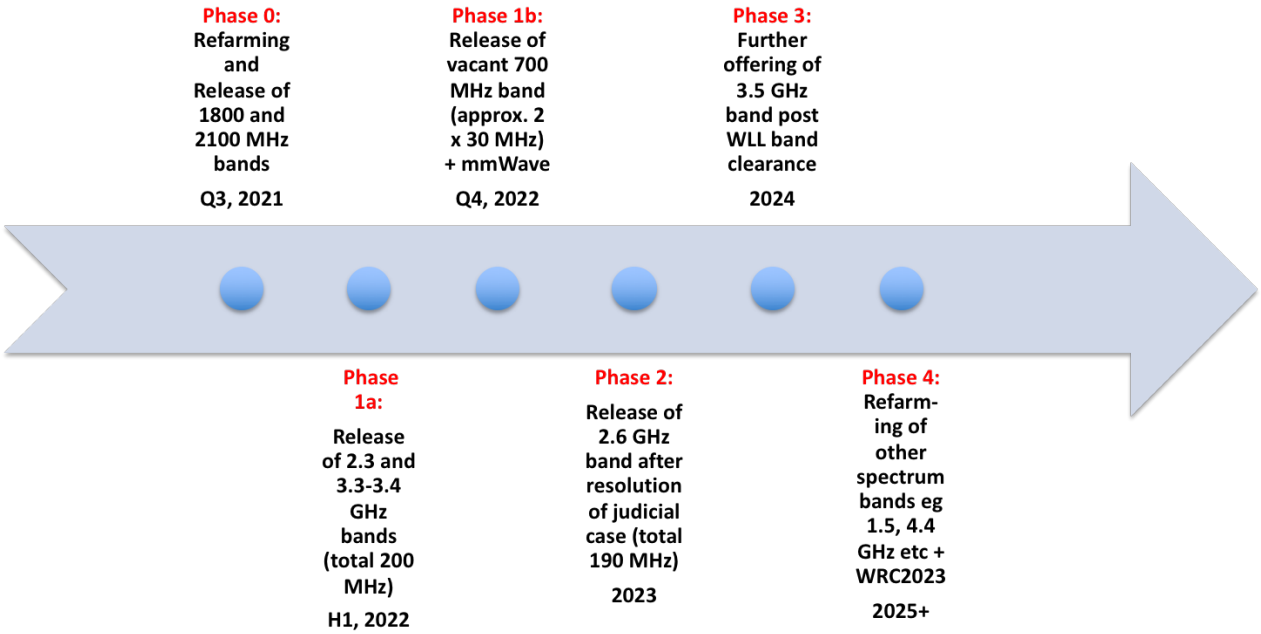
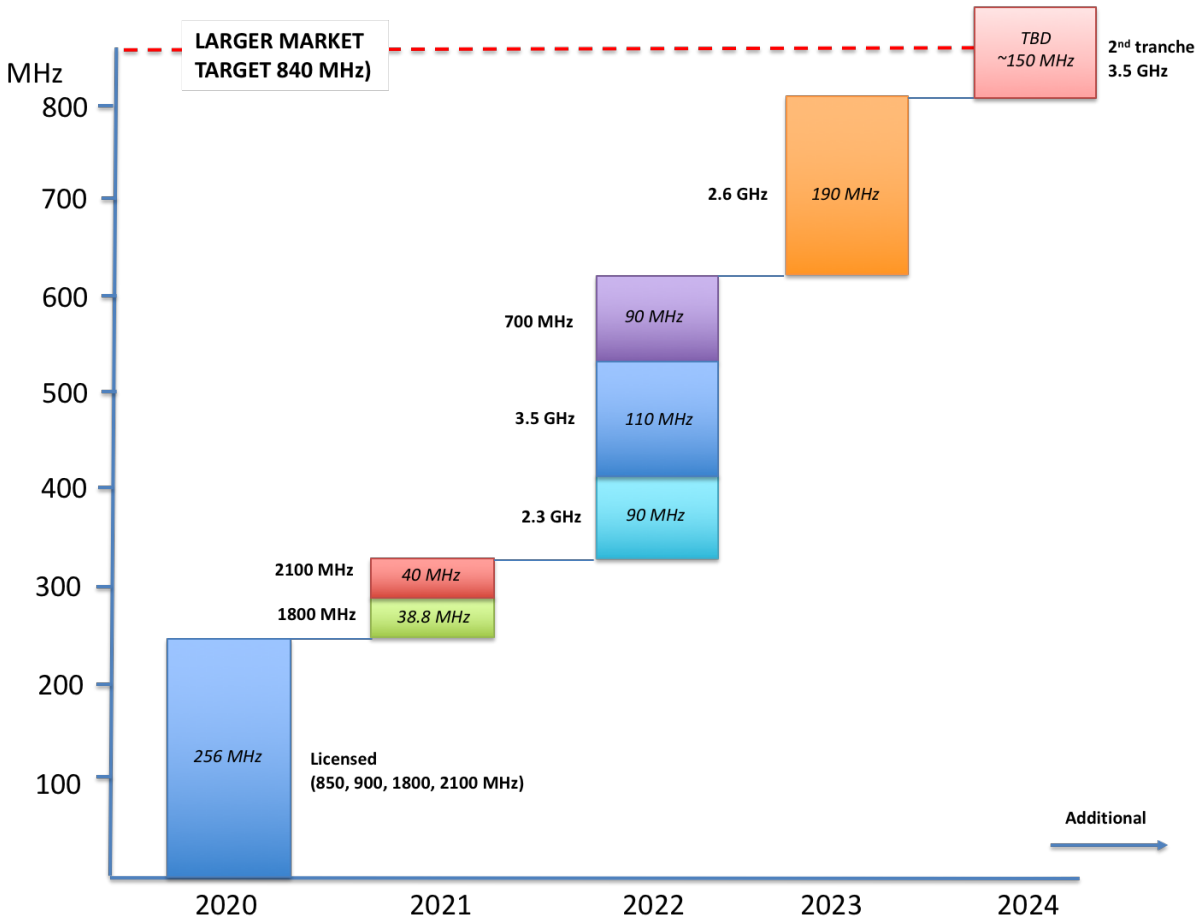


Exhibit 49: Annual releases of IMT Spectrum for 4G/5G to achieve the ITU IMT Spectrum Target of 840 MHz (excluding mmWave spectrum)



Note excludes mmWave spectrum. Source: WPC, March 2021, *Modified version of ITU, Guidelines for the Preparation of National Wireless Broadband Masterplans for the Asia-Pacific Region*, October 2012

5.5 Pricing of Spectrum Licenses

Spectrum auctions are widely considered to be the appropriate and most transparent approach to assign spectrum where demand exceeds supply. This typically happens in the case of the IMT spectrum bands. However, there are sub-optimal outcomes from poorly designed auctions — especially those with artificially high reserve prices — which should be avoided.

There is growing global recognition that high spectrum fees can discourage network deployment, and negatively impact on consumer affordability.[128] This is a particular concern with 5G given the costs of network provisioning and at least the initial pricing of 5G enabled smartphones and other devices. It is important to highlight that 5G capital expenditure will put more pressure on MNO whose real rates of return have been under pressure due to intense sector competition.

Given the above, to encourage 5G network rollout in Pakistan including investment in backhaul transmission to support higher end-to-end broadband speeds, it is critical that spectrum be priced at reasonable and sustainable levels. This has also been recognized in Singapore, in its recent decision on 5G spectrum licenses and the applicable spectrum fees (see Exhibit 50 over). The French regulator, ARCEP has also taken a similar approach.[129] China has also facilitated the allocation of 5G spectrum including the 2.6, 3.5 and 4.8 GHz bands to the major Chinese MNOs while Japan allocated 3.5 GHz and other 5G bands for free to its major MNOs based on their level of 5G rollout commitments.[130]

As previous spectrum prices in Pakistan reflected artificial scarcity, the reserve prices for the 3.5 and/or 2.6 GHz bands should be determined based on the independent spectrum auction consultant's study to incentivize early deployment. Critically to maintain strong 4 MNO competition, the price should be set so that the 'weakest' MNO can afford to buy additional IMT spectrum. The economic benefits of making additional 4G and 5G services available at reasonable prices in Pakistan significantly outweigh any revenue forego from maximizing 5G spectrum prices.

Such prices per MHz should be lower than the current 900/1800 MHz spectrum prices reflecting the larger quantum of IMT spectrum which is needed by MNO to provide high speed 4G/5G services and larger quantum of overall IMT spectrum which will be released. High spectrum prices will act to reduce the investment which the MNOs/other stakeholders need to make in 4G/5G network equipment, backhaul and tower infrastructure. Too expensive spectrum undermines Pakistan's ability to have leading regional wireless broadband services.

[128] Refer to www.gsma.com/publicpolicy/wp-content/uploads/2020/03/Realising_5Gs_full_potential_setting_policies_for_success_MARCH20.pdf. This is supported by the comments made by in Zong, *5G Readiness and Support Required from Government,* 22 June 2021, page 1–2.

[129] ARCEP proposed a mixed allocation mechanism, which does not rely on pure financial bidding. The procedure will include a first stage, in which up to four operators can obtain frequency blocks for optional commitments (aiming to ensure 5G fosters competitiveness in other sectors of the French economy, increase operators' transparency and stimulate innovation), before a second stage (auction), which will allow candidates to obtain additional frequencies. Each bidder will be allowed to purchase a maximum of 100MHz. See https://en.arcep.fr/news/press-releases/p/n/5g-4.html

[130] See www.soumu.go.jp/main_content/000593247.pdf

Exhibit 50: Singapore IMDA's 5G licensing framework

On 17 October 2019, Singapore's telecoms regulator, Infocomm Media Development Authority (IMDA) announced how it had decided to allocate 5G-suitable spectrum in Singapore.[131] It envisioned that half the city-state would be covered by a standalone network by 2022 to 'maintain competitiveness in developing technology'. The allocation of spectrum for nationwide deployment was done via a call for proposal ("CFP") approach, instead of an auction. This was in recognition that the auction mechanism would not be able to bring about the desired policy outcomes in this first wave of spectrum assignment.

Each operator was required to submit detailed proposals for their 5G deployment. IMDA scored and ranked the proposals according to the following: (a) network design and resilience (40%); (b) network rollout and performance (35%); (c) price offered for one lot of 3.5 GHz band (15%); and (d) financial capability (10%). The weights reflect their relative importance vis-à-vis IMDA's 5G policy outcomes. At the close of the CFP on 17 February 2020, IMDA had received three submissions: one from Singtel Mobile Singapore, one from TPG Telecom Pte Ltd, and one from the Joint-Venture Consortium (JVCo) formed by M1 Limited and StarHub Mobile Pte Ltd.

On 24 June 2020, following an assessment of the submissions, two operators were awarded the 3.5 Ghz Spectrum Rights: Singtel Mobile Singapore and the JVCo. Their spectrum rights come into force on 1 January 2021, and are valid until 31 December 2035.[132] TPG was applied for, and was ultimately assigned two 400MHz lots in the mmWave band.

The IMDA required each operator to pay a base price of SGD55 million (USD40 million) for one 100 MHz lot of 3.5 GHz band spectrum (for a standalone 5G network). Singtel submitted the winning assignment bid of SGD2,100,128 to be assigned its preferred 100 MHz lot.[133]

Fitch Ratings, a credit rating company, noted that Singapore's base price translates to USD0.07 per MHz per capita. This is below Hong Kong's latest 5G spectrum auction which stood at USDD0.09.

The minimum block size to take advantage of 5G NR and allow MNOs (in relation to the 2.6 GHz band) to utilize 4G or 5G should be 50 to 60 MHz, with lot sizes being 10 MHz. Ideally the 2.6 GHz band would be sold into 2 lots of 100 and 90 MHz respectively to support high speed broadband.

A similar minimum block size applies in relation to the 3.5 GHz band in order to get the benefits of 5G in this 5G only band. The spectrum licences should contain a requirement to refarm the 3.5 GHz band into larger contiguous spectrum blocks post the availability of additional spectrum in that band (ie post 2024 or earlier if WLL licensees hand back spectrum).

[131] IMDA, *Op cit*

[132] www.imda.gov.sg/-/media/Imda/Files/Regulation-Licensing-and-Consultations/Frameworks-and-Policies/Spectrum-Management-and-Coordination/M1-and-StarHub-35-GHz-spectrum-right-2-Nov-2020.pdf?la=en

[133] www.imda.gov.sg/regulations-and-licensing-listing/spectrum-management-and-coordination/spectrum-rights-auctions-and-assignment/5G-CFP-2020

In the mid band, ideally between 80 and 100 MHz of contiguous spectrum per mobile network operator should be awarded to support the services that can be provided over 5G networks such as eMBB.[134] However, it is important that there be competition in the provision of 5G services, such that allocation of say the 2.6 GHz band should not be to 2 MNOs (100 and 90 MHz respectively) if the 2.3 GHz band (90 MHz say to one MNO) is also not concurrently released. Alternatively, the 2.6 GHz band could be split into two lots of 60 MHz and one lot of 70 MHz depending on the quantity of 3.5 GHz spectrum available.

While 5G will be deployed in some countries in the mid-band with as little as 30 MHz, it is recommended should be a minimum bandwidth of 50 – 60 MHz per MNO in Pakistan. This in line with the outcomes of recent 3.5 GHz awards in Australia, Germany and the UK. This should help ensure good quality and competitive provision of 5G services in the near term while further work to release more mid-band spectrum continues.

In relation to high band spectrum (ie mmWave), while the GSMA supports up to 1 GHz of spectrum per MNO,[135] 200-400 MHz is a good starting point. The key point to emphasise is that price of such mmWave spectrum should be very low as the spectrum has little value until MNOs make significant (costly) investment in network deployment. One option would be for the PTA to bundle mmWave spectrum with 2.6 and/or 3.5 GHz spectrum in any allocations/auction process.

5.6 Possible allocation of 5G spectrum for enterprises

With this in mind, demand for mmWave spectrum (26 GHz) for 5G may be subdued in the Pakistani context especially given the considerable costs of deployment (the cell sizes are small) except in relation to enterprise/private networks. Therefore, interest in these bands should be tested with the operators and broader industry with a reservation for private/enterprise use by localised licensing. It should be emphasized that this potion of spectrum has no value until an MNO or an enterprise is willing to substantially invest in it.

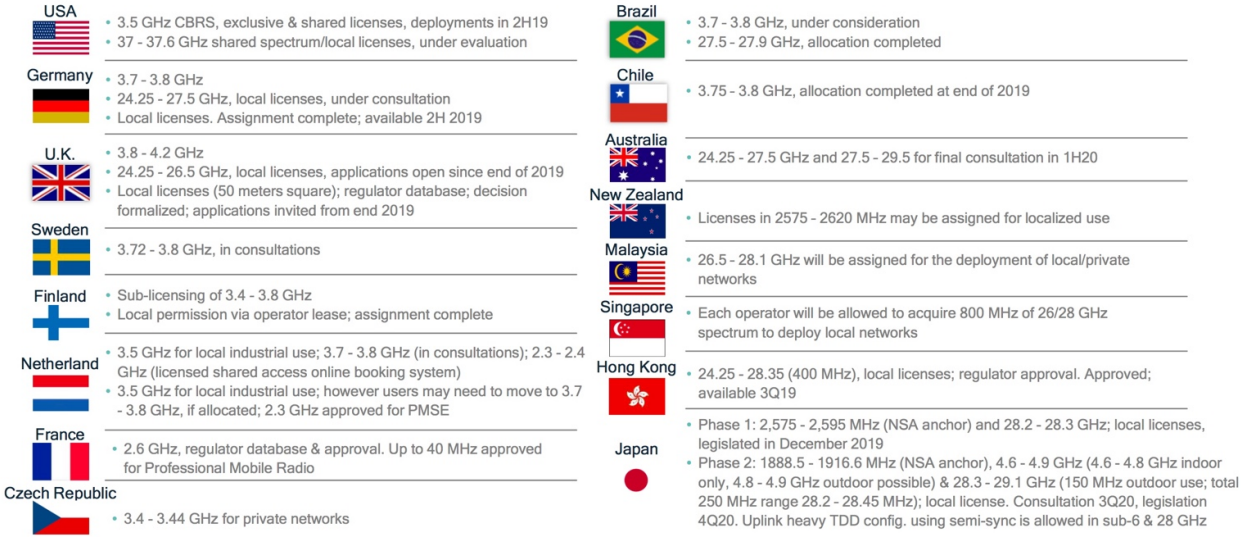
From World Bank's perspective, there are three broad categories of potential wireless broadband use especially with mmWave spectrum, namely:

- Type 1—traditional subscriber-based wide-area MNO or fixed network operator deployments;
- Type 2—smaller market/local subscriber-based networks; and
- Type 3— uncoordinated ad hoc deployments within the confines of private premises or property.

[134] If there is a need for a band such as 3.5 GHz to be released in phases due to WLL transition or coexistence issues, measures should be in place for MNOs to aggregate spectrum holdings at a later stage.
[135] Refer to www.gsma.com/spectrum/wp-content/uploads/2020/03/5G-Spectrum-Positions.pdf

Globally, private or integrated networks are expected to become more popular with the increased availability of 5G equipment. Currently, in many global markets, there are operational deployments across multiple segments of the critical communications and industrial IoT industries, as well as enterprise buildings, campuses and public venues. Other industries where standalone networks have been used include manufacturing, transportation, airports, utilities, primary industries, and stadiums. The spectrum which is being reserved for such enterprise or vertical use is summarised in Exhibit 51.

Exhibit 51: Global snapshot of spectrum optimized for private network use — local licensing or sharing



Source: Qualcomm, *Transforming enterprise and industry with 5G private networks*, 15 October 2020, page 19

There should be a reservation of some mmWave spectrum for their use in Pakistan. We do note however, that the final level of demand for such spectrum will only be likely to be determined once pricing for mmWave spectrum is determined. This could be tested in the market in 2022.

5.7 Possible licence conditions

5.7.1 Coverage Commitments

In terms of 5G coverage or rollout commitments (and the incentives to facilitate such investments by the MNOs), it is instructive to examine the requirements imposed by a range of other country regulators and Governments globally and in the region. A range of selected country 5G coverage requirements can be found in Exhibit 52 below. With reasonable pricing and/or a direct allocation of spectrum, the PTA should consider including a network rollout obligation in the 3.5 GHz spectrum license of say, 30 percent coverage of Pakistan's population within 3 years. This coverage commitment figure could be increased to 50 percent or more by possibly making available sub-1 GHz spectrum and the re-farming of legacy IMT spectrum for 5G.[136]

[136] Any such coverage requirements should be consistent with Pakistan's broader policy settings in relation to national broadband coverage, bridging the digital divide and universal services.

Exhibit 52: Selected country 5G rollout/geographic commitments

Country	Rollout/Geographic Coverage Commitments
Austria	A successful bidder for a 5G license must provide up to 1,000 locations. Around a third of these locations must be provided by the end of 2020. By the end of 2025, almost nationwide availability of 5G should have been realised.
China	The Chinese Government established a number of key policy initiatives to facilitate 5G rollout including *inter alia* that Beijing, Guangzhou, Shanghai and Shenzhen would have 100 percent coverage in 2 years. In addition, the Guangdong Province would have 100 percent coverage in 3 years. In March 2020, China's Ministry of Industry and Information Technology (MIIT) published a directive calling on localities to accelerate 5G network and applications to minimize the impact of the coronavirus.
France	ARCEP stipulated that each MNO that was a winning bidder for 3.5 GHz band spectrum must launch 5G services in at least 2 cities before the end of 2020. Operators must deploy 3,000 cellsites in 2022, 8,000 sites in 2024, and 10,500 sites in 2025. Eventually, all of the cell sites must provide 5G services using 3.5 GHz spectrum. 25% of 3.4-3.8 GHz band sites in the last 2 stages (2024 and 2025) must be located in sparsely populated areas, targeting economic activity, notably manufacturing, excluding major metropolitan areas. By 2022, at least 75% of cell sites must be capable of providing speeds of at least 240 Mbit/s at each site. This obligation will be gradually applied to all cell sites, up to 2030. Obligations also apply to coverage of the country's motorways (16,642 km) by 2025 then, by 2027, coverage of the main roadways (54,913 km). These obligations stipulate connection speeds of a minimum 100 Mbit/s at each cell site.
Germany	Operators winning 2.1GHz and 3.6GHz band licenses must supply minimum speeds of 100Mbps to at least 98% of households by the end of 2022. Operators must also install 1,000 5G base stations and extra 500 base stations in the 'white spot' areas.
Hong Kong	Spectrum assignees of the 26GHz, 28GHz 5G licenses are required to install 20% of the minimum number of radio units required to be installed within the first three years following spectrum assignment, an addition of 30% within four years, and an addition of the remaining 50% within five years.
Italy	Winners of both the 80 and 20 MHz and 3.5 GHz spectrum lots must cover 40 percent of the population in 2 and 4 years respectively at a minimum spectrum of 30 Mbps. Winners of the 700MHz band are required to roll out improved mobile coverage of national population, tourist locations and main national road and rail transport routes. Winners of the 3600-3800 MHz band must roll out improved mobile coverage in a mandatory list of municipalities within 72 months from the date of the award
Japan	While the 5G geographic coverage was set by the MIC at a minimum of at least 50 percent of national and regional blocks within 5 years, the MNOs who made a larger rollout commitment with higher spectrum utilization were allocated more mid- band spectrum. This was based on consolidated scoring and ranking of the MNO bids. 5G spectrum was also allocated for free. The final MNO coverage commitments were NTTDocomo 97.0%, KDDI 93.2%, Softbank 64% and Rakuten 56.1%.
Saudi Arabia	The population coverage target is 60 percent by 2021 with a user experience of at least 65 Mbps. As well as a reduction in spectrum fees, the royalty fee has also been reduced from 15 to 10 percent and other changes have been made in order to facilitate the MNO's expansion of their infrastructure over the next 3 years.
Singapore	The two winners of 3.5 GHz band spectrum in Singapore are required to deliver 50% island wide coverage by the end of 2022, and full coverage by the end of 2025.
South Korea	The MSIT regulatory requirement was for 150,000 5G base stations in the 3.5 GHz band with 15 percent (ie 22,500) to be deployed in 3 years and 30 percent in 5 years (ie 45,000) however, competition in the market is driving much faster 5G deployment. About 90 percent of the South Korean population is covered for 5G. Some 70,000 base stations have been deployed by SK Telecom and 80,000 by LGU+.

Country	Rollout/Geographic Coverage Commitments
Thailand	The NBTC is motivating 5G investment in Thailand by giving 3 years grace period for any repayment if 5G is deployed in 50 percent of Eastern Economic Corridor (ECC) Area within 1 year and 50 percent of smart city within 4 years.

Source: WPC Analysis, November 2020 from a range of regulator and industry sources

Any rollout obligation applying specifically to the 3.5 GHz band necessarily must take into account the urbanization rate of Pakistan, the high cost of 5G network deployment and the likely adoption/availability of 5G capable handsets and other devices in the country in the short term.

In addition, the PTA should mandate minimum 5G download speeds as this is the case in a number of global markets. To secure the benefits of 5G for Pakistan and to be significantly faster than current speeds, the minimum could be prescribed as at least 30 Mbps for users within 3.5 GHz 5G coverage areas and rising over time.

5.7.2 Facilitating Synchronization and Common Frame Structure

Inter-operator synchronization

With all TDD systems including 5G systems operating in the 3.5 GHz band, there are two levels of synchronisation which are needed. These are namely inter-operator synchronisation within Pakistan and synchronisation across Pakistan's borders with its neighbours.

Firstly, inter-operator synchronisation within Pakistan is needed. If 5G macro-cell networks are not synchronised, arguably an additional guard band and improved filtering of transceivers would be required.[137] This would result in additional costs for Pakistan's MNOs and/or result in key 3.5 GHz band spectrum not being optimally used. Thus, synchronisation of Pakistan's 5G macro-cell networks becomes the best way to avoid interference. In this way, efficient spectrum usage is ensured – no additional guard band is required – and network equipment costs can be reduced. This will assist in making 5G services more affordable in Pakistan.

This has been the approach adopted in Australia, China, France, the European Union,[138] Japan and South Korea. Singapore's regulator has also announced its support for full synchronisation for the 3.5 GHz band.[139]

Secondly, in relation to synchronization across borders, this comprises three elements: namely clock synchronization, slot synchronization and frame structure synchronization (i.e. the same frame structure).

[137] GSMA, Plum Consulting and WPC, *Roadmap for C-Band spectrum in ASEAN*, August 2019, Appendix D

[138] See ECC Report 296, *National synchronization regulatory framework options in 3400-3800 MHz: a toolbox for coexistence of MFCNs in synchronised, unsynchronised and semi-synchronised operation in 3400-3800 MHz,* Approved 8 March 2019

[139] IMDA *Op cit*, paragraphs 143 and 144.

For clock synchronization, there are two options for the MNOs:

- Type 1: distributed synchronisation scheme based on satellite (i.e. GPS) which is used in Japan and other countries
- Type 2: centralised synchronisation scheme based on IEEE 1588V2 system (which is used in Europe)

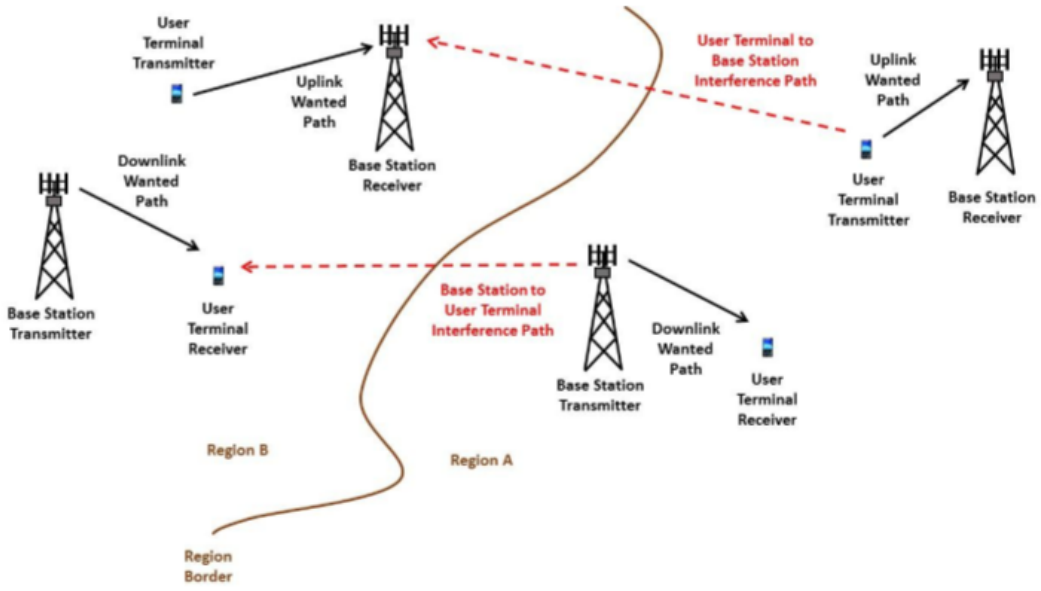
It is also possible to use a combination of methods in order to improve reliability (e.g. China). If the MNOs use the same frame structure, then frame structure is synchronized.

The most difficult aspect is the slot synchronization, which defines the time that each slot begins and ends. As it may not be feasible to have neighboring countries across SAARC synchronize their slots, the full synchronization across border might be not feasible even though it is optimal. If full synchronization is not possible, it is preferable if the same frame structure is adopted by Pakistan's neighbors. Adopting the same frame structure results in less interference and hence requires less regional coordination efforts. In Germany, the regulator, Bundesnetzagentur has set different rules including lower transmission limits for base stations for non-synchronized networks.[140]

Another approach involving synchronisation of networks on either side of the border that will eliminate base station to base station interference paths and coordination threshold conditions are driven by interference paths between base stations and user terminals as shown in Exhibit 53.

[140] Decision of the President's Chamber of the Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen of 26 November 2018 on the determinations and rules in detail (award rules) and on the determinations and rules for conduct of the proceedings (auction rules) to award spectrum in the 2 GHz and 3.6 GHz bands, pages 37 and Annex 3, page 3. Courtesy translation. Available at www.bundesnetzagentur.de/SharedDocs/Downloads/EN/Areas/Telecommunications/Companies/TelecomRegulation/FrequencyManagement/ElectronicCommunicationsServices/FrequencyAward2018/20181214_Decision_III_IV.pdf

Exhibit 53: Interference from Region A (say Pakistan) into Region B when synchronised TDD networks are deployed



Source: GSMA, August 2019

Common frame structure

It is expected that download traffic will continue to dominate mobile data traffic in 5G networks in South Asia. In particular for eMBB applications, it may go beyond 90 percent of the overall mobile data traffic. Anticipating this trend, the GSMA recommends only 5G macro-cell networks with a 2.5 ms single DL/UL switching period frame structure (DDDSU) [141] in C- band for high system capacity and efficiency as shown in Exhibit 54 below.[142]

The other advantage of the 3.5 GHz spectrum band is that it facilitates future evolution to URLLC scenarios as it has a lower reduced round trip time (RTT). This view on the overwhelming direction of traffic is also strongly supported by Zest. If more flexibility is needed, then Pakistan could do what the Swedish regulator has done provided that the frame structure will be reviewed every 5 years in order to follow technology developments.[143]

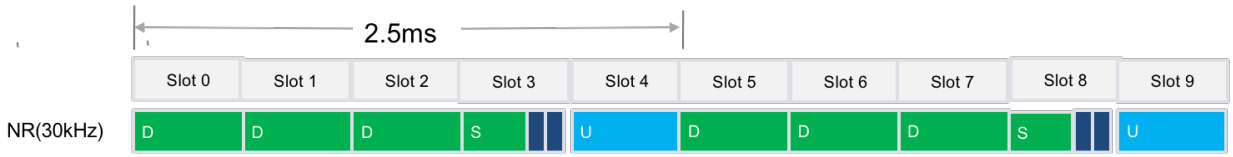
[141] Down link dominant special slot.

[142] Note for 2.3 and TDD 2.6 2.6 GHz networks where there is 5G coexistence with LTE TDD network. In such circumstances, a 5 ms frame structure of 8:2 (DDDDDDDSUU) should be adopted in order to be compatible with LTE TDD network

[143] See www.pts.se and http://5gobservatory.eu/wp-content/uploads/2019/10/90013-5G-Observatory-Quarterly-report-5_final.pdf

Exhibit 54

: Recommended National Frame Structure for 3.5 GHz spectrum



4:1 , DDDSU , 2.5ms DL/UL single switching period frame structure

The South Korean Ministry of Science, ICT and Future Planning (MSIP) in the June 2018 auction of 5G spectrum, observed that synchronisation in the bands 3.5GHz and 28GHz will use the same frame structure of DDDSU as recommended here. Japan's Ministry of Internal Affairs and Communications (MIC) in relation to the 3.4-3.6 GHz band requires synchronisation between all of Japan's domestic MNOs and a 3:1 DL:UL ratio. China's MIIT is actively organising MNOs and relevant stake holders to negotiate a single frame structure for synchronisation of 5G networks in 3.5 GHz band.

In ***Australia*** on 17 June 2018 following industry consultation,[144] the then Minister of Communications on advice from ACMA issued the *Australian Communications and Media Authority (Radiocommunications Licence Conditions—3.4 and 3.6 GHz Bands Interference Management Direction 2018*.[145] The direction also specified the adoption of a common frame structure (or equivalent in terms of duration and timing of downlink and uplink segments) if and when required to support the synchronisation fall-back solution. The frame structure specified supports a 3:1 downlink-to-uplink ratio, with the arrangements taking affect from 30 March 2020. This Direction has since been repealed as the synchronisation requirements have now been included within the various licensing frameworks. For example, see the framework for the 3.4 GHz band in Australia.[146] In particular, Licence Schedule 4 'Other conditions' of the actual spectrum licences now contains synchronisation requirements.[147]

Similarly, in France, on 1 August 2019, ARCEP published Decision n° 2019-0862 on synchronization of terrestrial networks in the 3.4-3.8 GHz band in the country. This decision requires that terrestrial networks operating in the 3.4 to 3.8 GHz band will have to use the same synchronization frame structure from 1 July 2020.[148] Furthermore, the Singapore regulator, the IMDA announced on 17 October 2019 that it was also supportive of full synchronization stating that:[149]

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[144] Refer to ACMA, 3.4 *GHz and 3.6 GHz band spectrum license technical framework— Outcomes and response to submissions,* August 2018

[145] Available at www.legislation.gov.au/Details/F2018L01045

[146] Refer to www.acma.gov.au/34-ghz-technical-framework

[147] Refer to https://web.acma.gov.au/rrl/browse_licences.licence_list?pSV_ID=85&pSS_ID=861. Further background can be found in the associated technical liaison group papers. Refer to www.acma.gov.au/publications/2018-01/report/34-ghz-36-ghz-tlg-package-2018

[148] EC, 5G Observatory Quarterly Report 5, Op cit

[149] IMDA Singapore, *Op cit*

"143. …. IMDA is inclined for the 3.5 GHz band to be fully synchronised while affording operators the flexibility on the choice of synchronisation for the mmWave band. ….

144. On the issue of synchronisation, as a start, IMDA will not mandate the synchronisation approach for both the 3.5 GHz and mmWave bands. IMDA will allow operators to coordinate amongst themselves in the first instance. In the event of disputes amongst operators, IMDA may require operators to synchronise and comply with certain parameters in order to minimise interference between the networks on a case-by-case basis. Similarly, for cross-border coordination, IMDA will also facilitate coordination with our neighbouring countries on the TDD synchronisation in order to avoid cross- border interference."

In conclusion, these synchronisation and frame structure issues are best addressed in the licence terms and conditions included in any 2.3, 2.6, 3.5 GHz and mmWave spectrum licence issued by the PTA.

5.8 Review of health and safety issues related to 5G

5.8.1 Overview

Although there are no established health effects from the radio waves used by 5G network, there is a lot of concerning misinformation circulating throughout the community. The electromagnetic frequencies used for 5G are part of the radio frequency spectrum which has been extensively researched in terms of health impacts for decades. Low and mid-band frequencies used for 5G have been in use for 2G, 3G and 4G services for some time while mmWave frequencies being for 5G are used today by the mobile and satellite industries for other purposes and are covered by international safety guidelines.[150]

The consistent conclusion of public health agencies and expert groups is that compliance with the international guidelines is protective for all persons including children against all established health risks.[151]

5.8.2 Transmitting Power

It is important to highlight that 5G devices will automatically minimize the transmit power to the lowest level in order to complete a satisfactory communication with the network. Base stations used for 5G will consist of various types of facilities including small cells, towers, masts and dedicated in-building and home systems. 5G networks are specifically designed to minimize transmitter power, even more than existing 4G networks. 5G networks use a new advanced radio and core architecture which is very efficient and minimizes transmissions consistent with service requirements which results in optimized Electromagnetic Field (EMF) levels.[152]

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[150] www.gsma.com/spectrum/resources/wrc-19-addressing-5g-and-emf/

[151] www.gsma.com/publicpolicy/wp-content/uploads/2019/06/GSMA_Safety-of-5G-Mobile- Networks_July-2019.pdf

[152] www.emfexplained.info

It is important to note that higher frequencies does not mean higher or more intense exposure. Higher frequency radio waves are already used in security screening units at airports, police radar guns and in medicine. These uses have been thoroughly tested and found to have no negative impacts on human health.[153]

Changes to Exposure

The WHO conducted the EMF project which researched potential changes to exposure levels. The WHO and ICNIRP have assessed that there is no established scientific evidence to support any claims of adverse health effects from very low RF EMF exposures.

The WHO findings are:

- no significant change in overall RF-EMF levels;
- no significant change in network exposure levels;
- no significant change in personal exposure; and
- no risk increases near broadcast transmitters.[154]

5.8.3 Comprehensive International Guidelines

WHO and ICNIRP

Safe exposure limits are set by independent, publicly funded organizations; the WHO and the ICNIRP.

Comprehensive international guidelines exist which govern exposure to radio waves including the frequencies proposed for 5G. Independent scientific organizations such as the ICNIRP have established the limits,[155] and include substantial margins of safety to protect everybody from all established hazards

These guidelines have been widely adopted as standards around the world, and are endorsed by the WHO.[156] Over 50 years of scientific research has already been conducted into the possible health effects of the radio signals used for mobile phones, base stations and other wireless services including frequencies planned for 5G including mmWave exposures.

ITU

The ITU has also released numerous Resolutions concerning human exposure to electromagnetic fields. The ITU has found that no adverse health effects have been established from RF fields' exposures. The results of the simulation indicate that where RF-EMF limits are stricter than ICNIRP or IEEE guidelines, the network capacity buildout (both 4G and 5G) might be severely constrained and may prevent accommodating the growing data traffic demand and the launching of new services on existing mobile networks.

Mitigation measures include:

- avoiding wireless communications if the transmitter & receiver stations are fixed;
- avoiding WiFi routers based on cellular infrastructure;

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153 www.arpansa.gov.au/news/misinformation-about-australias-5g-network
154 www.gsma.com/spectrum/wp-content/uploads/2019/11/Jrowley_201911_WRC_EMF.pdf
155 www.icnirp.org
156 www.emfexplained.info/?ID=25914

- using satellite and cable TV;
- maximizing sharing, including active frequencies sharing among cellular operators; and
- maximizing the RF to operators in order to decrease sites[157]

GSMA

GSMA indicates that with regards to radio signals, 5G is similar to current wireless technologies and covered by national and international safety guidelines which protect the public and the environment. The European Commission points out that these 'strict and safe' guidelines include all the frequencies both currently used and under consideration for 5G. Further research indicates that there are no established health effects and 5G trials demonstrate that the overall levels of radio signals in the community remain low and well below international safety guidelines. GSMA suggests that as the world move into the 5G era, there is an important role for national authorities to communicate accurate and reliable information.[158]

5.8.4 Global Views on EMF issues

The prevailing view among researchers in many countries today is that that the radiation from wireless technology is not hazardous to health, as long as the levels are below the recommended limit values.[159] Despite the public concern, health authorities have consistently declared 5G safe for use. There is a large body of research on the radio signals used by mobile technologies. The scientific evidence is continuously monitored by independent expert groups to ensure that safety guidelines remain valid.

WHO

While an increased risk of brain tumours from the use of mobile phones is not established, the increasing use of mobile phones and the lack of information on mobile phone use for more than 15 years warrant further research of mobile phone use and brain cancer risk.[160]

Australia

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) are not aware of any well-conducted scientific investigations where health symptoms were confirmed as a result of radio wave exposure in the everyday environment.[161]Additionally, Australia's largest MNO, Telstra, completed extensive testing of its 5G network infrastructure in real-world settings using commercially available 5G devices. Telstra reported that testing of their 5G network with commercial devices in real-world setting shows levels similar to 3G, 4G and Wi-Fi and in many cases around 1,000 times below the safety limits.[162]

Canada

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157 www.itu.int/ITU-T/recommendations/rec.aspx?rec=13643&lang=en

158 www.gsma.com/publicpolicy/emf-and-health

159 https://amta.org.au/international-health-authorities-on-5g-and-eme-health-risk/

160 www.gsma.com/spectrum/wp-content/uploads/2019/11/Jrowley_201911_WRC_EMF.pdf

161 www.arpansa.gov.au/news/misinformation-about-australias-5g-network

162 https://exchange.telstra.com.au/5-surveys-of-5g-show-eme-levels-well-below-safety-limits/. For the approach of other MNOs see – Vodafone - www.vodafone.com/what-we-do/public-policy/mobiles-masts-and-health/health-the-science-and-evidence/is-5g-safe-to-use.

According to the Government of Canada, international studies have concluded that effects associated with exposure to RF energy (one form of electromagnetic energy) depend on the frequency range. For example, higher frequency ranges may result in tissue heating, while short-term exposure to lower frequency ranges may produce nerve stimulation like a tingling sensation. RF exposure limits have been established to prevent these effects from occurring.[163]

European Union

The European Commission has emphasized that since existing scientific evidence on electromagnetic field exposure confirms that 5G networks will not cause more electromagnetic emissions than permitted, 5G will not have a negative effect on people's health.[164]

Finland

Finland have stated that from the point of view of exposure to radio frequency radiation, the new base stations do not differ significantly from the base stations of existing mobile communication technologies (2G, 3G, 4G).

France

Measurements on 4G small cells by the French spectrum regulator, ARCEP found that levels in nearby areas did not change significantly and remained well below the safety guidelines. Small cells also increased the data rates available to users.

Germany

Germany has publicly stated that where the limit values are adhered to, no health-relevant effects are to be expected according to the current scientific knowledge. They note however, that the use of additional frequency bands in the centi- and millimetre wavelength range require further research.

Norway

Norway have publicly announced that they have used cell phones and radio transmitters for decades and much research has been done on how this affects our health. Risk factors of concern to public health have not been found. With the knowledge we have today, there is no need to worry that 5G is hazardous to health.

South Africa

The Council of Scientific & Industrial Research (CSIR) issued a document to dispel some of the myths around 5G mobile telephony. Specifically, they stated that 'There is no evidence to suggest a link between 5G technology and SARS-CoV-2', the virus which is said to cause COVID-19. The claims that we have come across do not provide any credible scientific evidence to substantiate them. Our view is that the radio frequencies of 5G networks are not high enough to break chemical bonds or remove electrons in human tissue. Therefore, it is highly unlikely that 5G may cause mutations in the SARS-CoV-2 virus in-vitro or in-vivo'.

United Kingdom

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163 www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11467.html
164 https://ec.europa.eu/digital-single-market/en/electromagnetic-fields-and-5g

ICNIRP guidelines apply up to 300 GHz, well beyond the maximum (few tens of GHz) frequencies under discussion for 5G. In the UK, it has been noted that it is possible that there may be a small increase in overall exposure to radio waves when 5G is added to an existing network or in a new area; however, the overall exposure is expected to remain low relative to guidelines, and as such there should be no consequences for public health.

USA

The FCC has taken a position that there are no adverse health effects, based on the below information. First, hundreds of independent studies from international agencies have indicated there have been no established negative health caused by radio waves emitted from mobile phones and base stations complying with international limits.

Second, according to the FDA and the WHO among other organizations, to date, the weight of scientific evidence has not effectively linked exposure to radio frequency energy from mobile devices with any known health problems. Finally, in the US, several federal agencies constantly monitor research and update regulations relating to health and wireless, including the FCC, Centers for Disease Control & Prevention, National Institutes of Health, and Food & Drug Administration.[165]

5.8.5 EMF Regulations In Pakistan

Environmental, and health related concerns raised at the levels of the Government, highlighting the need for the introduction of radiation standards in Pakistan and appropriate mechanisms to deal with the environmental and aesthetic aspects of wireless infrastructure. For example, the Government of Pakistan has raised an issue of proliferation of towers and the resultant hazards affecting human health. It is also well aware of the responsibility to protect the health and well-being of the people.

As the FAB and PTA authorize or licenses most RF telecommunications services facilities, the PTA often receives inquiries concerning whether there are potential safety hazards due to human exposure to RF energy emitted by transmitters.

Current RF standards and regulations

Currently the RF Communication Standards remain as a 2016 draft for technical standards regulations in relation to terrestrial, mobile, satellite and wireless connectivity equipment.[166] Regulations in exercise of powers have been grouped into:

- Mobile Devices Communication Standards;
- Terrestrial Devices Standards;
- Satellite Standards;
- Wireless Connectivity Standards; and
- Miscellaneous Equipment Standards.

While papers on EMF issues are covered in the three papers on the PTA website as summarised in Exhibit 55 below, there has also been calls for further reforms in this area in Pakistan. Such reforms are meant to address national radiation safety guidelines, siting criteria for base stations, co-location and specific siting requirements for collocated

[165] www.5gamericas.org/5g-and-health/
[166] www.pta.gov.pk/assets/media/technical-standard-280616.pdf

antennas, work practices for personnel working on these base stations and mechanism of enforcement of these guidelines. [167]

Exhibit 55: Current PTA papers on EMF issues

Article	Summary

Radio Frequency Radiation (International Practice and Common Public Concerns)	The article is concerned with the issue of proliferation of towers as a main source of Radio Frequency (RF) Energy and the resultant hazards affecting human health. The article analyses the issue of "electromagnetic pollution" in causing significant risks to human health from environmental RF electromagnetic fields. RF Energy is harmful in humans due to its ability to cause biological effects, in which extensive research is being carried out by the U.S. Government and World Health Organization.
	Development of Exposure Guidelines
	The article further looks into exposure standards and guidelines that have been developed by various organizations and countries over the past several decades. In North America and most of Europe exposure standards and guidelines have generally been based on exposure levels where effects considered harmful to humans occur. Some published exposure limits in Russia and some eastern European countries have been generally more restrictive than existing or proposed recommendations for exposure developed in North America and other parts of Europe.
	The Federal Communications Commission (FCC) authorises and licenses devices, transmitters and facilities that generate RF radiation over all transmitting services in the U.S. except those operated by the Federal Government. A summary of public exposure covering:
	• **Radio and television antennas**
	• **Microwave and satellite antennas:**
	  ○ Point-to-Point Microwave Antennas
	  ○ Satellite-Earth Stations
	• **Cellular and PCS Towers and antennas:**
	  ○ Base stations
	• **Tower Sitings**

Environmental and Health Related Effects of the Cellular Base Station Antennas	The report classifies the different types of hazards related to cellular base station antennas. The entire report is summarised as follows:
	• It identifies the areas of negative impact of cellular base station proliferation as well as the issues and controversies that have been faced worldwide in this regard.
	  ○ Environmental effects from landscape cluttering
	  ○ Physical hazards due to tower related accidents
	  ○ Health hazards due to radiation (biological effects)
	• Summarises the technical background behind the principle of wireless communication, mobile phone base stations, effective radiated power and power density
	• Provides a summary of the studies that have been conducted worldwide for determining the associated health risks and the guidelines that have been adopted by the standards bodies and

[167] Environmental and Health Related Effects of the Cellular Base Station Antennas, an advisory report by Ministry of Information Technology

Article	Summary
	administrations worldwide as well as the prevalent regulatory mechanisms used for enforcing the guidelines. • Presents the Pakistani perspective on the growth of cellular networks and proposes guidelines addressing both the environmental and health related hazards as well as siting criteria for the cellular base stations to meet these guidelines. The report concludes with identification of the need of multi-stakeholder local studies to further strengthen and optimize these guidelines for better protection of our environment and public health.
Radio Frequency Hazard	The article provides a summary of the hazards of radio frequency including biological effects (intensity and frequency of RF electromagnetic wave, and the specific absorption rate), a brief comparison of international standards and guidelines and FCC limits for maximum permissible exposures and localised (partial body) exposure).

Source: PTA, 2020

Key points and recommendations

Key points

- Ideally, an MNO will require low band (up to 1 GHz) spectrum, mid-band spectrum (1-6 GHz) and high-band (>6 GHz) IMT spectrum as part of its spectrum portfolio
- Over time, legacy IMT bands including *inter alia* 1800 MHz (n3), and 2100 MHz (n1) would be used for 5G services subject to any technical and regulatory considerations.
- While the 3.5 GHz band can only be used for 5G, the 2.3, 2.6 GHz and 700 MHz bands can be used for 4G and/or 5G as well. Thus the MNOs are able deploy 4G and then convert the band to 5G where possible based on device penetration, demand etc in Pakistan
- The following bands may be appropriate for 5G in Pakisatn:
    - 3.5 GHz Band (part is currently available with more available post 2024)
    - 2.3 GHz (completely vacant)
    - 700 MHz band (the preferred global 5G coverage band, and some availability in Pakistan)
    - 2.6 GHz band (after resolution of judicial case, total 190 MHz)
    - Upper part of the 6 GHz band (in part dependent on WRC-23)
    - Legacy IMT bands like the 850, 1800 and 2100 MHz bands
- mmWave may not as appropriate in the parts of Pakistan where there is high rainfull and the monsoon season however could be released in Pakistan if demand exists. 26 GHz band is preferred. Demand for mmWave spectrum for 5G may also be subdued in the Pakistani context especially given the considerable costs of deployment (the cell sizes are small) except in relation to enterprise/private networks. Therefore, interest in these bands should be tested with the operators and broader industry with a reservation for private/enterprise use by localised licensing.
- The L-Band (1.5 GHz) is currently used by Pakistan Railway. As no migration plans have been prepared, there is no availability of this band in the near future.

Recommendations

- This report has a proposed a timeline for spectrum allocation in Pakistan:
    - Phase 0: The PTA should refarm and release the 1800 and 2100 MHz bands in Q3, 2021
    - Phase 1a: Release of 2.3 and 3.3–3.4 GHz bands (total 200 MHz) H1 2022
    - Phase 1b: Release of vacant 700 MHz band (approach 2 x 30 MHz + mmWave) Q4 2022
    - Phase 2: Release of 2.6 GHz band after resolution of court case (total 190 MHz) 2022/23
    - Phase 3: Further offering of 3.5 GHz band post WLL band clearance 2024
    - Phase 4: Refarming of other spectrum bands eg 1.5, 4.4 GHz etc.
- Spectrum must be priced at reasonable and sustainable levels. Reserve prices for the 3.5 and/or 2.6 GHz bands should be determined based on the independent spectrum auction consultant's study to incentivize early deployment. The price should be set so that the weakest MNO can afford to buy additional IMT spectrum
- The minimum block size to take advantage of 5G NR for the 2.6 GHz and 3.5 GHz bands should be 50 to 60 MHz, with lot sizes being 10 MHz
- In relation to high band spectrum (ie mmWave), while the GSMA supports up to 1 GHz of spectrum per MNO, 200-400 MHz is a good starting point. The key point to emphasise is that price of such mmWave spectrum should be very low as the spectrum has little value until MNOs make significant (costly) investment in network deployment. One option would be for the PTA to bundle mmWave spectrum with 2.6 and/or 3.5 GHz spectrum in any allocations/auction process.
- The PTA should consider including a network rollout obligation in the 3.5 GHz spectrum license of say, 30 percent coverage of Pakistan's population within 3 years. This coverage commitment figure could be increased to 50 percent or more by possibly making available sub-1 GHz spectrum and the re-farming of legacy IMT spectrum for 5G. In addition, the PTA should mandate minimum 5G download speeds of at least 30 Mbps for users within 3.5 GHz 5G coverage areas and rising over time.
- The Pakistan Government must also consider inter-operator synchronisation and synchronisation across Pakistan's borders, otherwise additional guard bands will be required and optimal use of spectrum will not be possible. If full synchronisation across borders is not possible, it is preferable that the same frame structure is adopted by Pakistan's neighbours.
- There is considerable misinformation regarding the health effects from the radio waves used by the 5G network. This highlights the need for the introduction of radiation standards in Pakistan and appropriate mechanisms to deal with the environmental and aesthetic aspects of wireless infrastructure.

6 Infrastructure Readiness In Pakistan

6.1 Overview

This section analyses the existing telecom infrastructure in Pakistan, and how to best address identified deficiencies. The current state of backhaul infrastructure in Pakistan is considered, as well small cell deployment for 5G rollout in urban areas and the impact of 5G on energy efficiency. It should be read in conjunction with Section 4 of this Report.

6.2 Analysis of existing telecommunications infrastructure

6.2.1 Backhaul Infrastructure

In overall terms, the current telecommunications state of play on infrastructure can be summarised in Exhibit 56. Specifically, Pakistan currently has more than 124,000 kilometres of fibre optic cable: see Exhibit 57. Outside of urban areas, the optical fibre communication (OFC) network is available in almost 90% of districts in Pakistan (covering 130 districts and nearly all the 400+ sub-districts, offering accessibility to almost 87 percent of Pakistanis).

Exhibit 56: Key State of Play Metrics

Key sector indicators	Current State
Total cellular mobile subscriptions – in Millions	165 Million+
Total Fixed Telephony Users (incl. xDSL)	2.65 Million+
Access Network for Fixed Network (Copper/Fiber) – in %	85%/15%
Mobile Voice Services (TDM/VoLTE) – in %	100%/0
Mobile backhaul infrastructure (Microwave/Fiber) – in %	90%/10%
Metro Networks (SDH/IP) – in %	30%/70%
Inter-connects (TDM/IP) – in %	80%/20%

Source: Various, ITU and World Bank analysis

The total long-haul OFC Network is 55,000+ kms, owned by four operators: Jazz, PTCL, Wateen and Multinet. There were no major bottlenecks in the long-haul networks until the onset of COVID-19 in 2020. As a response to the increased traffic, the capacities of all inter-city trunk routes are currently being enhanced and are expected to be ready by Q3, 2021.

Exhibit 57: Available infrastructure in Pakistan

Description	Current Situation
Total long haul Optical Fiber Cable laid (in KMs)	> 124,000 kms
Total NGMS/WLL Towers	44,000 +
Total Leased Fiber (in % of total laid OFC)	23%
Internet Backbone Cables	6

Source: PTA, Telco Operator Planning and Commercial Teams. Short haul OFC laid is not currently known.

Pakistan's four telecom operators have a total of 45,000 mobile towers, over 90 percent use microwave backhaul. Approximately 8 percent of base stations/sites in Pakistan are operating with a fibre backhaul. It is estimated that the fiberisation of towers per operators is:

- Zong – 11%
- Jazz – 9%
- Telenor – 9%
- Ufone – 5%[168]

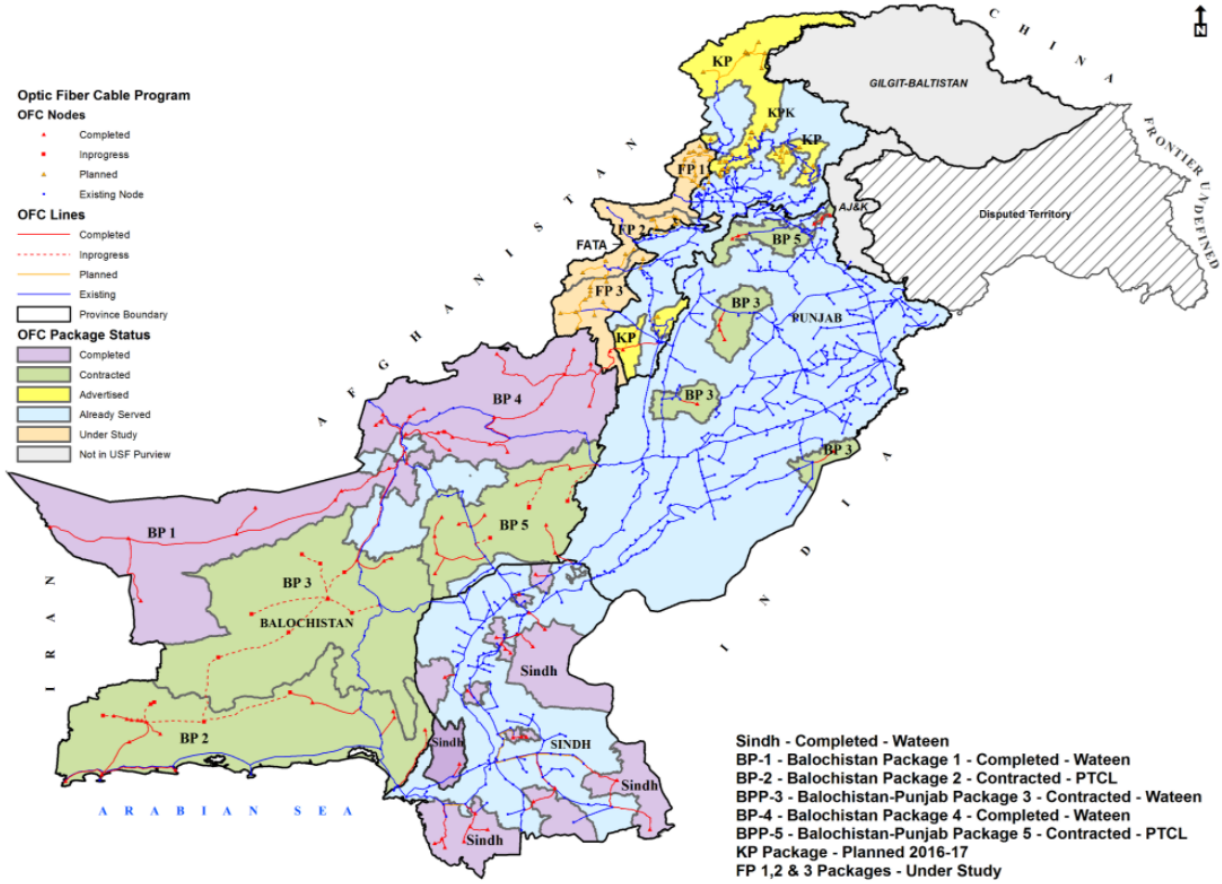
Ideally, for 5G such backhaul networks should be fibre optic cable networks given their superior capacity and reliability compared to microwave backhaul networks. Voice traffic, text messages, instant messages, mobile data and video traffic all need to be backhauled to and from the mobile cellular base stations to the core network. As 5G employs significantly more spectrum in the access portion of the networks, it will also require significantly higher bandwidth backhaul solutions.[169] Therefore, upgrading to OFC should be a continuing high priority.

Universal Service Funds (USF)

Pakistan's USF is being used to help upgrade backhaul networks to OFC. The USF aims to promote the development of telecommunication in underserviced areas by deploying OFC to meet the growing demand of voice, data and video.[170] The map in Exhibit 58 shows the current OFC program.

[168] The World Bank, *Initial Assessment Report for Pakistan,* DE4SA.
[169] GSMA, *Mobile Backhaul Options,* September 2018, p 9.
[170] MoITT, *Universal Service Fund: Optic Fibre Program.*

Exhibit 58: Optic Fibre Cable Program



Source: MoITT, Optic Fibre Program.

The USF has recently awarded contracts under *the Next Generation Broadband for Sustainable Development* and *Next Generation Optical Fibre Network and Services Program*. These projects aim to enable USF areas to have sufficient backhaul and backbone connectivity.[171] For example, in October 2020 USF awarded PTCL a contract for *Next Generation Optical Fibre Network*, worth approximately PKR 3 billion.[172] The project aims to lay 1,078 km of OPC and will connect 140 villages. Such projects aim increase fibre deployment and should continue to be supported to enable the fiberizing of Pakistan for wireless broadband services.

6.2.2 Small cell deployment

5G will continue to use towers with transmitters using lower bands, providing wide area coverage. In areas with greater concentrations of users and traffic, 5G will use high band frequencies to carry larger amounts of data with less latency but over shorter distances, and will use more small cells to do this. Typically small cells are used in high traffic areas such as transport hubs or office buildings, as is common with 4G today.

[171] The World Bank, *Initial Assessment Report for Pakistan,* DE4SA.
[172] Mashable, *MoITT Awards Contract to PTCL for Next Generation Optical Fibre Network in Sindh,* 21 October 2020

Small cells need to be placed close to end users, and therefore, existing physical infrastructure such as street furniture (for instance, lamp posts) can be efficiently repurposed to deploy small cells. The use of street furniture for small-cell deployment has been used in leading markets including the USA, but deployment can be costly, and therefore deployment locations must be selected carefully.

Small cells, which generate less power, collect and transmit the signals in a short range from one another and require collocating the cells on other infrastructure. This means that they will be many more installations per unit area than were necessary for 4G rollout. To make it economically feasible for wireless companies to deploy 5G small cell wireless facility deployment will require streamlined approval and permit processes for rights of way and relatively low application fees.

6.2.3 Energy efficiency of the 5G networks

The 5G era networks will face some challenges in delivering greener and more energy efficient operational outcomes, at least in the short-term. At present, the telecommunications industry consumes around 3% of global energy.[173] The rise of 5G is expected to further exacerbate these levels of energy consumption.

For example, a 2020 Ericsson Mobility Report projects that by the end of 2026, 5G will attract 3.5 billion subscriptions, generating 45% of the world's total mobile traffic data.[174] The potential increase in data traffic of up to 1,000 times more, as well as the building 5G infrastructure to cope with this traffic, could make 5G consume up to two to three times as much energy.[175] This potential energy increase may also be caused by an increased number of base stations, maintenance of legacy and 5G networks, and the greater cost of energy supply.[176] Until older networks are retired, operators are likely to see an energy increase in maintaining legacy networks in 2G, 3G and 4G networks in addition to new requirements in deploying 5G.[177]

As such, the 5G era raises the need for increased reliability and energy efficiency in order to optimise the overall power consumption of networks. One important dimension of 5G technology in terms of addressing such concerns is the Massive Multiple-Input Multiple-Output (MIMO). MIMO involves the use of a large-scale antenna system or base station antennas that control the transmission and reception of radio signals.[178] Although the increased number of hardware components per base station will likely increase the total energy consumption of 5G base stations, its energy efficiency is expected to improve in the long-term.[179]

With the refinements to massive MIMO hardware over time, a system of multiple antennas working together have advantages including:

- more paths to the 5G client, providing stronger signal strength;

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[173] https://millgens.com/innovation/owning-the-green-revolution-can-5g-be-sustainable/
[174] https://wcm.ericsson.net/4acd7e/assets/local/mobility-report/documents/2019/emr-november-2019.pdf
[175] www.gsma.com/wp-content/uploads/2019/04/The-5G-Guide_GSMA_2019_04_29_compressed.pdf
[176] *Ibid.*
[177] *Ibid.*
[178] www.a10networks.com/blog/5g-energy-efficiency-explained/
[179] https://spectrum.ieee.org/energywise/telecom/wireless/will-increased-energy-consumption-be-the-achilles-heel-of-5g-networks

- more parallel antennas can serve a larger number of users; and
- antenna arrays can track mobile clients and direct the transmission beam at the client.[180]

Since the massive MIMO antenna and base station systems can direct radio transmission signals using a focused beam, 5G networks using beamforming use around four times less power than comparable 4G networks.[181]

In addition, MNOs have also taken action in formulating solutions to enhance network energy efficiency, in part due to energy being the highest of all operating expenses (opex) for telecom businesses.[182] Solutions by operators fall in two major categories:

1. increasing the use of alternative energy sources to reduce dependence on the main power grid; and
2. network load optimisation to reduce the energy consumption.[183]

Alternative Energy Sources

Operators have a number of options for sourcing alternative energy. First, MNOs may purchase green energy directly from their utility provider if available. They may also use a third-party power purchase agreement to shift supply to renewables without the initial capex investment. Finally, MNOs can also self-generate energy at the base station with standalone or hybrid solar based solutions, or with larger scale solar and wind farms, which requires capex investment.[184]

T-Mobile and Vodafone in the USA are examples of operators exploring green power alternatives to address the challenge of maintaining reliable and energy-efficient 5G networks. T-Mobile has committed to using 100% renewable energy across its business by 2021. Vodafone also announced that it would do the same by 2025. [185]

Network Load Optimisation

Network load optimisation is likewise crucial to ensuring that total energy consumption in the 5G era is reduced (Exhibit 59). Improving energy efficiency to consume less energy can be achieved through solutions including smart building, virtualising the core, and improving RAN efficiency through modernisation of legacy equipment.

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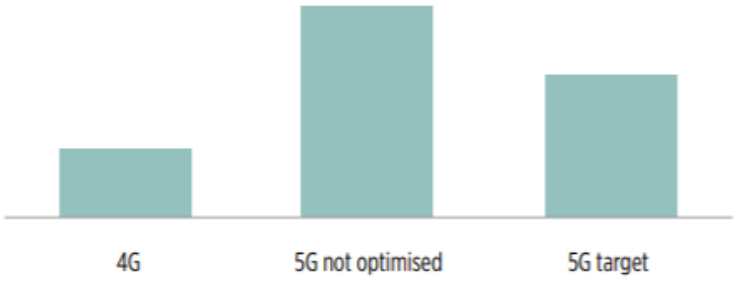
180 www.a10networks.com/blog/5g-energy-efficiency-explained/
181 *Ibid.*
182 www.gsma.com/membership/resources/the-green-power-opportunity-for-5g-operators/
183 www.gsma.com/wp-content/uploads/2019/04/The-5G-Guide_GSMA_2019_04_29_compressed.pdf
184 *Ibid.*
185 www.gsma.com/membership/resources/the-green-power-opportunity-for-5g-operators/

Exhibit 59: Projected Impact of Energy Optimisation in 5G Networks



Source: GSMA, The 5G Guide: A Reference for Operators, April 2019

Key points and recommendations

Key Points

- Pakistan currently has more than 124,000 kilometres of fibre optic cable. Outside of urban areas, the optical fibre communication (OFC) network is available in almost 90% of districts in Pakistan. The total long-haul OFC Network is 55,000+ kms
- As a response to the increased traffic generated by COVID-19 lockdowns and similar, the capacities of all the inter-city trunk routes are currently being enhanced and are expected to be ready by Q3 2021
- 5G will require significant energy and therefore raises the need for increased reliability and energy efficiency in order to optimise the overall power consumption of networks. MNOs could purchase green energy from their utility provided, a third-party power purchase agreement, or self-generate energy

Recommendations

- Backhaul networks for 5G should ideally be fibre optic cable given their superior capacity and reliability. As 5G employs significantly more spectrum in the access portion of the networks, it will require significantly higher bandwidth backhaul solutions. Therefore, upgrading to optical fibre should be a high priority.
- Instalment of small cells will be required for a 5G rollout. To make it economically feasible, small cell wireless facility deployment will require streamlined approval and permit processes for rights of way and relatively low application fees.

7 Regulatory Interventions by Government to accelerate market readiness and 5G adoption in Pakistan

7.1 Overview

In meeting with the objectives of the study, the World Bank has identified five additional key recommendations necessary for the success of 5G in Pakistan. These are namely:

- Improving ROW to facilitate 5G deployment
- Need for improved access to towers and sites for 5G deployment;
- Need to accelerate the fibre connectivity to base stations to support traffic loads;
- International transmission capacity and cloud infrastructure; and
- Internet of Things (IoT).

Prior to such an assessment we examine the relevant ITU and GSMA recommendations in order to facilitate 5G.

7.2 ITU and GSMA recommendations to facilitate 5G

In addition to making key 5G spectrum available, there is also a need for the PTA to enact supportive polices and regulatory approaches to facilitate the efficient and timely deployment of 5G network infrastructure and services in the country. The ITU has recently identified the number of various 5G deployment challenges as shown in Exhibit 60 below.

Exhibit 60: 5G Deployment Challenges

Summary	For consideration
Investment case	Policymakers may consider undertaking their own independent economic case assessment of the commercial viability of deploying 5G networks
Harmonize spectrum	Regulators should allocate/assign globally harmonized 5G spectrum eg 3.5, 2.6 TDD GHz, 700 MHz
Spectrum roadmap	Regulators should adopt a spectrum roadmap and a predictable roadmap renewal process
Spectrum sharing	Regulators may consider allowing sharing to maximize efficient use of available sharing spectrum, particularly to benefit rural areas
Spectrum pricing	Regulators may consider selecting spectrum award procedures that favour investment
Sub-1 GHz spectrum	Policymakers should consider supporting the use of affordable wireless coverage (eg through the 700 bands) to reduce the risk of digital divide
Fibre investment incentives	Policymakers, where the market has failed, may consider stimulating fibre investment and passive assets through PPPs, investment funds and the offering of grant funding, etc.
Fibre tax	Policymakers may consider removing any tax burdens associated with deploying fibre networks to reduce the associated costs
Copper to fibre	Policymakers may consider adopting policies/financial incentives to to encourage migration from copper to fibre & stimulate deployment of fibre
Wireless backhaul	Wireless Operators may consider a portfolio of wireless technologies for 5G backhaul backhaul in addition to fibre, including point-to-multipoint (PMP), microwave and mmWave radio relays, satellites etc
Access/ sharing of passive infra-structure	Policymakers may consider allowing access to government-owned infrastructure such as utility poles, traffic lights and lampposts to give wireless operators the appropriate rights to deploy electronic small cell apparatus to street furniture. Regulators may consider continuing to elaborate existing duct access regimes to encompass 5G networks allowing affordable fibre deployments
Access costs	Policymakers/Regulators may consider ensuring reasonable fees are charged to operators to deploy small-cell radio equipment on street furniture
Asset database	Policymakers may consider holding a central database identifying key contacts, showing assets such as utility ducts, fibre networks, CCTV posts, lampposts, etc. This will help MNOs cost & plan their infrastructure deployment more accurately
Wayleaves (ROW) Agreements	Policymakers may agree upon standardized wayleave agreements to (rights of way) reduce cost and time to deploy fibre and wireless networks
5G test beds	Policymakers to encourage 5G pilots and test beds to test 5G technologies, & use cases, and to stimulate market engagement

Source: ITU, Setting the Scene for 5G: Opportunities & Challenges, 2018

Likewise, the GSMA has released a paper in March 2020 on realizing 5G's full potential. It is summarised in Exhibit 61 below.

Exhibit 61: Key Challenges for Implementing 5G

Recommendations for MNO's	
Strengthen the consumer proposition	○ ***Fixed Wireless Access (FWA).*** Operators have an opportunity to strengthen the core business by extending their connectivity offerings. ○ ***Smart Connectivity & Content Partnerships.*** These provide opportunities for operators to accelerate 5G adoption and increase the value proposition.
Vertical partnership	Operators have multiple opportunities to identify promising verticals and find partners that can help deliver high-value, data-centric products or services to be distributed over the 5G network.
Optimize network costs	○ **Value-Based Deployment Strategies.** Operators should make careful assessments on the value of infrastructure deployments. ○ **Network-Sharing Agreements.** Infrastructure sharing with other operators has the potential to reduce network costs significantly. ○ ***Network Virtualisation and Centralisation.*** Virtualisation of networks allows the development of new, more cost- efficient network architectures ○ ***Automation and Self-Organising Networks.*** There is substantial potential to automate configuration, management, and operation of mobile networks.
Recommendations for Policy Makers and Regulators	
Additional, affordable, spectrum	Making additional spectrum available in a timely and affordable fashion is a top priority for accelerating advanced network deployment.
Facilitate access to site locations	Ensuring that local regulations allow for easy access to sites.
Enable small cell deployments	Facilitate next-generation infrastructure investments by streamlining approval processes for small cells.
Facilitate deployment of backhaul	Policy changes that facilitate the rollout of new fibre backhaul and other backhaul technologies, and encourage sharing of facilities and costs, can help to reduce the overall costs of backhaul. Governments are looking at the arrival of 5G as an opportunity to promote fibre infrastructure.
Freedom to establish network sharing agreements	Allowing operators to share networks. It is vital for the wider success of 5G that regulators permit, or even encourage, shared deployment, especially for small cells, recognising that network operators need the flexibility, to share infrastructure assets.
Harmonize power density limits	Overly strict power density limits for radio signals transmitted by network antennas undermines the ability of MNOs to speed up deployment of next-generation infrastructure.
Provide financial support for deployments	To unlock the full value of 5G for the entire country. Governments should consider providing financial support to achieve the widest coverage.
Provide regulatory flexibility for B2B partnerships	Regulatory authorities should acknowledge the dynamic nature of 5G networks and services and that optimised connectivity built on network slicing is compatible with the open internet principle.

Source: GSMA, Realizing 5G's full potential: Setting policies for success, March 2020

7.3 Need for Improved Access to Towers and Sites for 5G Deployment

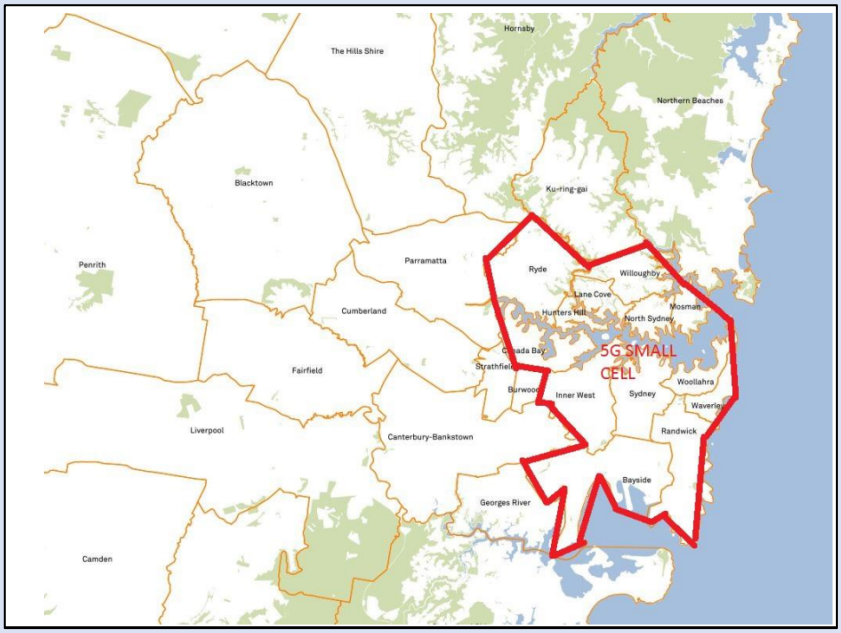
There are a number of ways to improve the access to the necessary towers and sites required for a successful 5G deployment. Two case studies are presented and analysed detailing how the attainment of requirement was facilitated in Australia and China. A national infrastructure database also has significant merit.

Exhibit 62 details the challenges of 5G deployment in Australia with the number of tower sites increasing by almost 4 times.

Exhibit 62: Australian 5G deployment case study

The transition to 5G networks in New South Wales (NSW) Australia has resulted in a fundamental change in radio access network design and a significant growth in the number of sites, as demonstrated here. This example covers the Local Government Areas (LGAs) around Sydney – namely, Sydney, Woollahra, Waverley, Randwick, Bayside, Inner West, Canada Bay, Ryde, Hunters Hill, Lane Cove, Willoughby, North Sydney and Mosman. These LGAs have a combined landmass of 295 square kilometers and a residential population of around 1.5 million.

Map of proposed Local Government Area (LGA) in Sydney



Source: Singtel Optus, Unlocking the Potential of 5G; Deployment Reform, March 2019

3G and 4G radio design provide services in this area mainly through a layer of macro and micro towers on buildings. These sites primarily utilize low and mid band spectrum to provide mobile wireless services. Under this model of radio design, the landmass of the LGAs are covered by around 400 sites.

However, the deployment of a 5G network fundamentally alters this design. 5G radio design is based primarily on small cells integrated onto existing fixtures such as light posts, street signs, and utility poles. The features of 5G such as low latency and very high throughput require a dense radio network, utilizing low to high bandwidth spectrum.

Australia is currently deploying 5G networks in the 3.4-3.6 GHz band, with 26-28 GHz spectrum planned to be made available soon. 5G will require many more sites than current networks. For example, Ericsson has shown that to offer 1 Gbps speeds, cells would have a coverage area of around 200 to 300 meters. This implies that to provide 5G services to the limited number of dense metro LGAs listed above, ***a MNO would need to deploy up to 1,500 small cells to cover an area of less than 300 square kilometers. This is a fundamental re-design of current radio networks, which provides services in these LGAs with around 400 sites***.

In light of the above, Singtel Optus argues that costs in relation to rental arrangements for mobile towers should be kept at a reasonable rate. Under the proposed rates (and assuming that the rates apply to all sites), annual rental charges for just these small number of LGAs would increase from AUD15.2 to AUD57 million. Singtel Optus cautions that such an increase in the cost to deploy sites is prohibitive and likely to delay or prevent the deployment of 5G in NSW. In more general terms, Singtel Optus is calling for significant changes to the regulatory regime to facilitate 5G network deployment.

Exhibit 63 below summarizes China's approach to facilitate 5G deployment.

Exhibit 63: Summary of China's MIIT Guidelines on Telecom Passive Site Sharing

- Local telecom regulators are to promote access to state-owned public areas free of cost, and to coordinate road, railway, metro, airport etc, to provide site infrastructure at a reasonable cost.
- Encourage telecom operators to consult with municipal government, police offices, road transport bureau and railways for the opening of public sites. Encourage telecom and tower operators to trans-sector cooperation with power and railways for bilateral resource sharing
- The respective passive infrastructure for 5G including telecom pipes, fibre & cable, equipment room in newly built residential or commercial building, must follow engineering guidelines.
- Open and reuse existing fixed broadband cabinets in residential areas, commercial buildings and campuses. Fixed and mobile operators are encouraged to share the passive site infrastructure
- Unified site information system: consolidate public site passive information into a government database including macro site, micro/pole site and indoor sites.
- Consolidate public assets including light, monitoring and traffic pole for 5G site readiness.
- Share indoor passive infrastructure in public places (metro, railway, express way, airport, bus station, etc.), public infrastructures (stadium, business building, government office building)

Source: Translation of MIIT Guideline, 2019[186]

National Infrastructure Database

To avoid costly damage to infrastructure, disruption of service and possibly personal injury, it is important to ensure that underground infrastructure such as fibre optic cable and ducts are protected from subsequent construction projects.

[186] Ministry of Industry and Information Technology (MIIT) of the People's Republic of China, Implementation Guideline of Ministry of Industry and Information Technology and State-Owned Assets Supervision and Administration Commission of the State Council on Promoting Joint Construction and Sharing of Telecom Infrastructure, MIIT Letter [2019] 123, 6 June 2019

International best practice demands the creation a national infrastructure database so that before any new project commences, the location of existing infrastructure can be identified. Such databases require creating a 'dial before you dig' organization. These organizations are supported by electricity, gas, communications and water companies – as well as many other private enterprises. They provide an 'on call' service which provides very detailed information of the location of underground infrastructure in a given area. In order to establish these organizations, operators in Pakistan would essentially need to share their existing records and agree on common practices in the recording of infrastructure-related data.

7.4 Accelerating Fibre Connectivity to Base Stations

Backhaul infrastructure is an essential component of mobile telecommunications networks. Fixed and mobile broadband access networks both require fibre speed backbone networks to support dense deployment of access points and base stations among other wireless networks. Voice traffic, text messages, instant message, mobile data and video traffic all need to be backhauled to and from the mobile cellular base stations to the core network.[187]

As the number of mobile subscribers continues to grow and their average monthly downloads increase, mobile operators need to ensure there is sufficient network capacity. Additionally, 5G requires significantly more spectrum in the access portion of the networks than previous technologies, requiring higher bandwidth backhaul solutions.[188] Operators have a number of options for backhaul networks, including fibre optic and microwave.

Fibre Optic Backhaul

Ideally, backhaul networks should be fibre optic cable networks given their superior capacity and reliability compared to microwave backhaul networks. Fibre-optic backhaul is expected to grow to 40.2% of macrocell sites by 2025, which just eclipses microwave in the 7 GHz to 40 GHz band with 38.2%.[189] Fibre-optic has become increasingly popular for mobile service providers as the cost of cable has reduced and more efficient deployment solutions have come into play, such as microtrenching and fibre optic insertion solutions. A key benefit of fibre optic is that is scales well as operators move from older technologies to 5G. Fibre connectivity of Pakistan's mobile networks is likely to be necessary for 5G and will drive future business activity for the country's transmission infrastructure providers.

Microwave Backhaul; E-band and V-band

Different microwave spectrums can be used for wireless backhaul. It can be in the 7 GHz to 40 GHz band, but the higher microwave bands such as V-band (60 GHz) and the E-band (70/80 GHz) are more suitable for backhaul. E-band microwave beams are narrow, so there is minimal interference between sites, dense site deployment is possible, and reuse of spectrum resources is facilitated.[190]

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[187] GSMA, *Mobile Backhaul Options: Spectrum Analysis and Recommendations,* September 2018, page 6.
[188] *Ibid* page 9.
[189] *Ibid*.
[190] E-band has been highlighted to be made available in Pakistan. see PTA, *5G & Digital Divide: Challenges and Opportunities,* October 2018, slide 15.

Backhaul links using the V-band or the E-band are well suited to supporting 5G due to their 10 Gbps to 25 Gbps data throughput capabilities.[191] At such high frequency, atmospheric absorption limits the propagation of the signal and the antenna has to be highly directional.[192] The comparative benefits of these different backhaul solutions are outlined in Exhibit 64. As of July 2020, microwaves in Pakistan are used by commercial telecommunication operators for backhaul transmission in the 7 GHz to 57 GHz band, as well as in the E-band.[193]

Exhibit 64: Mobile Backhaul Technology Trade-Offs in Relation to 5G: Wireless versus Fixed

Segment	Microwave (7–40 GHz)	V-Band (60 GHz)	E-Band (70/80 GHz)	Fiber-optic
Future-Proof Available Bandwidth	Medium	High	High	High
Deployment Cost	Low	Low	Low	Medium
Suitability for Heterogeneous Networks	Outdoor Cell-Site/Access Network	Outdoor Cell-Site/Access Network	Outdoor Cell-Site/Access Network	Outdoor Cell-Site/Access Network
Support for Mesh/ Ring Topology	Yes	Yes	Yes	Yes, where available
Interference Immunity	Medium	High	High	Very High
Range (Km)	5-30, ++	1-	~3	<80
Time to Deploy	Weeks	Days	Days	Months
License Required	Yes	Light License/ Unlicensed	Licensed/ Light License	No

Source: GSMA (modified), Mobile Backhaul Options: Spectrum Analysis and Recommendations, September 2018.
Note: for mountainous and remote areas, satellite can also be used as a backhaul technology

[191] *Ibid* page 13.
[192] PTA, *Rolling Spectrum Strategy*, July 2020, page 23.
[193] *Ibid*, page 24.

7.5 Infrastructure Sharing and 5G

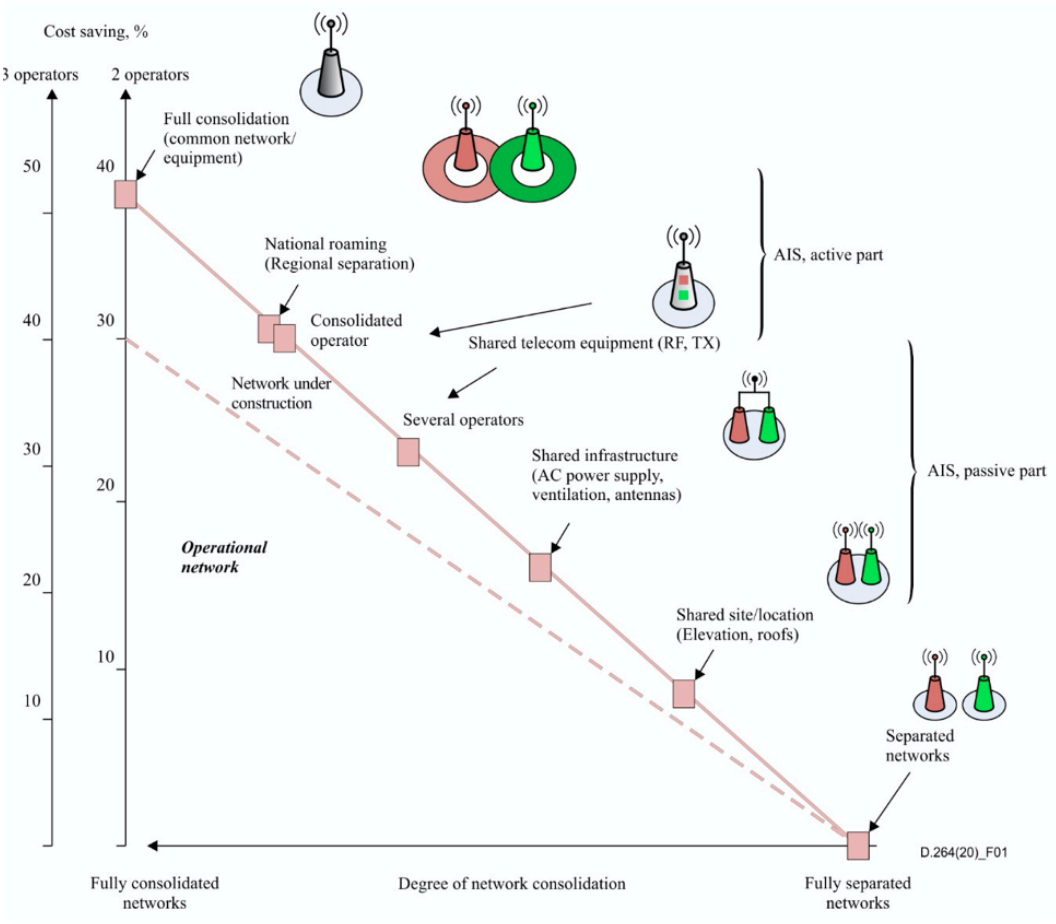
7.5.1 Telecom Infrastructure Sharing Guidelines

In October 2020, the PTA began a public consultation on the Telecom Infrastructure Sharing Guidelines. Comments invited from all telecom users, stakeholders, interested persons and the public.

In the Consultation Paper, the PTA recognised that infrastructure sharing promotes resource optimization by better utilization of assets, avoiding duplication of network, saves time and cost in network and service rollouts.

Indeed, implementation of active sharing will bring number of benefits to the Pakistani telecommunications sector. Exhibit 65 demonstrates the potential for increased cost savings by allowing active infrastructure sharing as identified by the ITU. However, it is important to note that active sharing, while more cost-efficient, requires more rigorous market and competition analysis than passive sharing.[194]

Exhibit 65: ITU estimates of potential scenario of cost savings



Source: ITU, 2020[195]

[194] A4AI, *Affordability Report 2019* page 6. Available at www.A4AI.org
[195] ITU, *Shared uses of telecommunication infrastructure as possible methods for enhancing the efficiency of telecommunications*, D.264, 04/2020, page 3

To ensure that infrastructure sharing is implemented in efficient manner that is consistent with international best practice, we consider certain principles/initiatives should be adopted. For instance, active or passive sharing should be agreed on commercial terms, rather than mandated by the government . As the ITU puts it, "[p]rices for infrastructure sharing are best set through commercial negotiation so that they embed a commercial rate of return on investment."[196] However, the ITU also notes that regulators should have oversight of the terms and conditions so as to ensure that infrastructure owners do not abuse their dominant market position and decrease competition.[197]

PTA should also facilitate the establishment of industry bodies to develop uniform conditions/self-regulatory models for infrastructure sharing, as well as provide financial incentives to encourage infrastructure rollout and sharing in Pakistan.

7.5.2 5G and Infrastructure Sharing

The PTA should promote collaboration on network infrastructure, particularly for 5G. This is because infrastructure sharing is critical to facilitating accessible and reliable internet access in Pakistan, particularly in regional and remote locations. As global infrastructure-sharing experiences have shown, developing countries can save billions and speed universal broadband access by sharing infrastructure.

It is therefore a ideal time for Pakistan in to consider what sort of networking sharing agreements would be most cost efficient and able to avoid redundant future CAPEX. 5G deployment requires significant investment, so network sharing and partnerships with other MNOs is an attractive option. In urban areas, where there will be a large number of small cells/street furniture to deploy, network sharing makes particular financial sense. It would also be the most cost-efficient strategy in rural/less economic areas (with low band spectrum).

When entering into agreements on 5G infrastructure sharing, in addition to determining pricing and bundling schemes, MNOs need to determine the scope of the sharing arrangements. Globally, MNOs have often chosen to exclude legacy technologies like 2G and 3G from an active sharing arrangement, to avoid transformation costs of the legacy technology, or due to asymmetries in existing legacy technology between operators.[198] The key considerations for operators when deciding which sharing model to adopt for 5G deployment are outlined in Exhibit 66:

[196] ITU, in conjunction with the World Bank, *Digital Regulation Handbook: Conference Edition*, August 2020. Page 38. Available at www.itu.int/en/myitu/Publications/2020/08/31/09/09/Digital-Regulation-Handbook

[197] *Ibid.*

[198] Arthur D Little, *Network Sharing in the 5G era: Choosing the Right Sharing Model to Maximise Efficiently of 5G Rollout,* November 2020.

Exhibit 66: Key considerations for selecting technology scope for sharing[199]

	Criteria	5G-only sharing	4G/5G sharing	2G/3G/4G/5G sharing
1	Key driver for savings	5G ambition *Savings potential relies fully on high 5G ambition (e.g., fast rollout, nationwide coverage)*	4G densification and 5G ambition *Ideal for operators that still expect some 4G deployment in the next three to five years*	Maximizing operational benefits and grid optimization *A lean venture, with maximal synergies between the MNOs*
2	Ease of upgrade to MORAN/MOCN configurations	Limited upfront costs *Legacy is left as-is, with no additional sharing-upgrade costs*	Only the 4G layer needs to be upgraded for MORAN/MOCN *Avoid investments into legacy equipment that is not generating further savings*	The whole MNO grid should be MORAN/MOCN-ready *Upgrade the entire grid to MORAN configurations for both MNOs*
3	Flexibility to sunset legacy	Each MNO can pursue independent strategies on legacy roadmaps *Full independence in legacy network*	MNOs can independently sunset 2G/3G, depending on their own roadmaps for transition to VoLTE *Ideal for operators with high asymmetry in 2G/3G usage and plans (e.g., incumbents vs. newer players)*	MNOs need to align on 2G/3G sunset *Need to find an optimal, compromise strategy that suits both partners*
4	Vendor selection	Full flexibility to focus on 5G vendors; no need to harmonize legacy vendors *In many cases, the most innovative 5G solutions are coming from new vendors*	Flexibility to choose different vendors for 4G/5G vs. legacy 2G/3G *MNOs need to harmonize 4G layer before proceeding to sharing, allowing the retention of any beneficial vendor deals in 2G/3G and focusing on future innovation*	Vendor lock-in for all technologies (2G/3G/4G/5G) *The best 4G/5G vendors may not be the same as the best legacy vendors, yet MNOs would have reduced choice due to legacy*
5	Impact on services	Seamless handover between 4G and 5G through different vendors may be tricky yet allows MNOs to focus fully on 5G services *Better for MNOs that focus on 5G-centric use cases and/or expect strong 5G device penetration*	Keeping 4G and 5G together allows synergies in handling data capacity *Keep 4G and 5G together, without disrupting 2G and 3G*	Keep full technology stack together to minimize any disruption of services *Minimal risk on user-facing services*
6	Complexity of sharing venture	Easy to set up and run *MNOs share the least, minimizing operational complexity*	Medium complexity, as only 4G/5G is shared, and legacy is kept separate *High complexity, due to creating duplications of 2G/3G*	More complex, as all technologies are shared, and transformation might take longer *Optimizes legacy the most for the leanest shared network*

The regulatory challenges of a 5G rollout are substantial. There are many considerations that need to be taken into account when considering how 5G infrastructure is optimally deployed. Selecting the most appropriate network-sharing model requires a balance the strategic considerations of the future 5G network, competitive positioning while ensuring favourable financial outcomes.

Arguably, 5G deployment in Pakistan would benefit from active network sharing under an MCON or GCN agreement, and while prohibited under the current Guidelines they are to be permitted in accordance with the proposed amendments.[200]

It should be noted that globally, other jurisdictions have adopted spectrum sharing models to counter the scarcity and high cost of spectrum:[201] Hong Kong has implemented high traffic demand priority areas, so that the 26/28 GHz band is subdivided in to shared and non-shared spectrum. 400 MHz is allocated for the provision of wireless broadband services in locations with high traffic demand. Italy has implemented club sharing, which allows multiple MNOs to use spectrum if there is more than one 5G provider in the area. Spectrum sharing should certainly be part of the PTA's regulatory strategy for infrastructure sharing, as it may help alleviate cost and resource issues with 5G rollout in Pakistan.

7.6 Improving ROW to Facilitate 5G Deployment

Rights of Way are dealt with under section 27A(1) of the PTA Act. Every licensee has the right to share any Public Right of Way or Private Right of Way for the purpose of installing or maintaining its telecommunication equipment or for the purpose of establishing or maintaining its telecommunication system.[202]

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[199] *Ibid* page 6.
[200] *Ibid*.
[201] www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2020/Spectrum_EUR_CIS/Pavel%20Mamchenkov%20%281%29.pdf
[202] PTA Act s 27A(1)

If a request is made to an owner of a Right of Way, and they do not respond within 30 days, the request is deemed to be granted. In granting this request, the owner may impose reasonable conditions on the payment of fees and the mode or timing of the execution of the work.[203]

Importantly, a licensee also has the responsibility of exercising powers conferred in a manner that causes minimal interference of the enjoyment of the Right of Way by the owner or other users. Further, if no fees are to be paid by the licensee to the owner of the Right of Way, the licensee shall make reasonable reparation to the owner.[204] If there is a dispute over a refusal of Right of Way, the matter is referred to the appropriate Government who decide the matter within 60 days.[205]

Public and Private Right of Way Policy Directive

A cumbersome approval process with high Right of Way charges has historically hindered deployment of OFC in Pakistan. To overcome this, on 9 October 2020 the 'Public & Private Right of Way Policy Directive' was enacted by the Federal Government. Its objectives are to promote modern telecommunication services, resolve the issues of licensees concerning Right of Way in installation or maintenance of telecommunication equipment, and to introduce a fast-track process for Rights of Way.[206] Under the policy, the public authority is not to impose any discriminatory or anti-competitive conditions on a licensee (s 16), and telecommunication infrastructure is treated as 'critical infrastructure' (s 11). Key features of the policy include:

- **Fee determination:** The Right of Way fee is to be assessed on the basis of 'no profit no loss' and the fee should include any charges incurred in issuing or maintaining the Right of Way (s 7(b)). The Public Authority is forbidden from engaging in discrimination or preferential treatment when determining fees.
- **Dispute resolution:** Disputes can be submitted to the Cabinet Secretary, Secretary of the Division or any other officer appointed by the respective appropriate government (s 8). The establishment of an online complaint system is also encouraged by the policy.
- **National security:** Licensees must ensure that before the commencement of an operation related to the Right of Way, they have complied with a set of conditions concerned with national security, including that contractors are verified by local police authorities, and any foreigners involved obtain security clearance (s 9).
- **Measures for safety:** All telecommunication licensees are under an obligation to lay down their network in a proper manner in accordance with preventative measures for safety and protection from health-hazardous effects (s 10).
- **Sharing of right of way**: Upon a request in writing by any licensee, an existing licensee holding a Right of Way shall share it (s 13(2)). Compensation for having to share shall not be more than 50% of the amount paid by the licensee.

[203] PTA Act s 27A(2)
[204] PTA Act s 27A(3)
[205] PTA Act s 27A(6)
[206] Government of Pakistan: Ministry of Information Technology and Telecommunication, *Right of Way Policy Directive*, 9 October 2020, s 3.

- **Establishment of common services corridors:** Relevant civil infrastructure development organisations shall ensure the availability of telecom service corridors for the installation of telecom infrastructure or cables along in new land development, railways, roads, highways, buildings, and electronic distribution poles.

However, there are still challenges for Pakistani operators. They must forecast the likely demand for network services in the face of uncertain future consumer behavior, unknown behavior of competitors and rapid technological change. The rapid pace of technological change accelerates obsolescence and makes long-term planning inherently more difficult. Additionally, Pakistan's land law adds complexities in facilitating RoW (see Exhibit 67).

Exhibit 67: Land Law in Pakistan

There is lack of a comprehensive legal framework governing land rights in Pakistan. Statutory law specific to land rights in Pakistan is dated, fragmented, and incomplete. Rather, Pakistan has a well-developed and diverse body of customary law governing land rights. Customary law governing land issues extends to principles governing boundaries. Particularly in the Tribal Areas, people regulate their own affairs in accordance with customary law, and the government functions through local tribal intermediaries.

All land in Pakistan can fall into one of three categories: state owned land, private owned land and village common land. Land for which there is no rightful owner vests in the Provincial Government if within a Province, or with the federal government if not.

- *State owned land:* State land can be granted to individuals under various schemes. Ownership will still belong to the state but can be possessed by citizens on a temporary basis against a nominal annual rent. There are many parcels of state land that are under illegal occupation of citizens and state does not have the will or does not want to evict them
- *Private owned land:* Farmlands usually fall under private ownership. Private owned land is subject to automatic inheritance under the Muslim personal law.
- *Village common land*: Common land is subject to communal rights under customary law. The land is a grant given by the State, out of State land, to owners of the village to be used for their common purposes. It is jointly owned and possessed by landowners of that village.

Major tenure types are summarised as follows:

- **Ownership**. Ownership is the most common tenure type in Pakistan. Private individuals and entities can obtain freehold rights to land. Further, communal ownership rights are recognised under customary law.
- **Lease**. Term leases are common for parcels of agricultural land over 30 hectares. Leases are for fixed rates, generally running at least a year. Leases may be written or oral agreements.
- **Sharecropping**. Sharecropping arrangements are common on agricultural lands less than 30 hectares. Approximately 67% of Pakistan's tenant-operated land was sharecropped in 2000. Most agreements are unwritten.

Foreign-controlled companies that are incorporated in Pakistan can own land in Pakistan. Foreign individuals must obtain permission from the Home Department before acquiring land in Pakistan.[207] Freehold land in Pakistan tends to be retained by families and passed inter-generationally by inheritance. Ownership is rarely registered. Despite formal laws mandating registration, incentives for registering land are weak or non-existent and procedures complicated and lengthy. Land is typically titled in the name of the head of household or eldest male family member of an extended family. While community property rights are recognised under formal law, joint titling of land is uncommon.

[207] www.martindale.com/xp/legal/Professional_Resources/Law_Digest/intro.xml

7.7 International Transmission Capacity and Cloud Infrastructure

7.7.1 International Transmission Capacity

Pakistan engages submarine cable and satellite systems in its international data transmission. Pakistan also has engaged usage of a cross-border terrestrial cable providing a direct connection to China (see Exhibit 68).

Exhibit 68: Infrastructure in Pakistan

Description	Current State of Play
Internet Traffic Optimization - Local:Foreign (as ratio)	66:33
Total Available/Used Capacity (in Tbps)	13Tbps+/2.5Tbps
Carrier Centric Cable Landing Stations	4
Carrier Neutral IXPs	1
Public Cloud Data Centers	12+ (approx. 600 racks)

Source: PTA, Telco Operator Planning and Commercial Teams

Pakistan's international data transmission is anchored by its extensive network of submarine cables. PTCL is the landing party for all submarine cable systems except TW1 (a private cable owned by Transworld). Pakistan Telecommunications Limited Company (PTCL) is the national telecommunication company in Pakistan and an incumbent telecommunications operator in Pakistan. Pakistan currently has six submarine cable systems as follows:

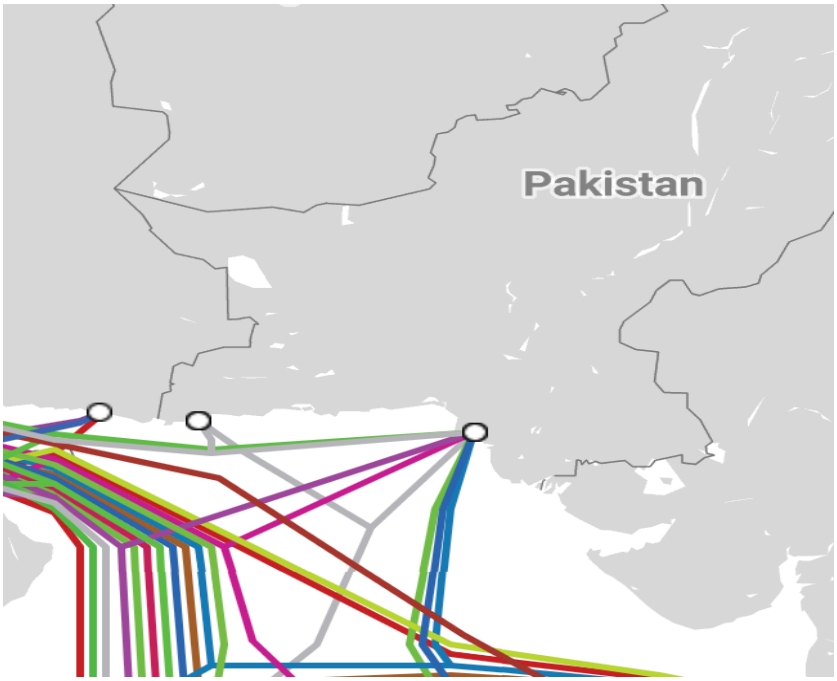
- SMW3 (South East Asia – Middle East - Western Europe)
- SMW4
- SMW5
- IMEWE (India – Middle East – Western Europe)
- AAE-1 (Asia – Africa – Europe)
- TW1 landed by Transworld (Pakistan – UAE – Oman)

Currently there are two additional systems under construction:

- Orient Express (Pakistan - UAE): the cable will be built by Wi-Tribe LDI Pakistan and landed in Karachi and Gwandar.
- The PEACE cable (Pakistan & East Africa Connecting Europe): it will span three continents providing the lowest latency service from Pakistan to Europe. It will be landed by Cybernet in Karachi and Gwadar. The PEACE Cable is expected to increase Pakistan's internet infrastructure capacity by 96 terrabits per second with the country's first carrier-neutral, open-access submarine cable system.

As illustrated in Exhibit 69, these submarine cable systems have their Pakistan landing points in Karachi (West) and Gwadar (East).

Exhibit 69: Submarine Cable System Landings in Pakistan



Source: Telegeography, 2020

In 2019, two main submarine cables, IMEWE and SMW5, that carry almost 50 per cent of Pakistan's internet traffic, went offline due to a fault caused by a cyclone. Internet outage also occurred earlier in that year when services were disrupted due to "multiple cable cuts".[208] This gives rise to potential concern over Pakistan's ability to cope with 5G's greater international bandwidth demands.

7.7.2 Cloud Infrastructure

Whilst the IT industry in Pakistan has undergone a revolution, cloud computing hasn't established its roots yet. Specifically, the country's lack of foreign investment in cloud computing has negatively affected the growth and development of the industry. However, the demand for Cloud computing is rapidly growing in Pakistan as companies realise the expense of maintain their own IT infrastructure. The main advantage of cloud computing is that it had cut down the storage costs and provided greater reliability, scalability and flexibility.

Pakistan's Data Centres

Despite a slow start in the cloud computing industry, the Pakistani government as well as private companies have taken positive steps. There are four top cloud hosting providers whose data centres are physically present in Pakistan. They are as following:

[208] www.news18.com/news/world/internet-services-disrupted-in-pakistan-due-to-fault-in-submarine-cable-2366465.html

- ***PTCL:*** a semi-government body with one of the largest data centres in Pakistan in terms of size. They predominantly host data of government organisations. PTCL, using IBM cloud platform, offer cutting edge services such as IaaS, VPS, DRS and Backup and Storage;
- ***TallyMarks Cloud:*** a private organisation providing IaaS for Enterprise Cloud application with complete Managed Services and Disaster Recovery Services (DRaaS);
- ***Wateen:*** a private company and leading internet provider; and
- ***Rapid Compute***: a company by Cybernet (an ISP provider in Pakistan). They offer Enterprise Class public cloud computing platform.[209]

Additionally, Amazon has formed a team for Amazon Web Services (AWS) in Pakistan with an aim to push cloud computing adoption. The company has registered a local office under Amazon Data Services Pakistan (Pvt) Ltd name.[210]

There are multiple reasons why having cloud infrastructure located within Pakistan is important for companies operating in Pakistan.[211] One reason being that a cloud service provider has multiple locations where they store copies of their data. Having a cloud infrastructure provider in Pakistan enables an enterprise to simply arrange for a hard backup of their data and collect it on disk if needed, while still maintaining multiple soft backups at different locations. Furthermore, tests in Pakistan for latency show that cloud infrastructure located outside the country can have a delay of more than 350% compared to cloud infrastructure located within Pakistan (without use of VPN).[212]

Key points and recommendations

Key Points

- The regulatory challenges of a 5G rollout are substantial. There are many considerations that need to be taken into account when considering how 5G infrastructure is optimally deployed. In the digital infrastructure area, there are four additional key recommendations for the success of 5G in Pakistan:
  (a) Improving ROW to facilitate 5G deployment
  (b) Need for improved access to towers and sites for 5G deployment;
  (c) International transmission capacity and cloud infrastructure; and
  (d) Support for the Internet of Things (IoT).
- 5G requires significantly more spectrum in the access portion of the networks than previous technologies, requiring higher bandwidth backhaul solutions. Fibre connectivity of Pakistan's mobile networks is likely to be necessary for 5G and will drive future

[209] www.tallymarksconsulting.com/2019/09/02/top-cloud-data-centers-in-pakistan/
[210] www.technologytimes.pk/2020/08/09/amazon-web-services-to-push-cloud-computing-adoption/
[211] Zong have stated their support for the promotion for making Pakistan a global hub for cloud computing: Zong, *5G Readiness and Support Required from Government,* 22 June 2021.
[212] www.tallymarksconsulting.com/2019/09/02/why-having-a-cloud-infrastructure-located-within-pakistan-is-important/

business activity for the country's transmission infrastructure providers. Alternatively, backhaul links using the V-band or E-band could be another backhaul solution.

- Pakistan's cloud infrastructure is still in a nascent stage due to lack of foreign investment. However, demand is rapidly growing due to its reduced storage costs. Having cloud infrastructure located within Pakistan is valuable for companies operating within Pakistan for convenience and lower latency.

Recommendations

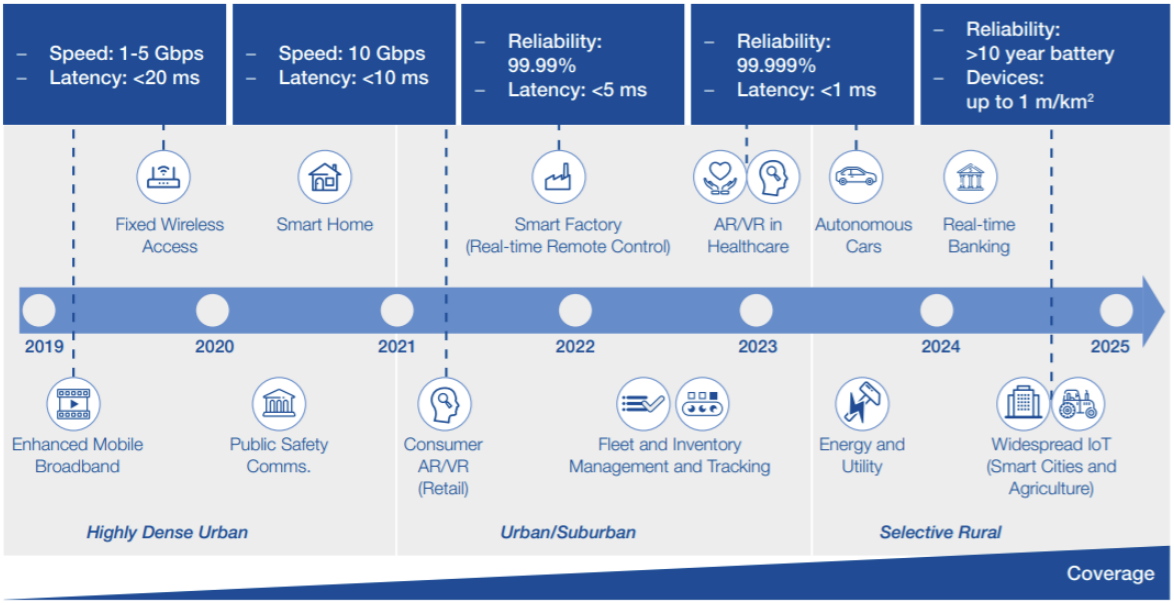
- A national infrastructure database should be established to avoid costly damage to infrastructure, disruption of service and possibly personal injury.
- The PTA should promote active sharing of infrastructure under a MCON or GN agreement, however, it is important to note that active sharing requires more rigorous market and competition analysis than passive sharing. Any active sharing should be agreed upon in commercial terms, rather than mandated by government.
- PTA should also facilitate the establishment of industry bodies to develop uniform conditions/self-regulatory models for infrastructure sharing, as well as provide financial incentives to encourage infrastructure rollout and sharing in Pakistan.

8 Applications and Use Cases for 5G

8.1 Overview

This section highlights the enormous economic value that 5G can create in Pakistan, through commercial opportunities across various industry sectors (Exhibit 70). Some of the different technologies that 5G can benefit are explored, including for Fixed Wireless Access (FWA), Enterprises, and the Internet of Things (IoT), as well practical applications of 5G in Pakistan.

Exhibit 70: 5G use cases enabled across industry sectors



Source: PwC[213]

A report by the World Economic Forum and PwC found that the most significant ways that 5G will contribute to industrial advances are by enabling faster and effective inspections through predictive intelligence; improving workplace and worker safety; and enhancing operational effectiveness.[214]

In practical terms, the above outcomes will be enabled by the key 5G use cases that are likely to be the most relevant based on their potential and anticipated socio-economic benefits on the economy. For example, high-speed broadband in the home and office has many potential applications that are enabled by the provision of high-speed broadband. In the field of education, it is expected to increase access to and quality of education, especially in cases where online learning opportunities are necessary.

[213] www.pwc.com/gx/en/about-pwc/contribution-to-debate/wef-the-impact-of-fiveg-report.pdf
[214] Ibid.

Additionally, 5G enables the use of remote operation of different types of devices that can enable the remote control of equipment and vehicles. This is expected to increase safety by preventing human workers from operating machinery in risky situations. 5G also enables the use of next-generation transport connectivity. That is, intelligent transportation systems using data from connected vehicles and smart infrastructure could improve commute times and reduce pollution by optimising pedestrian routes and public transportation.[215]

Due to the numerous use cases enabled and improved by 5G, robust internet connectivity enabled by 5G technology is expected to create around USD3.6 trillion in economic output and 22.3 million jobs by 2035 in the global 5G value chain. This will translate into global economic value across industries of USD13.2 trillion.[216] Particular Asian studies have mapped potential 5G use (see Exhibit 71 below).

Exhibit 71: 5G use case mapping

	Power Networks and Energy Savings	IoT/ IoMT Sensors	Ultra-High Definition Camera	RFID/ Indoor location	Tactile Internet	Remote Monitoring & Remote Control	Connected Vehicles/ Connected Ambulance	Drone surveillance/ Drone usage	Artificial Intelligence & Data Analytics	Cloud Services/ Blockchain	Robotics & Automation	Augmented Reality/ Virtual Reality
Agriculture	X	X				X	X	**O**	X		X	X
Banking and Finance		X	X	X					X	**O**		X
Digital Healthcare		X	X		X	X	**O**		**O**			X
Education		X							X	X		**O**
Manufacturing and Process Industries	X	X	X	X	X	X		X	**O**	X	X	X
Oil and Gas	X	X	**O**			X		X	X	X	X	X
Retail and Services	X	X	X	X				X		**O**		X
Smart City	X	X	**O**	X		X	X	X	X	X		X
Smart Transportation		X				X	**O**	X	X			X

Legend:

X: Potential application

O: High potential application – used as example

Source: MCMC, Public Consultation, National 5G Taskforce Findings and Recommendations to Government, 14 August 2019, page 8-9

[215] www.gsma.com/spectrum/wp-content/uploads/2019/10/mmWave-5G-benefits.pdf

[216] www.pwc.com/gx/en/about-pwc/contribution-to-debate/wef-the-impact-of-fiveg-report.pdf

8.2 Using 5G for FWA

Globally, fixed wireless broadband access (FWA) has reached a landmark global take-up of over 100 million customers. In emerging markets, including but not limited to Thailand, Sri Lanka and South Africa 4G (and 5G) technology offers a way to improve overall telecommunication service quality with FWA rapidly and affordably. Of the 169 operators that have launched commercial services as of June 2021, GSA has catalogued 63 operators that have announced the launch of either residential or business 5G FWA broadband services.[217]

FWA is both a viable substitute as well as complement to FTTx fixed services. Early FWA provisioning not only makes emerging country businesses more competitive, but also offers a way to quickly and cost-effectively bring high-speed broadband services to high-rise residential buildings in urban centres. Given the demand for video streaming and other content services, the delivery of faster broadband services with good-quality service at a lower cost is desired by many subscribers.

In addition, FWA deployment offers a stepping-stone towards future deployments of fixed infrastructure. Deploying higher speed 4G and 5G services will entail additional fibre to wireless base stations/nodes. This lays the groundwork for future fibre-to-the-premises deployments, while still delivering high-quality FWA services earlier than would otherwise be possible. In effect, FWA offers immediate benefits to telecommunications consumers as fibre reaches out from national telecommunications nodes to wireless distribution points and on to businesses and residences at later dates, assuming that OFC deployment is much improved.

From a spectrum management perspective, regulators including the PTA should acknowledge the growing use of FWA, and include such services in their spectrum roadmaps and demand analysis. It must also be recognised that 4G, and especially 5G, work best if harmonised IMT spectrum using the 2.3, 2.6 or 3.5 GHz spectrum bands is allocated to licensees in larger contiguous blocks. Larger spectrum allocations – if they can be done at reasonable prices – allow mobile operators to deploy wireless networks which can be shared for both mobile and FWA applications. This provides something of a 'silver bullet' for the problem of encouraging competitive pressures in the broadband markets.

Certainly, artificial limitations on the use of spectrum for "fixed" and "mobile" services should be removed. Spectrum allocations should be technology-neutral as well, allowing providers to invest in and deploy optimal technology solutions.

Furthermore, to ensure that not only city dwellers have access to the digital economy. Freeing up additional sub-1 GHz spectrum allows FWA services to also make use of these bands. 4G and 5G FWA services at sub-1 GHz offer the fastest and most cost-effective pathway to bridging the digital divide between urban and rural populations. The 2020 announcement between China Mobile and CBN in China which includes access to the 700 MHz spectrum to improve 5G access is a good example of this.

Lastly, given the global coronavirus (COVID-19) pandemic, FWA services are becoming more critical. FWA services can be quickly deployed to regions where existing digital

[217] GSA, *Networks, Technologies & Spectrum Snapshot: June 2021*

infrastructure is inadequate, antiquated or needs augmentation to meet increased customer demand.

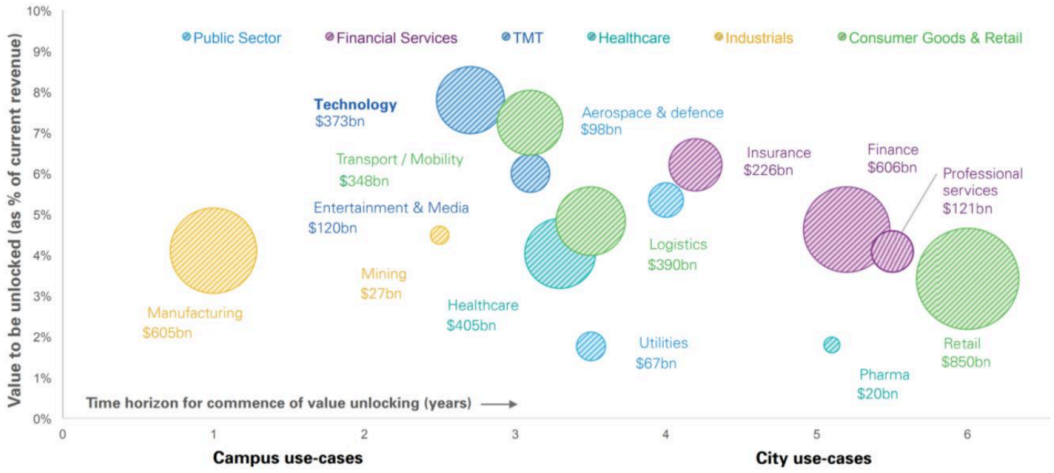
8.3 Using 5G for Enterprises

The 3GPP put the spotlight on industry expansion in July with 5G NR Release 16 and set the stage for enterprise and industry verticals to look at how to provide high-performance wireless connectivity with 5G private networks. With a variety of options for spectrum, different network architectures, a rich feature set to meet the demanding needs of the industrial Internet of Things (IIoT), and the privacy and security required for business assurance, 5G private networks are poised to transform enterprise and industry.

In 2019, HMS Labs, an industrial communications specialist, predicted that 5G would provide "safer, flexible and more efficient manufacturing systems," filling an urgent hole.[218] ABI Research has forecasted that manufacturing will provide a significant percentage of revenue for the 5G Ultra Low Latency Use Cases market.[219]

5G will unlock value across major industry verticals. As shown below in Exhibit 72, certain industries are likely to benefit more from 5G systems.

Exhibit 72: KPMG: DNA of 5G industry value of various vertical industries



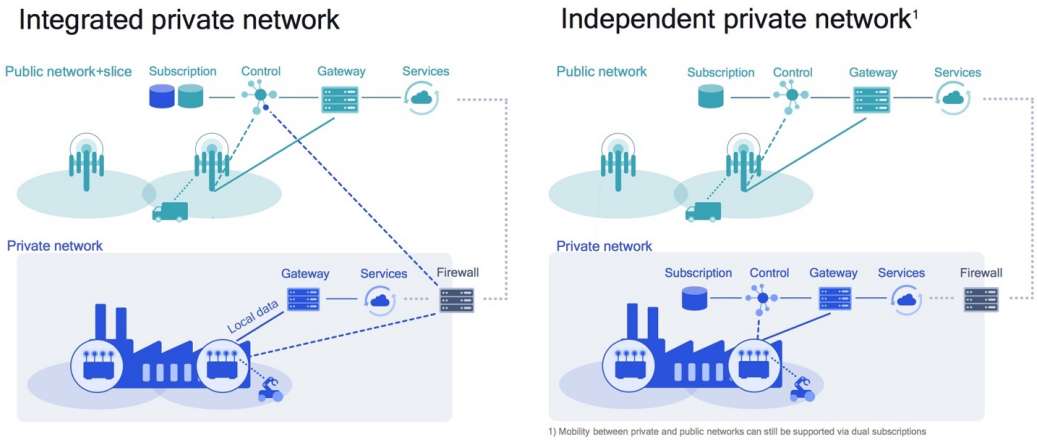
Source: KPMG, Unlocking the benefits of 5G for Enterprise Customers, 2019

Manufacturing companies run highly precise, high-output, and largely automated operations using low-latency commercial and private 5G network. It is expected that by 2030, USD400 to $USD50 billion of GDP will in business value resulting from manufacturing sector use cases running on improved connectivity.[220]

[218] https://5g.co.uk/news/5g-factories-super-smart/4834/
[219] https://5g.co.uk/news/manufacturing-will-generate-25-of-5g-revenue-by-2028/5140/
[220] McKinsey Global Institute (business and economics research arm of McKinsey & Company), *Connected world: An evolution in connectivity beyond the 5G revolution,* February 2020

There are a number of different models which could be adopted including enterprises running their own private networks or the MNOs assisting the enterprise customer by providing capacity, reliability, latency, bandwidth and efficiency (as shown in Exhibit 73 below) . There has been an increase in the number of MNO's working with businesses to create a variety of 5G powered businesses. Globally licensing approaches have endorsed a licensing option for small-area, multi-device deployments, including for proposed 5G applications. Such arrangements, while not exclusively restricted to industrial or commercial applications of spectrum, have often been utilised by a variety of 'industry verticals' – industries outside of the MNOs, such as mining and infrastructure that use spectrum to facilitate their operations.

Exhibit 73: Multiple private network architectures for flexible deployments



Source: Qualcomm, *Transforming enterprise and industry with 5G private networks*, 15 October 2020, page 10

8.4 Internet of Things (IoT)

8.4.1 Overview of IoT

The current global view is that the Internet of Things ('IoT') is rapidly transforming the way individuals, enterprises and governments communicate and work. There will be a fundamental shift in lifestyles on the back of a large number of devices communicating with one another. In turn, this will collaboratively result in increased optimization and enhanced productivity.[221] Its adoption by the agriculture sector including animal farming will be critical in the Pakistani context.

The IoT ecosystem involves interaction of telecommunications services with a range of new services and machine to machine ('M2M') communications. The IoT will enter into every aspect of lives and cities, as well as support all industries. According to the GSMA, the global IoT market will be worth $1.1 trillion in revenue by 2025.[222] By that time, the GSMA estimates that there will be more than 25 billion IoT connections driven largely by growth in the industrial IoT market.

The IoT first emerged in the 2G/3G network environment. However, the development of 4G LTE networks featuring advantages in spectral efficiency, latency and data throughput

[221] See www.gsma.com/iot/
[222] See GSMA, *'IoT: the $1 trillion revenue opportunity* (May 2018)'

provided the initial stimulus for widespread IoT deployment. 5G provides superior transmission speed and lower latency enabling greater capacity for connected devices. The capacity of 5G networks to carry more data faster will push significant growth in IoT applications. 5G provides a range of benefits to IoT, which are not available with 4G or other technologies. These include 5G's ability to support a massive number of static and mobile IoT devices, which have a diverse range of speed, bandwidth and quality of service requirements.

8.4.2 Recommendations in relation to 5G IoT

As Pakistan prepares itself for the deployment of 5G networks, Pakistan's policy makers must carefully balance implementing new specific IoT regulation with creating an environment that allows IoT innovation to thrive. Overstepping regulatory intervention is capable of stifling industry initiatives and eroding consumer benefits. On the other hand "do nothing" or a "wait and see" approach have the potential to create risks for public safety.

In relation to the spectrum needs and the spectrum road-map for 5G IoT in Pakistan, we recommend following:

(1) Align regulatory framework with global and regional development

Given the global nature of 5G IoT device availability, it is in Pakistan's interest to align itself, where possible, with global and regional developments. An optimal approach would be a regulatory framework that facilitates the development and growth of IoT, and does not impose service or technological restrictions that could hold back innovation.

The European approach to IoT as articulated by the RSPG has merit given the above argument. Specifically, the RSPG concluded that *inter alia*:

- As IoT is heterogeneous - there is no single solution for access to spectrum that fits all these possible use cases since their technical requirements differ dramatically; and
- Frequencies allocated or identified for electronic communication services (mobile networks) may be used for emerging IoT applications and services – including the 700, 800, 900, 2100 and 2600 MHz bands.

These views are arguably different from those of the GSMA which are advocating for the following:

- Regulators should adopt a service/technology neutral framework to support cellular IoT services;
- Licensed spectrum has the capacity and coverage capabilities to support IoT growth.[223]

Pakistan should not restrict IoT spectrum and hence deployments solely to the MNOs. Both IoT versions (MNO as well as stand-alone) should be allowed to co-exist. The MNOs already

[223] See GSMA, *Spectrum for the Internet of Things, GSMA Public Policy Position,* August 2016.

have significant advantages, it seems that if they make the requisite investments in the necessary systems, then they will stake a strong if not unassailable market position.

(2) Utilize sub 1 GHz bands for IoT

It is recommended that Pakistan utilises the 700 MHz band for NB-IoT, post its release. The wide and deep coverage it can provide and the fact that NB-IoT chipset fully supports it, make this band a viable candidate.

In Australia, the 700 MHz band has been instrumental in extending 4G coverage to regional and remote areas of Australia that would have been economically problematic to do so otherwise. Prior to the deployment of 700 MHz, Australia's leading provider Telstra had networks covering approximately 85 percent of population and 100,000 sq. km.[224] The use of this band in conjunction with existing and new 4G sites helped push Telstra's 4G coverage to over 99 percent of the population and more than 1.6M sq. km of Australia including NB-IoT coverage.[225]

In emerging markets such as the Philippines, the ability of 700 MHz to support NB-IoT/LTE-M services is excellent given the improved coverage and lower costs.[226] It is also important to emphasize that IoT encompasses a broader set of applications and use cases than those enabled by today's mobile cellular networks. New IoT use cases will be enabled by 5G since some specific IoT functionality will be designed into 5G from the start, with features including network slicing, low energy consumption and scalability. As previously discussed, such factors may be addressed by including a requirement to support MNOs in relation to 5G spectrum, including the 700 MHz band.

8.5 Specific 5G Use cases in Pakistan

This section highlights the practical use cases and 5G applications for Pakistan and proposes a way forward to assist the market to become more ready for 5G applications and use cases. The use cases are prioritized by relevance (key issue being addressed, technology requirements, business model/impact, stakeholder monetization, key challenges, concerned sector deliverables) and feasibility to implement in Pakistan.

5G use cases

5G enables different types of use cases that require varying levels of speed, latency, number of connections and mobility. While previous IMT generations have been monolithic in its physical infrastructure and applications, 5G offers flexibility and modularity that can interface with different IMT and non-IMT technologies. These characteristics allow different applications, previously unimagined, such as smart cities, autonomous vehicles, and telesurgery.
For countries like Pakistan, 5G could present ways to accelerate digital transformation and fuel new paths to prosperity.

As of the first half of 2021, 5G use cases have been largely explored through trials and pilots. The applicability of 5G use cases in a specific sector varies by country based on sector maturity, digital maturity, national interest and a variety of other factors. In Pakistan, Zong

[224] See GSMA, *Securing the Digital dividend across the entire ASEAN*, August 2018, page 11
[225] *Ibid*
[226] *Ibid*

and Jazz completed 5G trials as of January 2020[227] while Telenor Pakistan and PTCL/Ufone did so in March 2021.[228] However, evidence of 5G-enabled applications for industry verticals are limited. The government can play a more active role in the development of 5G use cases by coordinating amongst the different stakeholders including telecom operators, government agencies and industry verticals; providing support for 5G testbeds; promoting digital skills development and allowing regulatory flexibility to explore different use cases. Besides establishing an enabling environment for 5G development, a crucial step for the government is to make spectrum available as early as possible.

5G applications and use cases for Pakistan

To meet its goals of becoming a top 25 global economy by 2025 and a high income country by 2047, Pakistan will need to strengthen the platform for a sustainable and resilient growth. Advanced technologies such as 5G can help Pakistan boost national competitiveness and economic resilience. Specifically, use cases of 5G technology in sectors such as agriculture, smart cities, healthcare, energy and education can aid the country in addressing its challenges.

8.5.1 Agriculture

Pakistan's vision for 2030 is to ensure "efficient and competitive sustainable agriculture ensuring food security and with ability to contribute to the economic development for Pakistan." Agriculture is one of the largest sectors in the country that provides food security and employment. The sector accounts for 18.5% of Pakistan's GDP and employs around 38.5% of the labour force.[229] Over the years, however, productivity in the sector has declined due to lack of water resources stemming from inefficient irrigation systems and practices and the impact of climate change.[230] The 12th Five Year Plan aims for a 3.1% growth in the agricultural sector from 2018-2023. The government is aiming to achieve this by also leveraging Climate Smart Agriculture that enhances sectoral productivity while building resilience to climate change.

The use of IoT technology in agriculture has allowed farmers to boost productivity and production through the collection and analysis of data on crop yield, soil-mapping, fertilizer use, weather, machinery and animal health (3GPP 2018, p. 146). 5G can scale-up IoT technology through MMTC applications and enable precision-agriculture that can lower inputs to sustainable levels while maintaining high crop yields. This can mitigate the impact of agriculture on the environment and foster climate change adaptation for farmers.

Automated irrigation system

- Application: A 5G-enabled automated irrigation system with valves and sensors deployed across the field can inform farmers with data on temperature, humidity

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[227] Barton, James. 2020. *Two of Pakistan's MNOs complete 5G trials.* Developing Telecoms. October 20. www.developingtelecoms.com/telecom-business/market-reports-with-buddecom/10151-two-of-pakistan-s-mnos-complete-5g-trials.html.

[228] Also Telenor and PTCL/Ufone – as of Mar. 2021! Refer to https://propakistani.pk/2020/03/13/telenor-conducts-successful-5g-trials-in-pakistan/ and https://ptcl.com.pk/Home/PressReleaseDetail/?ItemId=751&linkId=130

[229] Government of Pakistan. n.d. *Pakistan Economic Survey 2018-19: Agriculture.* www.finance.gov.pk/survey_1819.html

[230] https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

and soil moisture level. The information from the field can be collected in real-time or collected when triggered. All the information can be analysed using an information management system (3GPP 2018, p. 146). The information can be used to improve water productivity.

- Technology Requirements: Users will need to setup 5G-compliant sensors or drones with imaging capability. The data can be processed in the cloud and communicated to the users via channels such as mobile apps, texts
- Key stakeholders: National Water Council and National Water Policy Implementation Committees; and
- Key Challenges: Devise cost; scalability in rural, smallholder farm settings.

8.5.2 Healthcare

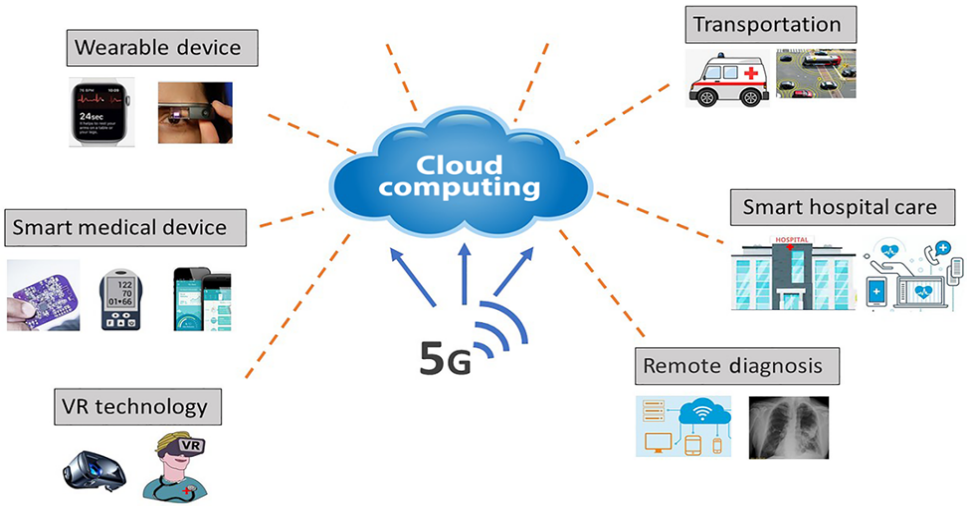
Pakistan faces challenges in providing citizens with quality, accessible and affordable healthcare. In 2018, the country spent around 3.2% of its gross domestic product (GDP) on health which was slightly lower than the regional average of 3.5% and significantly lower than the OECD average of 12.5% in the same year.[231] The number of physicians per 1,000 people is less than 1.[232] The mortality rate of children under 5 is 67 per 1000 live births in Pakistan; in comparison, the regional average is 40 per 1000 live births.[233]
Stunting, a key obstacle to early childhood development and human capital formation and yet preventable, is also largely prevalent in the country. Pakistan also faces geographic inequalities in health and health-related social indicators.

The ongoing COVID-19 pandemic underscores the importance of efficient healthcare systems and equitable distribution of medical resources within countries. Reasonably, with the constraint of delivering medical services while maintaining social distance, countries have increasingly adopted telehealth. For example, the US signed into law the Coronavirus Aid, Relief and Economic Security Act ("CARES ACT") in March 2020.[234] This Act expanded the availability of telehealth services in rural and medically underserved areas.

While telehealth is not new, 5G-enabled telehealth can significantly elevate the access to and quality of health services for citizens and optimize the healthcare system. With a fully realized IoT system powered by 5G, medical professionals can offer real-time remote diagnostics, image analysis and treatment. Applications of 5G technology in healthcare are illustrated in Exhibit 74. Data from the network can also be optimized to allow the efficient use of medical resources and personnel. As 5G matures, mobile edge computing will offer lower latency, higher data volumes and improved data privacy. 5G-powered Artificial Reality (AR) and Virtual Reality (VR) technologies will facilitate innovative treatments and enhance the quality of medical training of doctors and nurses.

[231] https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS?locations=PK-OE-8S
[232] https://data.worldbank.org/indicator/SH.MED.PHYS.ZS?locations=PK
[233] https://data.worldbank.org/indicator/SH.DYN.MORT?locations=PK-8S
[234] www.congress.gov/bill/116th-congress/house-bill/748

Exhibit 74. Applications of 5G technology in healthcare settings



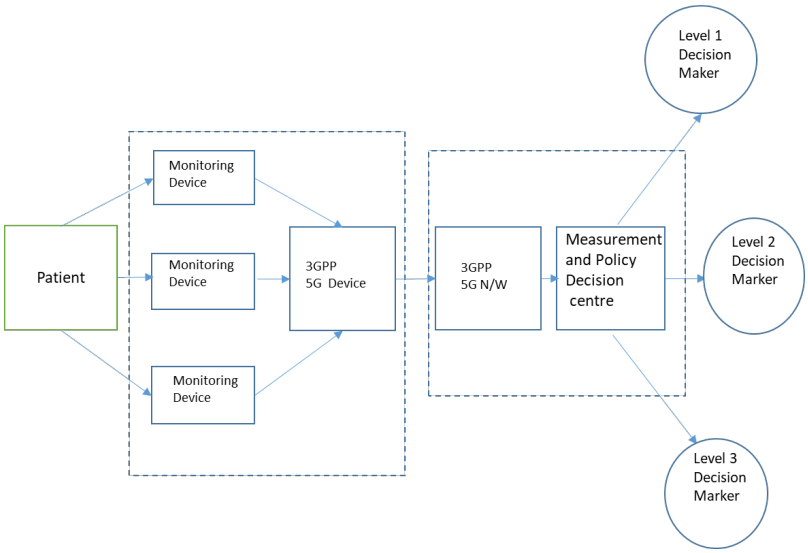
Source: Prec Clin Med, Volume 2, Issue 4, December 2019, Pages 205–208, https://doi.org/10.1093/pcmedi/pbz020

China was one of the first countries to apply 5G in medical services due to COVID-19. A telemedicine network powered by 5G was created in Sichuan Province. According to Hong et al. (2020) around 200 hospitals in Sichuan Province provided real-time video-based consultations using 5G networks to over 400 patients between January and March 2020. Hong et al. (2020) also note that besides remote consultations, approximately 152 patients underwent remote computed tomography (CT) scans using the 5G network.

Remote monitoring (RM) of patients

- Application: 5G networks can help medical professionals remotely monitor a patient's health in real-time. 5G offers higher data capacity and data security for video consultations or transfer of sensitive medical data. Medical professionals can offer video-based consultations or utilize a 5G-enabled wearable medical device to remotely monitor the health status of patients. RM can improve clinic efficiencies by reducing in hospital visits, time required for patient follow-up, and reduce both time and cost burden for the medical facility as well as its workforce. This application can enhance utilization in a resource-constrained setting such as in rural and medically underserved communities. Additionally, patients in medically underserved areas will gain access to high quality medical services and reduce the time spent physically traveling to medical facilities.
- Technology Requirements: The 5G network should be available in all designated hospitals and in the households or the communities served by the hospitals. Patients should have 5G-enabled wearable medical device or 5G-compatible devices such as mobile phones, tablets or laptops. Edge cloud computing systems will be required for image processing from an AR device (3GPP 2018, p.79). The remote monitoring and authorization system is illustrated in Exhibit 75**.**

Exhibit 75: Remote Monitoring and authorization



Source: 3GPP 2018

Note: Decision markers allow medical professionals to triage the incoming cases, especially those that warrant further investigation at the hospital.

- Key stakeholders: Ministry of National Health Services Regulation and Coordination; provincial and local governments and clinics, telecom operators, equipment vendors and device manufacturers.

- Key Challenges: For more complex procedures that are time-sensitive, latency will be crucial. Device affordability and weak cybersecurity foundation will add to the challenge.

8.5.3 Education

Deprivation in education is the latest contributor to the multi-dimensional poverty index (MPI) in Pakistan according to the Ehsaas strategy. The World Bank estimates the economic costs from learning loss can be as much as USD67 to USD155 billion.[235] Pakistan's literacy rate for adults aged 15 years and older is 57%, which is one of the lowest in the South Asia region.[236] During 2007-2016, the primary school dropout rate was 26.5%, coming in as the second highest in the region after Bangladesh.[237] Gender gap in education is significant and persists through adulthood. From 2017-18, female literacy rate for 10 years and above stood at 51.8%, 20.7 percentage points below that for males.[238]

The impact of the COVID-19 pandemic on education has been significant. Due to the school closures from March through September 2020, around 10,000 schools out of 207,000 non-state schools in the country have closed permanently.[239] Around 13 million children remained unenrolled in September 2020 when school had reopened; over half of those who did not return were girls.[240]

Remote learning through 5G

- Application: 5G's ultrafast speed will offer seamless videoconferencing for students and teachers and improve the overall learning experience. The curriculum can be altered to offer more active-learning and video-based content, including immersive content in virtual reality and augmented reality. Immersive learning can be tailored to each student's needs and can provide numerous benefits such as improved attention skills, expanded curriculum (*e.g.* virtual field trips) and soft skills (*i.e.* collaborative problem-solving) that are desirable in future employees.[241]
- Technology Requirements: Students will need a 5G device and CPE or wireless modems and router.
- Key stakeholders: The Ministry of Federal Education and Professional Training, provincial and local governments, Pakistan Teachers Association, employers, telecom operators, equipment vendors and device manufacturers.
- Key Challenges: Schools and educators will require support in the development of standardized online educational resources and platforms. Students will also need affordable devices and internet connectivity for learning.

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[235] Geven, Koen, Amer Hasan, and Cristian Aedo. 2020. *Strengthening the fight against Pakistan's learning crisis [Blog].* The World Bank. October 22. https://blogs.worldbank.org/endpovertyinsouthasia/strengthening-fight-against-pakistans-learning-crisis.

[236] Government of Pakistan. 2019. *Ehsaas Strategy.* April 10. www.pass.gov.pk/Document/Downloads/Strategy_Ehsaas_for_online_consultation.pdf.

[237] Ibid.

[238] Ibid.

[239] Ali, Ommara Raza. 2020. *More girls drop out and schools close due to COVID-19 in Pakistan.* Opportunity EduFinance. November 25. https://edufinance.org/latest/blog/2020/more-girls-dropout-and-school-close-due-to-covid-19-key-insights-from-covid-19-study-pakistan.

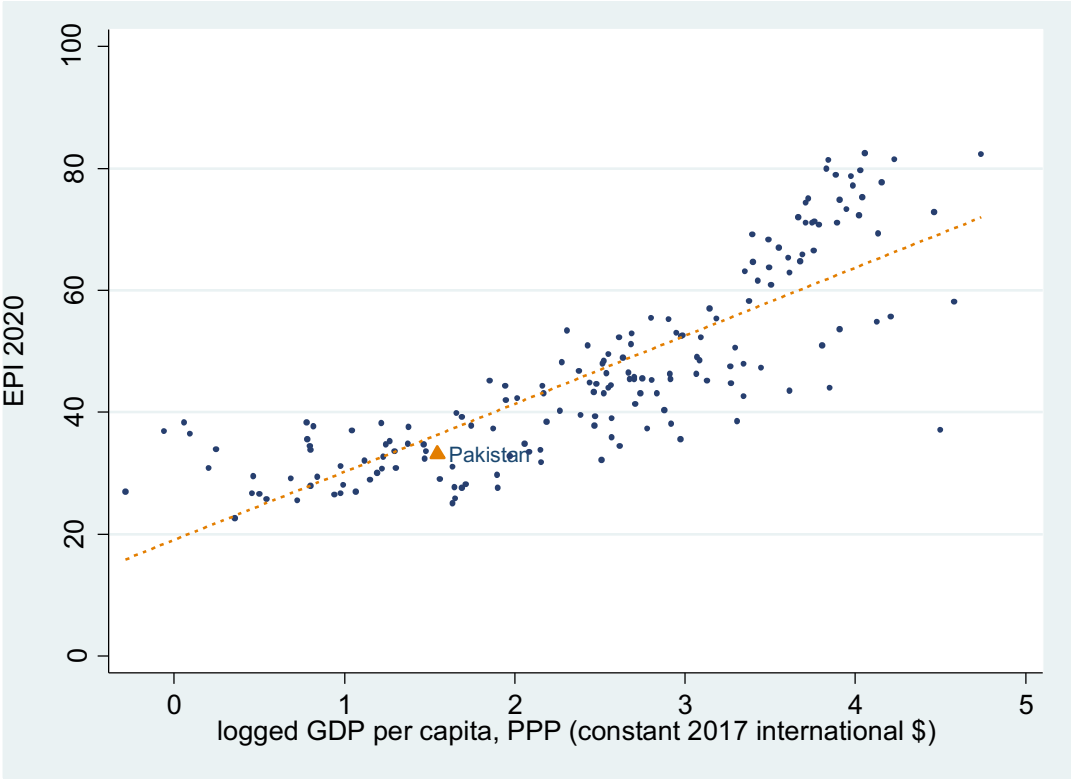
[240] Ibid.

[241] Zimmerman, Eli. 2019. *AR/VR in K–12: Schools Use Immersive Technology for Assistive Learning.* EdTech, August 22. https://edtechmagazine.com/k12/article/2019/08/arvr-k-12-schools-use-immersive-technology-assistive-learning-perfcon.

8.5.4 Smart Cities

One of the most pressing environmental sustainability challenges in Pakistan are managing air and water pollution, land and water sustainability and resilience to natural disasters.[242] Pakistan lags behind its economic peers and ranks 169 out of 180 countries in Environmental Performance Index (EPI) 2020 (see Exhibit 76). Most importantly, Pakistan ranks the lowest among 180 nations in air quality[243], which contributes to annual seven million premature deaths globally and have accounted for around 173.6 deaths per 100,000 in Pakistan in 2016.[244]

Exhibit 76: EPI Score and logged GDP per capita, PPP (constant 2017 Int'l $)



Source: Environmental Performance Index (2020); World Bank

[242] World Bank. 2019. *Pakistan@100: Shaping the Future.* Washington, DC, March 18. www.worldbank.org/en/region/sar/publication/pakistan100-shaping-the-future.
[243] EPI measures air quality using three indicators: PM2.5 exposure, household solid fuels, and ozone exposure
[244] www.who.int/health-topics/air-pollution#tab=tab_1

Moreover, urbanization and inefficient use of resources have put a strain on drinking water quality and availability. The percentage of Pakistanis using safely managed drinking water services have decreased from 38% in 2004 to 35.3% in 2017.[245] The annual cost of the lack of water, sanitation and hygiene (WASH) in 2016 was estimated at US$2.4 billion in urban areas (0.9 percent of GDP) and US$5.1 billion in rural areas (1.8 percent of GDP in 2016).[246] Improving water productivity remains a challenge due to the lack of investments in technology and distortions due to subsidies despite the country's economy being largely dependent on its water supply.[247]

5G provides a technical foundation for infrastructure, data and services for sustainable and resilient cities. Although various LPWAN and Wi-Fi technologies will also be used in smart city applications, 5G, as an "all-in-one" connectivity platform, will enhance the flexibility and reliability of the network to accommodate different use cases with different network performance requirements. Smart city domains include road traffic, electric and water systems, waste management, public safety, etc. (3GPP 2018, p.105). Multi-access edge computing will also enhance smart city solutions, providing both computing and storage capabilities at the edge. Globally around 18,989 5G deployments took place in cities by 159 telecom operators.

Monitoring of air and water quality

- Application: A real-time and reliable monitoring of air and water quality is a crucial step in achieving cleaner air and safe drinking water. Sensors deployed throughout the targeted areas (e.g. on street furniture, vehicles, buildings) can collect real-time data on air and water quality. Various stakeholders, such as local city administrators, health officials and academics, will be able to gain new insights through the data. For example, city administrators will be able to access carbon trading and green bond markets and improve urban planning.[248] Predictions could also be made through the data analytics, which could be invaluable in planning future interventions.
- Technology Requirements: IoT sensors/cameras to collect data, platforms to process the data.
- Key stakeholders: National Environmental Quality Standards, local city administrators, device manufacturers.
- Key Challenges: A massive number of sensors will need to be deployed for a granular data on water and air quality. This would require a massive number of sensors that can produce highly accurate measurements. High cost and accuracy of the sensors may pose as a challenge in implementing this application.

[245] https://data.worldbank.org/indicator/SH.H2O.SMDW.ZS?locations=PK

[246] World Bank. 2019. *Pakistan@100: Shaping the Future.* Washington, DC, March 18. https://www.worldbank.org/en/region/sar/publication/pakistan100-shaping-the-future.

[247] https://nation.com.pk/04-Dec-2019/per-unit-productivity-of-water-in-agriculture-very-low-in-pakistan

[248] GSMA. 2018. *Air Quality Monitoring Using IoT and Big Data: A Value Generation Guide for Mobile Operators.* February. https://www.gsma.com/iot/wp-content/uploads/2018/02/iot_clean_air_02_18.pdf.

Way forward for 5G use case development in Pakistan

Beyond these applications illustrated, there are innumerable opportunities to improve development challenges in Pakistan through 5G networks. Even before 5G reaches market maturity, there are several ways that the government can support to speed up the use case discovery process that can subsequently accelerate the uptake of the technology.

Firstly, the government's support for 5G trials can stimulate the innovation capacity of industry verticals. For example, the Department for Culture Media and Sport of the United Kingdom (UK) introduced the 5G Rural Integrated Testbed Project (5GRIT) in partnership with SMEs and academia to test 5G services in rural areas. The testbed seeks to reap benefits from 5G through applications such as augmented reality tourism, efficient management of livestock, rural broadband use and unmanned aerial systems.[249] In the case of Singapore, the government identified key strategic industry clusters, namely maritime operations, urban mobility, smart estates and Industry 4.0, and set aside SDG40 million to offer grants to enterprises for trials and investments.[250] The government also released 39GHz band for 5G trials.

Secondly, the government can also explore a regulatory sandbox to encourage 5G use case development and applications in each sector. Addressing regulatory bottlenecks in each of the sectors and offering regulatory flexibility can be useful in exploring new business models and a faster path to digital transformation of the sector. For example, in South Korea, the government revised the *Location Information Act* to reduce regulatory barriers to entry for 5G use cases that utilize location information.[251]

Thirdly, the government can offer digital skills training. Digital skills are important to 5G technology adoption and utilization. Existing training programs within the Ministry of Information and Technology can incorporate digital skills that can support the 5G use case discovery process. This includes a wide array of skills and knowledge such as programming, cybersecurity, cloud-based technologies, virtualization, AI and big data analytics, telecoms engineering and electrical engineering. Governments also support startup incubators and accelerators that are specific to 5G. Support can also be offered to the private sector to provide certified training, upskilling and re-skilling of workers to increase the digital capacity of the labourforce.

Lastly, the government can facilitate multi-stakeholder collaboration. The use of 5G goes beyond the purview of the ICT sector. A strengthened partnership among enterprises, MNOs, governments, academia and Civil Service Organizations (CSO) can stimulate new business models and converged services that require diverse expertise. The government can also explore ways to coordinate 5G use case development initiatives with existing SME development programs or initiatives in high-tech parks and Special Economic Zones (SEZ) to ensure that activities are coordinated towards a strategic outcome.

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[249] UK5G. 2018. *5G Rural Integrated Testbed (5GRIT).* March 10. https://uk5g.org/discover/testbeds-and-trials/5g-rural-integrated-testbed-5grit.
[250] Jacob, Sheena, and Toby Grainger. 2021. *5G Regulation and Law in Singapore.* CMS Legal. January 11. https://cms.law/en/int/expert-guides/cms-expert-guide-to-5g-regulation-and-law/singapore.
[251] Kim, Eun-jin. 2019. *Korean Gov't Determined to Foster Core 5G Services and Industries.* Business Korea. April 9. www.businesskorea.co.kr/news/articleView.html?idxno=30733.

Key points and recommendations

Key Points

- 5G can create enormous economic value in Pakistan across agriculture, workplace safety, healthcare, manufacturing, education and smart cities, among others

Recommendations

- In order to realise the benefits of 5G in Pakistan, the government should support 5G trials, explore a regulatory sandbox to encourage 5G use case development, and offer digital skills training which will be crucial for 5G technology adoption and utilisation.
- The Pakistan Government should also facilitate multi-stakeholder collaboration to coordinate development and strengthen partnerships in relation to 5G applications .

9 Recommendations, Way Forward & Conclusions

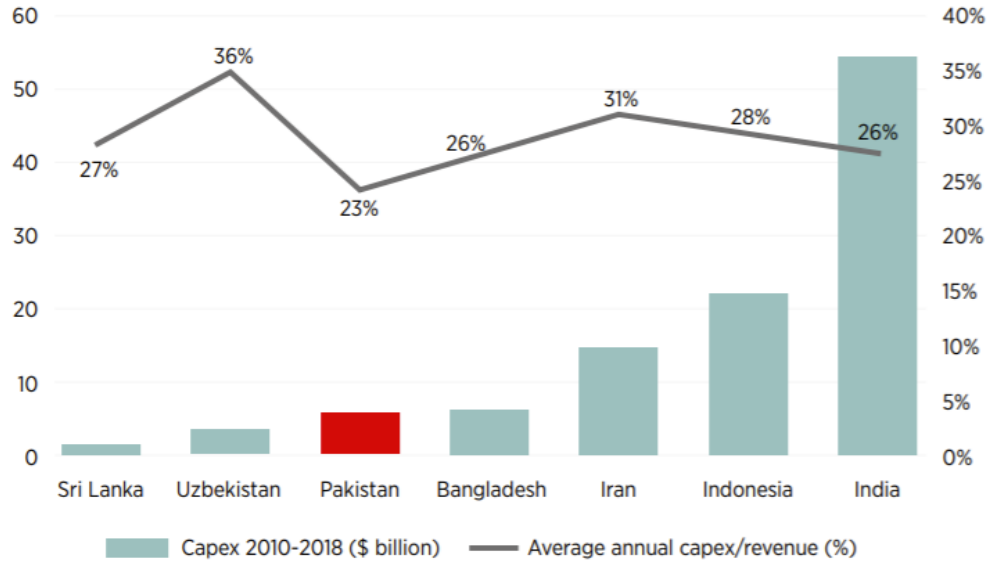
9.1 Overview

Digital connectivity is a key enabler of the Pakistan's future social and economic activity. 5G is the next exciting step in the evolution of mobile wireless communications technology revolution, promising improved connectivity, greater network speeds and bandwidth, and very low latency. It is the 5th generation in mobile technology which, at each step, has seen significant developments in communications networks.

5G is a transformative technology that could have significant implications; supporting greater innovation (eg Internet of Things (IoT), cloud computing and artificial intelligence (AI)), productivity and international competitiveness. 5G will allow communities – including those in Pakistan- to realise and participate in the socio-economic benefits delivered by an advanced, data-intensive, digital economy. It will facilitate Pakistan's recovery from the effects of the global COVID-19 pandemic.

In order to realise these gains from 5G, it must be emphasized that significant investments must be made to introduce 5G networks and supporting digital infrastructure across Pakistan. Around USD67 billion is expected to be spent on mobile networks in South Asia between 2019 and 2025, with USD3.5 billion of this from Pakistani operators. According to the GSMA, around 30 percent of the region's capex will be devoted to 5G networks – however, this figure falls to just 10 percent in Pakistan (Exhibit 77).

Exhibit 77: Investment in mobile networks in South Asia

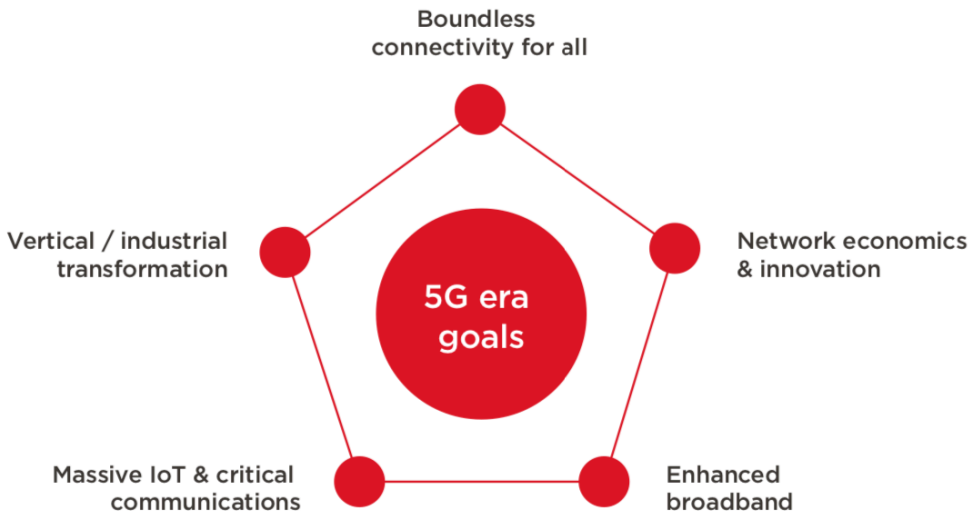


Source: GSMA[252]

While Pakistan's MNOs invested USD5.3 billion between 2010 and 2108, average capex as a proportion of revenue was below several peers.[253] In addition to investment by MNOs, investment from licensed telecommunications infrastructure providers (TIP) and towercos is critical in order for Pakistan to meet its sector targets.

5G is an opportunity for policy-makers in Pakistan - to empower citizens and businesses and it will play a key role in supporting governments in transforming their cities into smart cities. It is an opportunity for the PTA/FAB to facilitate sector investment in high speed services promoting mobile competition as well as fixed competition with the acceleration of 5G FWA services. It will help achieve the 5 mobile industry goals detailed in Exhibit 78 below.

Exhibit 78: Five mobile industry goals



Source: GSMA Intelligence, The 5G era: Age of boundless connectivity and intelligence automation, 2017: www.gsmaintelligence.com/research/2017/02/the-5g-era-age-of-boundless-connectivity-and-intelligent-automation/614/

Globally, 5G adoption is very rapidly occurring with 438 operators in 133 countries are investing in 5G as at July 2021. Following multiple announcements of 5G launches in 2020, 174 operators have now launched 3GPP compliant commercial 5G services in 71 countries. These include a number of emerging markets.

Importantly, the Pakistan economy exhibits multiple characteristics that strongly suggest that early 5G deployment will generate significant economic benefits. It faces ongoing service quality challenges in wireless telephony and broadband services, it has relatively undeveloped fixed line infrastructure, its regional South Asia competitors are moving strongly to improve their telecommunications infrastructure, and it has significant opportunities for economic growth given its young population.[254] All these factors suggest that the benefits to the country from supporting 5G deployments and accelerating 4G

[252] *Ibid*

[253] www.gsma.com/asia-pacific/wp-content/uploads/2020/06/24253-Pakistan-report-updates-LR.pdf

[254] Refer to http://hdr.undp.org/en/content/unleashing-potential-young-pakistan

adoption in the short term would be significant. This is an opportunity for the country which ought to be exploited.

In addition, 5G deployment offers a stepping-stone in an incremental development path that includes future deployments of fixed line infrastructure. Deployment of 5G will entail additional fibre to 5G base stations/nodes and this lays the ground work for future fibre to the premises deployments while still delivering high quality broadband over 5G (ie FWA services) earlier than would otherwise be possible.

These considerations, means that the Report concludes that Pakistan can harness significant economic benefits if it facilitates the early deployment of 5G by a range of supporting policies and actions. In the long term the economic benefits to the Pakistan economy of 5G are very substantial. In contrast, stopping, delaying or other not releasing spectrum for 4G/5G services runs the risk that:

(i) Pakistan and Pakistani citizens will be unable to be 'digital ready' and benefit from new innovative mobile technologies;

(ii) MNOs will overinvest in older legacy technologies to support continued traffic growth when better more spectrally efficient options are available; and

(iii) Pakistan will miss out on the transformation effects of 5G technology meaning that key industries are disadvantaged versus their regional and global competitors.

There exists a considerable number of factors to address in facilitating Pakistan's market readiness for 5G especially the lack of large contiguous blocks of affordable spectrum, broader access to fibre backhaul and widespread availability of affordable 5G smartphones and other devices which are necessary preconditions in order to make 5G a success. Importantly, taking such steps now will also advantage existing 3G and 4G customers in Pakistan.

Readiness for 5G in Pakistan or in any country does not occur at a single point of time or as the result of a binary decision. Building a country's digital economy and support for 5G and other service innovations is a journey. Built on the Government's sector policy and regulation, successive deployments of technology – 2G, 3G and 4G – combine to create the environment where future 5G and in the 2030 timeframe future 6G services, will see investments from industry stakeholders, new services and applications and increased customer and enterprise demand.

In this context, unfortunately, it is arguable that Pakistan's IMT spectrum management policy has been the key factor which has held back the sector. By creating artificial spectrum scarcity and releasing only minimum levels of new IMT spectrum without the requisite levels of regulatory certainty (and not in accordance with a long term spectrum roadmap), the industry has been unable to fully invest in 4G deployment.

This is a view shared by the industry which has stated:

"…spectrum plays a critical role in realising the full extent of these new capabilities. it is essential that PTA makes the right policy and regulatory decisions. In particular, an effective spectrum licensing process is critical to support the long-term operator investments required to further expand mobile access, as well as to enhance the quality and range of services offered in the country. Policymakers can maximise the societal gains from finite spectrum resources by developing a transparent and comprehensive spectrum roadmap. This would help ensure that spectrum is available to meet the requirements of future 5G services. A comprehensive forward-looking roadmap can negate risks and encourage operators in Pakistan to make positive investment decisions."[255]

9.2 Recommendations for an optimal approach to 5G in Pakistan

Given the above, this World Bank *5G Readiness Plan for Pakistan* recommends that:

Overall policy parameter recommendations

(4) The Government of Pakistan, PTA and the FAB support the introduction of 5G services in Pakistan encouraging MNOs to invest in this transformational technology and take further facilitative steps as required including in relation to spectrum management, facilitating improvements to backhaul transmission and make 4G/5G handsets more affordable ensuring affordable 5G services are widely available in the 2022 and beyond timeframe.

(5) The Government of Pakistan should facilitate the creation of domestic content and exemplar applications which highlight the possible use of high speed wireless broadband services including 5G in the country in order to 'seed' the market for a range of innovative and productive use cases/applications.

Spectrum management recommendations

(6) It is critical to increase regulatory certainty and provide Pakistan with a 5G spectrum future, by the Government of Pakistan, PTA and FAB committing to a IMT spectrum roadmap required to achieve the ITU's IMT Spectrum Target of 840 MHz (excluding mmWave spectrum) as shown in Exhibit 76 below. This roadmap could be done by an update to the 2020 Spectrum Rolling Strategy. Specifically:

   (a) Ensure that IMT spectrum reserve pricing for the 1800/2100 MHz bands is reasonable and other auction rules are set so as to provide an opportunity for non-market leaders to acquire IMT spectrum. It is critical for suture sector competition that all MNOs be able to offer competitive 4G services and in the future 5G services;

[255] *Ibid*.

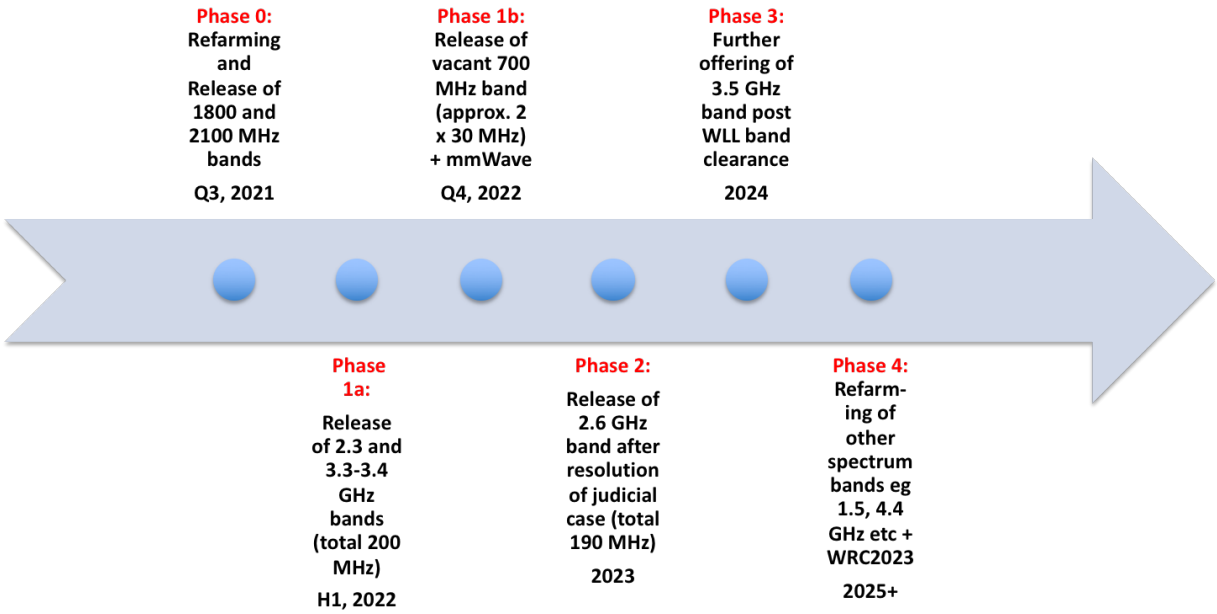
(b) Given device availability and affordability and the focus on Pakistan's urban areas first (given available backhaul and higher income levels), the optimal pioneer 5G bands for Pakistan are the 3.5 GHz (n78) and the 2.3 GHz (n40) bands. Both are TDD capacity bands and available now. n40 has the advantage of it being used by MNOs initially for 4G services before transitioning to 5G services;

(c) In the next phase, making the 2.6 GHz band (n41) available would add additional 4G/5G capacity spectrum in urban areas; while the 700 MHz (n28) band is optimal for coverage and would help to extend 4G/5G services outside Pakistan's cities/towns.[256] Subject to the resolution of the court case, the 2.6 GHz band could be concurrently released with the 2.3 GHz band, if so desired; and

(d) While the 3.5 GHz band can only be used for 5G given harmonisation, the 2.3, 2.6 GHz and 700 MHz bands can be used for 4G and/or 5G as well. Thus the MNOs are able deploy 4G and then convert the band to 5G where possible based on 5G device penetration, demand etc in Pakistan. mmWave could be made available to the market in late 2022, if demand exists from MNOs and enterprises.

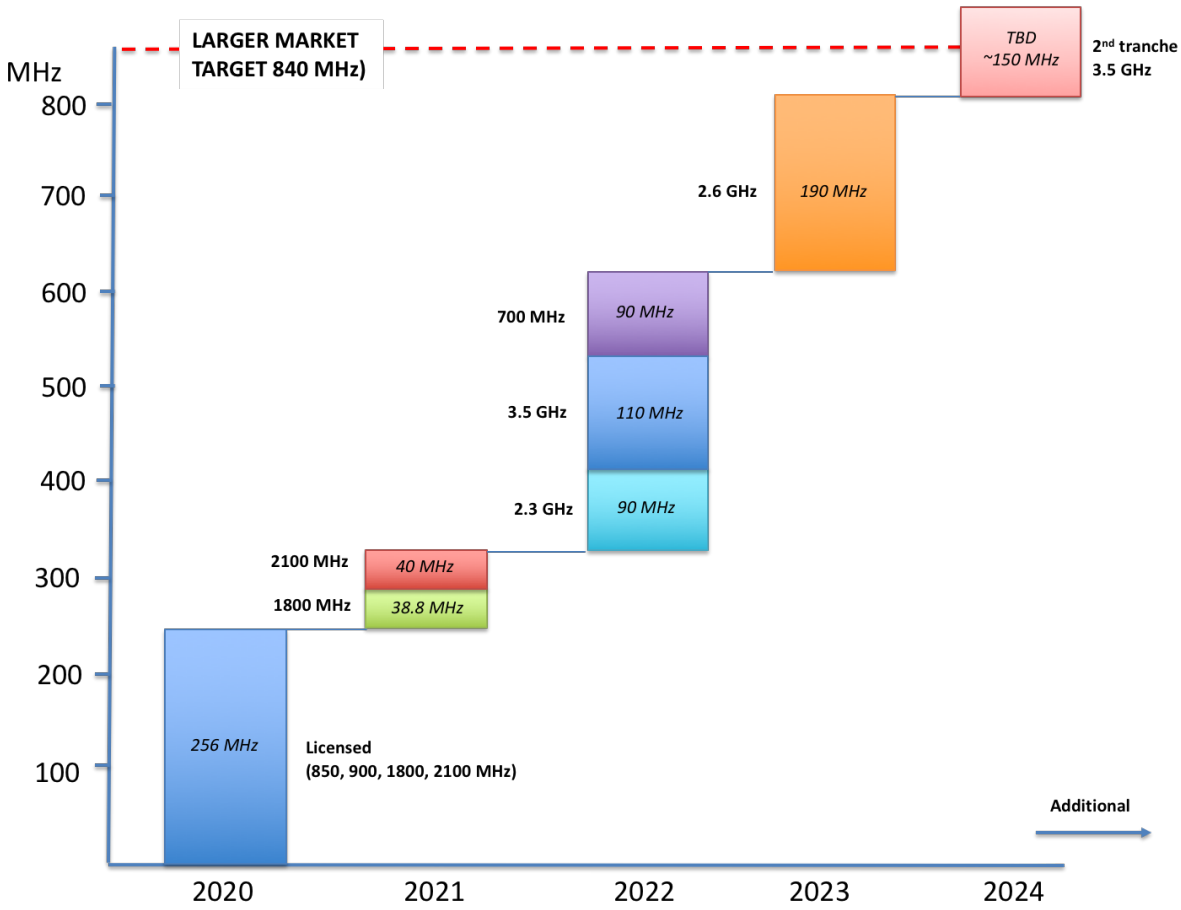
Exhibit 79 and Exhibit 80 shows the annual releases of IMT Spectrum required for Pakistan to achieve the ITU's IMT Spectrum Target of 840 MHz (excluding mmWave spectrum).

Exhibit 79: Recommended timeline for the release of IMT spectrum for 5G services



[256] Note Phase 1a and Phase 1b could be done simultaneously depending on the timing of the availability of 700 MHz spectrum.

Exhibit 80: Annual releases of IMT Spectrum for 4G/5G to achieve the ITU IMT Spectrum Target of 840 MHz (excluding mmWave spectrum)



Note excludes mmWave spectrum. Source: WPC, March 2021, *Modified version of ITU, Guidelines for the Preparation of National Wireless Broadband Masterplans for the Asia-Pacific Region*, October 2012

(5) Within Pakistan any allocation of 2.3, 2.6 and 3.5 GHz TDD spectrum, synchronisation between MNOs should be mandated with a 4:1 frame structure with it to be reviewed say in 5 years. Further, as required, Pakistan and its neighbouring countries with the assistance of the ITU, should agree synchronisation and frame structure for TDD systems in order to avoid harmful interference;

Other telecommunications policy recommendations

(6) The MoITT and the PTA should facilitate 5G deployment in Pakistan by instituting a range of policy and regulatory reforms detailed in this Report permitting improved (i) fiberisation of backhaul and (ii) site access for tower and small cell rollout over the next 12-24 months or so especially in relation to public land, sites etc. Recent policy announcements on infrastructure sharing should be fully implemented; and

(7) The PTA along with the Ministry of Health and other stakeholders should engage in a public education campaign in relation to 5G reassuring the public about the safety of the technology and that it is similar in terms of spectrum use that existing mobile services.

Facilitating Digital infrastructure

(8) In this area of digital infrastructure, there are four additional key recommendations which should be adopted by Government and the PTA for the success of 5G in Pakistan:

(a) Improving ROW to facilitate 5G deployment. A national infrastructure database should be established to avoid costly damage to infrastructure, disruption of service and possibly personal injury;

(b) Need for improved access to towers and sites for 5G deployment. The PTA should also facilitate the establishment of industry bodies to develop uniform conditions/self-regulatory models for infrastructure sharing, as well as provide financial incentives to encourage infrastructure rollout and sharing in Pakistan. Any active sharing should be agreed upon in commercial terms, rather than mandated by government.;

(c) Support continued investment in International transmission capacity and cloud infrastructure. Having cloud infrastructure located within Pakistan is valuable for companies operating within Pakistan for convenience and lower latency; and

(d) Support for the deployment of Internet of Things (IoT) in Pakistan by MNOs.

Supporting use cases in Pakistan

(9) In relation to use cases, there are innumerable opportunities to improve development challenges in Pakistan through 5G networks. Even before 5G reaches market maturity, there are several ways that the Government can support to speed up the use case discovery process that can subsequently accelerate the uptake of the technology. These include:

(e) Supporting 5G trials can stimulate the innovation capacity of industry verticals;

(f) Exploring a regulatory sandbox to encourage 5G use case development and applications in each sector. Further, addressing regulatory bottlenecks in each of the sectors and offering regulatory flexibility can be useful in exploring new business models and a faster path to digital transformation of the sector;

(g) The Government can offer digital skills training. Digital skills are important to 5G technology adoption and utilization. Existing training programs within the Ministry of Information and Technology can incorporate digital skills that can support the 5G use case discovery process; and

(h) The Government can facilitate multi-stakeholder collaboration. The use of 5G goes beyond the purview of the ICT sector. A strengthened partnership among enterprises, MNOs, governments, academia and Civil Service Organizations (CSO) can stimulate new business models and converged services that require diverse expertise.

APPENDIX A – SUMMARY OF SUBMISSIONS

SUMMARY OF MAJOR OPERATOR RESPONSES TO THE "5G SPECTRUM RECOMMENDATIONS AND ROADMAP" PRESENTATION

Operators	Spectrum Recommendations
Joint industry, Jazz, ufone, Telenor Pakistan, Zong	**It is recommended that the following important aspects determining the state-of-readiness of the industry be made part of the consultation process:** a) Achievement of minimum MBB especially 4G penetration thresholds desirable from a readiness perspective (tele-density, broadband penetration etc.) b) Level of digital literacy and internet adoption c) Maturity of the existing digital ecosystem (e.g., E-commerce, cloud computing, IOT, block chain technologies etc.) d) Maturity of e-services infrastructure (e.g., digital health, education, governance etc.) e) Assessment of measures to improve handset and device availability and affordability f) Need for necessary ancillary policy frameworks (e.g., identity, privacy, cyber-security etc.) g) Aspects of a favourable regulatory environment for improving investment appetite in the Telecom sector **The current state of Pakistan has encouraged the following further recommendations:** • **The focus of the Government should be to make the right bands available in Pakistan:** As spectrum assignment in Pakistan is inefficient and vulnerable to further aggravation, the joint operators submit that hasting the auction process without first allocating prime bands for 5G services is highly undesirable. To do so could lead to suboptimal results and may jeopardize the commercial viability of 5G services. Therefore, it is imperative that the Government's spectrum policy and actions focus on the most developed spectrum bands highlighted in the WB report. It is recommended that spectrum in the prime 5G bands – i.e., 3.4-3.8 GHz, 2.6 GHz, 700 MHz and mmW – be made available in sufficient quantities in Pakistan in the earliest possible timeframe • **Pakistan will lag behind ITU recommendations in its current state**: The ITU recommends increasing IMT spectrum availability to at least 840 MHz by the end of 2021. Spectrum allocation should be on a technology neutral basis and must come with conditions that encourage licensed operators to make long-term investments. Joint operators are fearful that Pakistan will lag further behind this goal of the ITU community due to the existing pricing structure, and pre-determining price expectations in their country. Pakistan will have to reset its general approach on spectrum pricing to focus on the realization of maximizing societal benefit balancing price with coverage and QOS obligations. Pricing of spectrum is recommended to be revised significantly downwards to

Operators	Spectrum Recommendations

	allow licensed operators to concentrate on service rollout and 5G ecosystem development in Pakistan
	
	• **Introduction of progressive spectrum policies:** There is a lacking state of readiness in Pakistan – e.g., Pakistan ranks amongst the lowest in GSMA's Mobile Connectivity Index (MCI), World Economic Forum's Readiness and Competitiveness Indices etc. Attention is to be given to addressing high demand side barriers of entry such as 4G handset adoption (limited by the lack of affordable smart devices). Otherwise, there will be a significant impact on the economically efficient and commercially viable launch of future technologies like 5G. Recommendations to address this include:
	  ○ Coverage and QoS obligations be kept at reasonable levels
	  ○ Handset taxes be removed to allow rapid adoption of devices
	  ○ License certainty and a presumption of renewal clearly articulated in the license templates
	  ○ Data taxes be abolished to encourage service uptake
	  ○ Fibre proliferation be done urgently along with a plan to enhance wireless backhaul frequencies.
	• Further recommended that lesser developed bands/part of bands – e.g. 2.3 GHz and 3.3 GHz – be assigned free-of-cost for an initial period of three-to-five years to mitigate the risk of commercial failure and enable the operators to try developing an overall eco-system supporting the 5G technology infrastructure in Pakistan.

GSMA	• **Spectrum resource allocation processes designed to meet mobile demands in Pakistan**: Unsold spectrum and low level of market readiness risks should be minimised through the design of the 5G spectrum roadmap as a primary objective • **Licensing arrangements to facilitate investment certainty and to incentivise investment in Pakistan's telecoms sector:** During consideration of a 5G roadmap for Pakistan, a licensing regime used to assign the spectrum should be carefully applied to ensure licences incorporate a clear presumption of renewal. Renewals demarcate the life span of the licence and flag investors on the potential for continuing investment in networks towards the end of life of the licence. It also ensures service continuity for users and minimises risks of costly service disruptions. • **Cost-efficient mobile spectrum access to enable timely and widespread network deployment across Pakistan:** The price of spectrum will directly impact on the CAPEX available to service providers following the spectrum release, which is critical as it will determine the extent of coverage and pace of deployment. • **Frequency arrangements and related assignments to support a full 4G and 5G ecosystem in Pakistan beyond 2025:** 4G will continue to provide the core of Pakistan's mobile connectivity beyond 2025. To build a robust 5G ecosystem, 4G spectrum requirements need to be met as to ensure cost- efficient and nationwide access to mobile broadband beyond metropolitan areas. Pakistan would further benefit from undertaking reasonable timeframes for comprehensive 5G trials according to its local conditions and across all

Operators	Spectrum Recommendations
	spectrum bands and deployment scenarios. In relation to reasonable time frames, Pakistan would benefit from first securing the necessary spectrum for a well-resourced national 4G coverage as a prerequisite. • **Spectrum assignment conditions to minimise undue costs and incentivise innovation**: Pakistan's geographical diversity poses challenges to cost-effective infrastructure deployment. Therefore, conditions placed upon spectrum licences should strive to minimise undue deployment costs (which could potentially create a reverse effect) impacting on quality- of-service provision. A more practical approach would be to identify a mix of investment incentives coupled with industry-government collaboration to tackle national mobile deployments across Pakistan. • GSMA further recommends the 5G roadmap should consider a timeframe of around 5 years in order to better accommodate emerging spectrum needs, technological evolution and international developments. The roadmap should also be able to present the release date of a certain range and the conditions the spectrum will be made available, including, but not limited to pricing parameters, obligations and commitments, technical studies to be made, and any other matter that can bring legal certainty to encourage vital investments.
Ericsson	• **5G BW in different phases needs to be reviewed**. 5G having BWs in range 40MHz, 50MHz or 60MHz will not provide better user experience compared to LTE advanced where multiple Carrier aggregation can be utilized now (reaching up to 5, 6 and 7 LTE carriers each of 20MHz) to provide peak speeds of ~1Gbps. It is recommended that: ○ Minimum of 100MHz Bandwidth to be allocated/made available to each operator with most preferred bands ▪ N78 (at least 200MHz BW available for auction) ▪ N41 (transform that band to TDD if it is FDD and make 194MHz available to all) ▪ N40 (make available 100MHz for allocation)

SUMMARY OF RESPONSES TO THE DRAFT 5G READINESS PLAN

Respondent	General Comments
Joint industry, Jazz, ufone, Telenor Pakistan, Zong 19 July 2021	The focus of industry's response was that Pakistan's telecom sector is not ready for 5G. They provided the following reasons for this conclusion: 1. Current low 3G/4G penetration in Pakistan means 5G rollout would require operators to maintain four concurrent networks (2G/3G/4G/5G). This would be prohibitively expensive; 2. Larger contiguous blocks of spectrum of 5G rollout are not currently available, and even if it were made available, the existing spectrum management policy in Pakistan would result in high costs for acquiring the spectrum required for quality 5G customer experience; 3. There is not enough mobile infrastructure in Pakistan connected through optical fibre cable for backhaul. Currently, 90% of existing towers would not be able to effectively backhaul 5G data; and 4. 5G handsets are not widely available in Pakistan and their cost is inflated by tax. More than 50% of the population cannot afford even 3G/4G handsets. Therefore, while the steps proposed by the World Bank were recognised as logical, the timeline was considered too ambitious. Suggested steps to be taken by the Government to accelerate 5G readiness included assigning free spectrum to all operators in the 2.3 GHz band, liberalisation of spectrum management policy, acceleration of spectrum availability in global pioneer bands and backhaul spectrum, and reduction of duties and levies on smartphones.
PTA 21 June 2021	• The PTA disagreed with the need for a compensation mechanism for the 3.5 GHz band, as the band is currently being utilised by few operators and will be available by 2024. • The PTA believed that the awareness campaign to the public that reassures them of the safety of 5G technology should have the engagement of all Government stakeholders. Different departments can inform the public about the benefits of 5G to their relevant industries, rather than the awareness campaign being solely run by the PTA. • It was requested the MoIT&T develops a nationwide strategic plan for 5G deployment in Pakistan to lead the PTA's future actions.
FAB 8 March 2021	FAB disagreed with the idea that Pakistan's IMT spectrum management policy has been the key factor which has held back the sector. They argued FAB has been making adequate spectrum available in consultations with the PTA as per market demand and hence there was no artificial scarcity. They pointed to a lack of participation by MNOs and demand for spectrum at auctions in 2014, 2016 and 2017 to support this argument.