Roadmaps for awarding 5G spectrum in the MENA region

January 2022

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About this study

This study for the GSMA seeks to identify a roadmap by which governments and regulators can make available spectrum to support the deployment of 5G services in the MENA region. The study goes on to identify where countries currently sit on this roadmap and identifies recommended actions for countries in the region.

This report has been updated to reflect the situation as in January 2022.

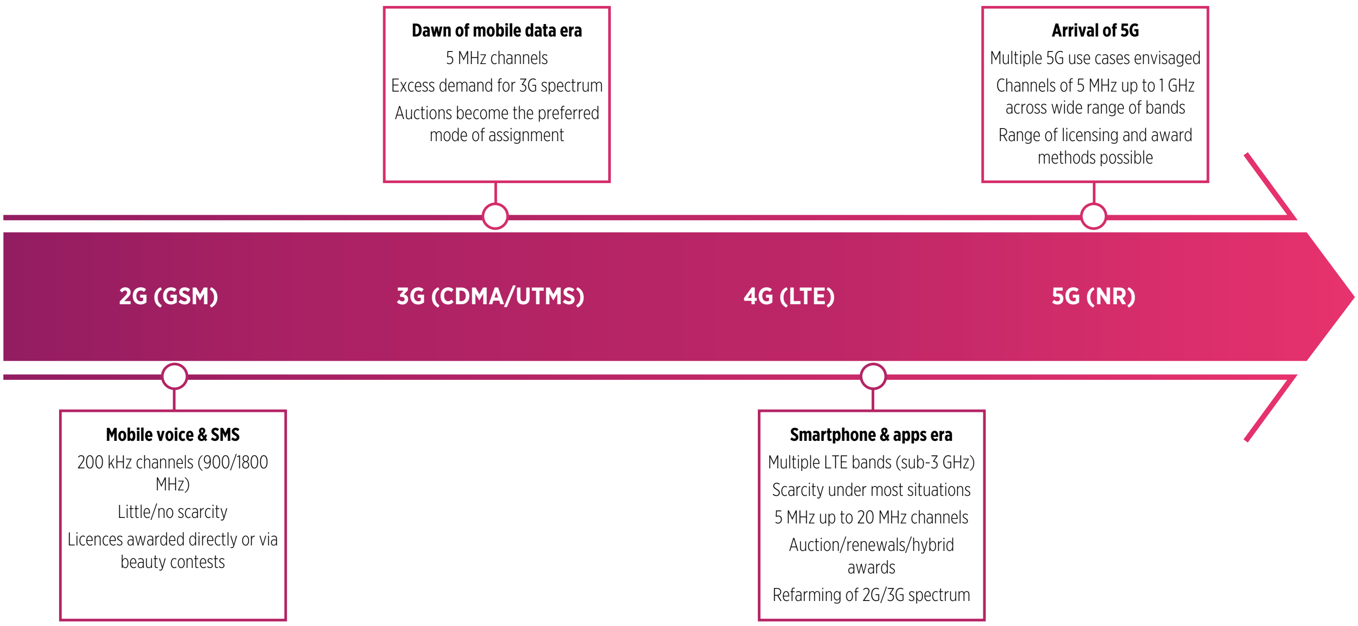
Contents

Summary

Roughly every 10 years, a new generation of mobile technology comes along, bringing fundamental improvements to the capabilities of mobile networks and changes to spectrum management approaches as illustrated in Figure 1. Today the mobile industry is still in the nascent stages of the 5G era. According to the Global mobile Suppliers Association (GSA) in December 2021 there were 189 operators in 74 countries or territories that had launched one or more 3GPP-compliant 5G services (177 mobile and 12 5G FWA or home broadband services)[1]. In countries such as China, South Korea, Finland, Germany, the UK and the US the markets are all relatively mature with high levels of smartphone adoption and 4G penetration, as a result of being among the first to deploy LTE in the early 2010s.

FIGURE 1

EVOLUTION OF MOBILE GENERATIONS AND CHANGES TO SPECTRUM MANAGEMENT APPROACHES



Widespread 5G adoption will take time, with 1.8 billion 5G connections by 2025, representing a share of approximately 20%[2]. Just as 2G and 3G still continue to exist alongside 4G in many places today, 4G will have a key role, coexisting alongside 5G well into the 2030s[3].

1 GSA 5G 2021 Review: 5G spectrum, networks and devices at https://gsacom.com/webinar/gsa-snapshot-5g-year-in-review/

2 GSMA https://www.gsma.com/mobileeconomy/

3 According to Ericsson, 4G will continue to be the dominant mobile technology in the mid-2020s, accounting for majority of connections globally. Source: Ericsson Mobility Report, November 2019.

5G in MENA countries

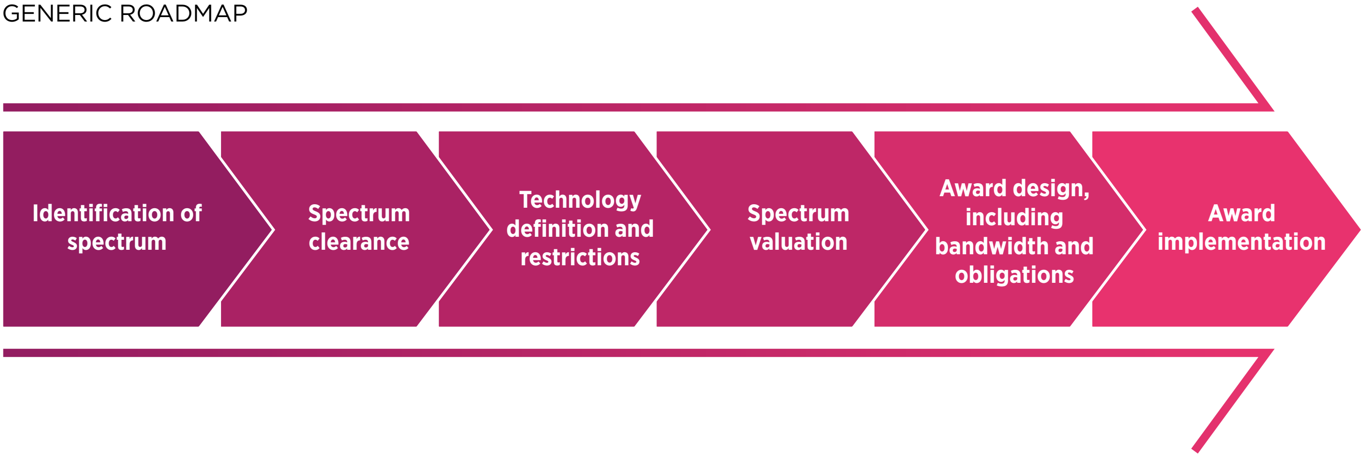
In the MENA region, GCC countries such as Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the UAE have become 5G pioneers, with governments and regulators awarding spectrum and mobile operators deploying some of the world's first 5G networks. This report looks at the need for 5G spectrum to be made available, and the current status across the MENA region. It then sets out a roadmap, to help governments and regulators enable 5G in the most efficient way possible. It also provides recommendations based on international best practices.

Roadmaps

Figure 2 provides a generic roadmap that can be applied to 5G or the introduction of any other previous generation of mobile technology.

FIGURE 2

GENERIC ROADMAP



It is important to recognise that although the steps may be the same for each country, the detailed activities under each may vary. Consultation with interested parties during the process is important to achieving optimum outcomes.

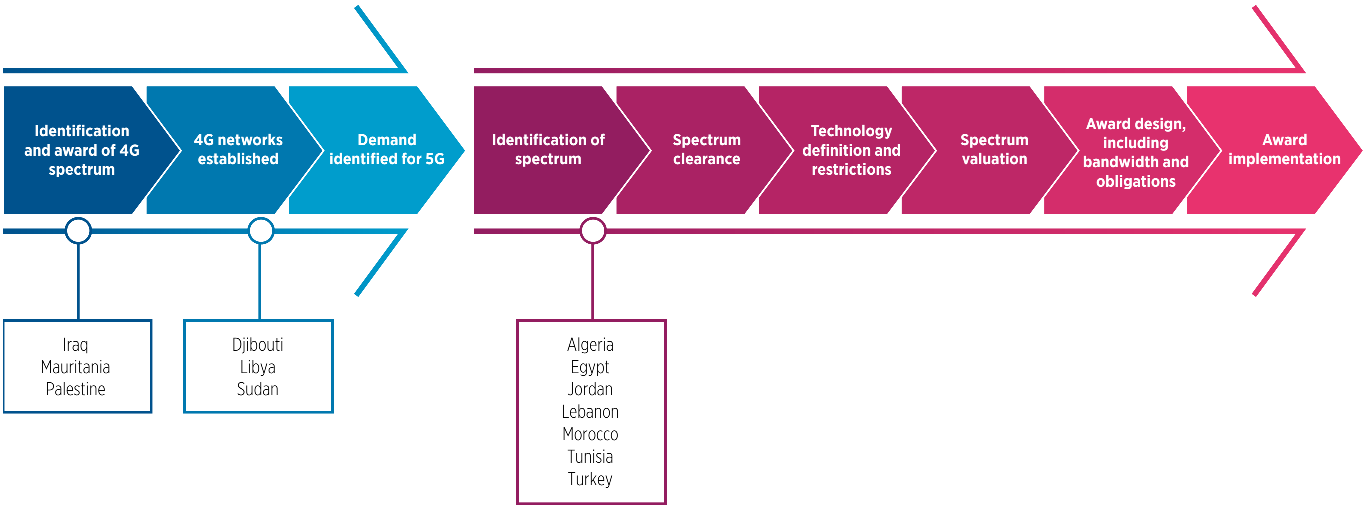
- **Identification of spectrum.** The key frequency bands to prioritise for 5G are, the 3500 MHz range, 700 MHz and mmWaves. However, it may be necessary to consider alternative bands based on what has already been awarded for mobile.
- **Spectrum clearance.** The approach may vary depending on factors such as the density of use; ease of moving incumbents to alternative frequency bands or alternative technologies; and impact on services and users. In some cases, the incumbents may be able to remain through geographic sharing (for example, where there is limited governmental use or existing regional licences). For assigned spectrum, it may only be necessary to realign the band assignments to provide contiguous frequencies and maximise spectrum efficiency for 4G and 5G.
- **Technology definition and restrictions.** This will inform the technical licence obligations and the amount of spectrum and geographic availability of the spectrum.
- **Spectrum valuation.** This will inform auction reserves or spectrum charges. When considering the level of investment necessary for new 5G networks it will be important that these are not set at levels that will impact on network roll-out and quality and drive up the cost of services.
- **Award design.** There are three main approaches to spectrum award: auctions, beauty contests and direct award[4]. The approach adopted and associated licence obligations will need to take account of policy objectives, available spectrum and market specifics (for example, the number of operators, or current spectrum holdings). It should be noted that depending on the timescales for availability of different frequency bands and award design it may be appropriate to have a single multi-band award or several separate ones.
- **Award implementation.** The final step is the actual award. This will normally be underpinned by documentation that provides all the necessary details of the award process, spectrum on offer, licence obligations and other essential information for potential licensees.

Not all the countries considered in this report are ready for 5G; some are still in the process of rolling out LTE services, as shown in Figure 3. The data comes from GSMA Intelligence, operators and inputs from regulators and, ministries and other online sources.

4 For the GSMA auction best practice position see https://www.gsma.com/spectrum/wp-content/uploads/2019/05/Auction-Best-Practice.pdf

FIGURE 3

ESTIMATED CURRENT STATUS ON ROADMAP



Still, a significant number of countries (Algeria, Egypt, Jordan, Lebanon, Morocco, Tunisia and Turkey) have started to identify suitable 5G spectrum and the most effective ways of clearing spectrum which will feed into any technical restrictions and associated technical licence obligations. It is anticipated that in these countries 5G networks and services will become available from 2023.

In the case of Djibouti, Iraq Mauritania, Libya and Sudan it is understood that 4G networks have been rolled out (and even upgraded in Libya and Sudan), but no demand has been identified for 5G in the short-term. The aim in these countries should be to ensure there is sufficient spectrum available for 4G as demand increases whilst starting to identify potential 5G spectrum.

Palestine only has 2G and 3G networks at the moment and the focus here should be on identifying and awarding 4G spectrum. It is important to encourage and support the development of broadband services and deliver the associated economic benefits. In November 2021 it was announced that the Israeli regulator had met with Palestine operators to discuss the rollout of LTE networks, but no firm details of spectrum awards have been made public.

Recommendations based on international best practices

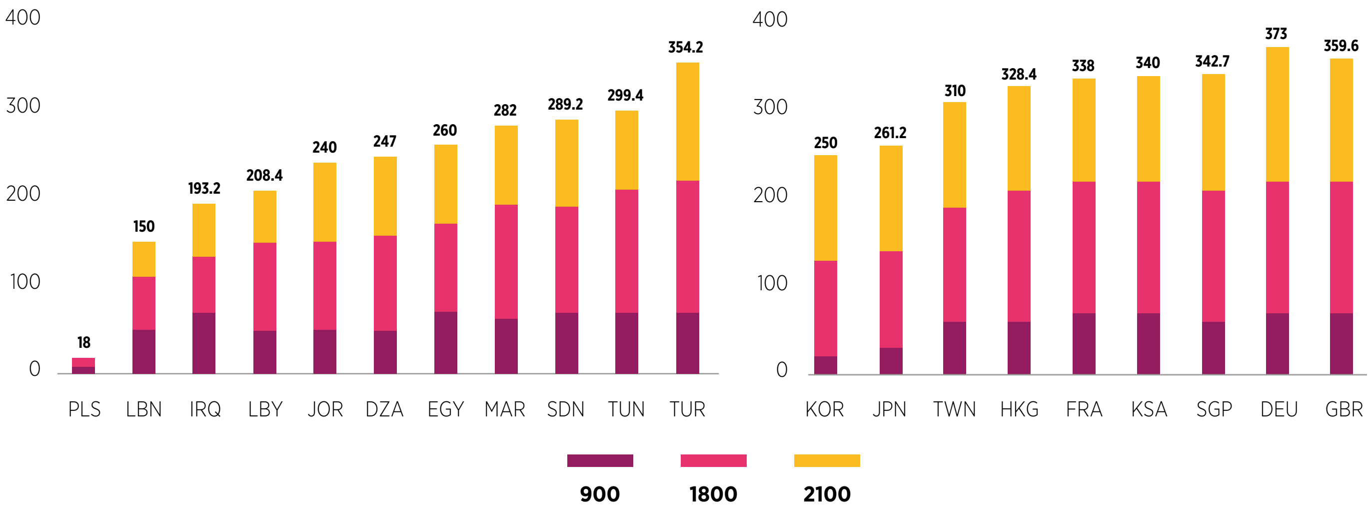
A number of general recommendations are based on the current status of spectrum award in the MENA countries and international best practices.

900, 1800 and 2100 MHz bands

The current level of spectrum availability varies considerably by country, but most states have released spectrum in traditional IMT bands for 2G and 3G services. For 900, 1800 and 2100 MHz, the amount of paired spectrum awarded across the MENA region is substantially less than in countries such as Saudi Arabia, Germany, UK, and Singapore.

FIGURE 4

900, 1800 AND 2100 MHz PAIRED SPECTRUM COMPARISON (MENA AND OTHER ITU-REGION 1 AND 3 COUNTRIES)[5]



Access to sufficient spectrum is essential to minimise operator deployment costs and enable countries to benefit from the potential growth in GDP afforded by mobile services. Limited spectrum will require operators to deploy additional base stations to meet traffic demand and this can have an impact on further investment in geographic roll-out, grade and quality of services and prices. It is recommended that regulators and administrations should seek to award further spectrum where limited spectrum is currently available.

700 and 3500 MHz

The 700 MHz band and in particular the 3500 MHz range are the preferred frequencies for 5G and should be the main focus for award. The 3500 MHz range (3300 MHz – 4200 MHz) has quickly become the prime option for commercial 5G deployments worldwide. Its ability to provide coverage and capacity combined with spectrum availability makes it that ideal candidate. This initial focus on one range is also resulting in a quickly developing ecosystem, with the launch of increasingly affordable devices.

800 and 850 MHz

Countries such as Mauritania, Morocco and Sudan have awarded the 800 or 850 MHz bands for CDMA 2000 technology. Depending on the band plan, the use of CDMA 850 can lead to potential interference with the 900 MHz (E-GSM) band, both within the country and with neighbouring countries. It is recommended that all countries adopt the Region 1 allocations and associated band plans. As part of this process, they should also identify how to migrate away from CDMA.

Removing WiMAX from 2300, 2600 and 3500 MHz

A number of countries (for example, Jordan, Libya and Morocco) have awarded the 2300, 2600 and 3500 MHz bands for wireless access using technologies such as WiMAX. These bands are potentially suitable for deployment of 4G and 5G and provision of mobile services, as well as wireless access; We therefore recommend that administrations should start the process of considering whether the licences should be revoked, and spectrum re-awarded or the current allocations retained. Unlocking these bands for mobile can significantly increase the capacity of mobile networks and enhance user experience.

Technology neutral licences

For any country that wants to offer the best possible mobile networks, support for technology neutral spectrum licences is key. They provide the necessary flexibility for operators to deploy new technologies based on market demand and their own service and network roadmaps. Without this flexibility uncertainty and delays can lead to reductions in network investment and impact on roll-out, quality, cost and availability of services. This approach should apply to existing and new licences and may require changes to a country's underlying legislation.

5 Source: GSMAi and Plum analysis. Country abbreviations are listed in Appendix B. For this chart, Palestine has been abbreviated as PLS.

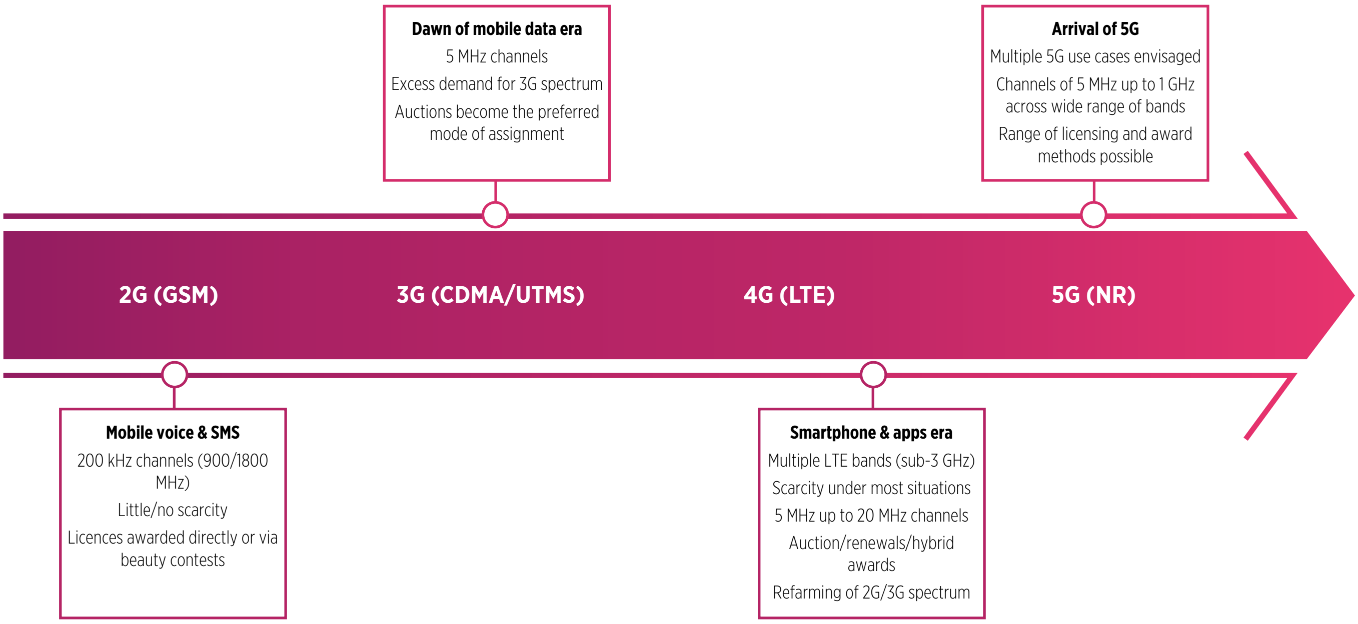
1 Introduction

Roughly every 10 years, a new generation of mobile technology comes along, bringing fundamental improvements to the capabilities of mobile networks and changes to spectrum management approaches as illustrated in Figure 1.1. Today the mobile industry is still in the nascent stages of the 5G era although the number of countries that have launched commercial 5G services is steadily increasing[6].

6 Global mobile Suppliers Association (GSA) identified 61 5G networks in mid January and 70 commercial 5G networks in March 2020 https://gsacom.com/technology/5g/

FIGURE 1.1

EVOLUTION OF MOBILE GENERATIONS AND CHANGES TO SPECTRUM MANAGEMENT APPROACHES



While operators in Europe, the United States and other advanced markets in the Asia Pacific are expected to ramp up 5G deployments over the next two to three years, widespread adoption is not anticipated until well into the 2020s. Just as 2G and 3G still continue to exist alongside 4G in many places today, 4G will have a key role in the 5G era as well, coexisting alongside 5G in the 2030s.[7] The economics of 5G are challenging and operators expect 5G investment cycles to be longer than 4G. The road towards 5G is thus more akin to a marathon than a sprint to the finish-line, and deployment will be gradual over a number of stages with 4G playing a key complementary role in the deployment of 5G non-standalone networks as well as in the provision of mobile broadband as the 5G ecosystem develops over the 2020s.

In the MENA region, GCC countries such as Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the UAE have become 5G pioneers, with governments and regulators awarding spectrum and mobile operators deploying some of the world's first 5G networks. This report looks at the need for 5G spectrum to be made available, and the current status across the MENA region; it then sets out a roadmap for governments and regulators to follow to enable this to be achieved in an efficient and effective way.

7 According to Ericsson, 4G will continue to be the dominant mobile technology in the mid-2020s, accounting for majority of connections globally. Source: Ericsson Mobility Report, November 2019.

2 Spectrum for 5G

To build a 5G network with the best possible performance, operators need access to a large amount of harmonised spectrum. This must be new spectrum separate from what is currently used for existing GSM, UMTS and LTE networks. In this section we discuss which bands are generally used for 5G services.

2.1 5G frequency bands

5G is envisioned to enable a variety of different applications from enhanced mobile broadband service (eMBB) to ultra-reliable and low-latency communications (URLLC) and massive machine type communications (mMTC). To ensure that 5G networks are capable of meeting all performance requirements, spectrum is needed across low, mid and high spectrum ranges.

In general, low-band spectrum (below 1 GHz) is ideal for the provision of 5G coverage across urban, suburban and rural areas and to help support IoT services. Mid-band spectrum (such as the 3.5 GHz range) offers a good balance between capacity and coverage. In this range, the GSMA recommends that regulators should aim to make available 80-100 MHz of contiguous spectrum per operator. High-band spectrum (such as 26 and 40 GHz) is suited for short-range, ultra-high speed applications which require low latencies. In this range, around 1 GHz per operator is recommended by the GSMA. Examples of the possible 5G applications and their spectrum requirements are summarised in Figure 2.1.

FIGURE 2.1

POSSIBLE 5G APPLICATIONS AND THEIR SPECTRUM REQUIREMENTS[8]

Usage Scenario	High-level Requirement	Potential spectrum-related implications	Spectrum ranges considered suitable
Enhanced mobile broadband	Ultra-high-speed radio links	Ultra-wide carrier bandwidths, e.g. 400 MHz Multi-gigabit fronthaul/ backhaul, indoor	> 24 GHz
	High-speed radio links	Wide carrier bandwidths, e.g. 100 MHz gigabit fronthaul/backhaul	3-6 GHz
	Support of low- to high-mobility	Depends on the throughput requirement	All ranges
	Ultra-low latency	Short-range implications	3-6 GHz, > 24 GHz
	Low latency	Mid-short-range implications	3-6 GHz
	Ultra-high-reliability radio links	Severe impact of rain and other atmospheric effects on link availability in higher frequencies, e.g. mmWave, for outdoor operations	< 6 GHz
	High-reliability radio links	Impact of rain and other atmospheric effects on link availability in higher frequencies, e.g. mmWave, for outdoor operations	< 6 GHz
Ultra-reliable Communications	Short range	Higher frequencies, e.g. mmWave	> 24 GHz
	Medium to long range	Lower frequencies, e.g. sub-6 GHz	< 6 GHz
	Ground/obstacle penetration	Lower frequencies, e.g. sub-1 GHz	< 1.5 GHz
Massive Machine-Type Communications	Operation in a cluttered environment	Diffraction dominated environment in lower frequencies Reflection dominated environment in higher frequencies[9]	All ranges
	Operation near fast-moving obstacles	Frequency-selective fading channels[10]	All ranges, especially below 6 GHz
	Mesh networking	High-speed distributed wireless backhauls operating in-band or out-of-band	> 24 GHz

Activities to identify and harmonise spectrum for 5G have been ongoing for a number of years at the international and regional levels. Over the World Radiocommunication Conferences in 2015 and 2019, a number of bands have been identified and allocated for IMT use. Taking advantage of the work to harmonise mid-band spectrum, the initial phase of 5G rollouts have focused primarily on the 3.3-3.8 GHz band. Figure 2.2 provides an overview of the 5G bands.

8 Source: 5G Americas

9 These are different types of propagation effects. Diffraction is defined as the bending of waves around the corners of an obstacle – for example a building. Reflection is where a radio signal is reflected by obstacles such as walls inside a building.

10 Frequency selective fading is where the wanted signal is reduced (faded) depending on the frequency of operation.

FIGURE 2.2

OVERVIEW OF 5G BANDS AND CURRENT DEVELOPMENTS[11]

Range	Main 5G bands	Main incumbent use	Notes
Low-band	600 MHz 700 MHz	Broadcast TV	700 MHz is much more widely harmonised for IMT than 600 MHz though 4G is currently used in 700 MHz by many countries.
Mid-band	2300 MHz 2600 MHz 3300-3800 MHz 3800-4200 MHz 4400-4900 MHz	Fixed satellite Fixed service (point-to-point, point-to-multipoint)	Initial phase of 5G rollout has focused mainly on 3400-3800 MHz though some countries are also considering the range 3300-3400 MHz as well as alternative bands
High-band	26 GHz (24.25-27.5 GHz) 28 GHz (27.5-29.5 GHz) 37-43.5 GHz 45.5-47 GHz 47.2-48.2 GHz 66-71 GHz	Earth exploration satellite Fixed satellite Fixed service Space research	Initial phase of 5G has focused mainly on 26 GHz and 28 GHz bands but there have been relatively few commercial deployments so far.

2.1.1 Spectrum awarded and status of 5G deployment in Gulf countries

Figure 2.3 shows the frequency bands that have been awarded in the Gulf countries and used to deploy 5G and the latest status of the networks. These countries are among the first to deploy and launch 5G (FWA and mobile) commercial services. These are all mid-band frequencies as in many cases the low-band frequencies have already been awarded, but on a technology-neutral basis.

FIGURE 2.2

SPECTRUM BANDS AWARDED AND NETWORK STATUS IN GULF COUNTRIES[12]

Country	Operator	5G network status	Commercial launch	Frequency bands
Bahrain	Batelco	5G deployed in network (2019)	Yes, 2019	2496-2690 MHz
	STC[13]	5G deployed in network (2019)	Yes, 2019	2496-2690 MHz
	Zain	5G deployed in network (2019)	Yes, 2020	2496-2690 MHz
Kuwait	Ooredoo	5G deployed in network (2018)	Yes, 2019	4400-5000 MHz
	STC[14]	5G deployed in network (2019)	Yes, 2019	3300-3800 MHz
	Zain	5G deployed in network (2018)	Yes, 2019	3300-4200 MHz
Oman	Omantel	5G deployed in network (2019)	Yes, 2020	3300-3800 MHz
	Ooredoo	Licensed (2018)	Yes	3300-3800 MHz
Qatar	Ooredoo	5G deployed in network (2018)	Yes, 2019	3300-3800 MHz
	Vodafone	5G deployed in network (2018)	Yes, 2019	3300-3800 MHz
Saudi Arabia	Mobily	5G deployed in network (2019)	Yes, 2019	2496-2690 MHz 3300-3800 MHz
	STC	5G deployed in network (2018)	Yes, 2019	2300-2400 MHz 3300-3800 MHz
	Zain	5G deployed in network (2019)	Yes, 2019	2496-2690 MHz 3300-3800 MHz
UAE	Du	5G deployed in network (2019)	Yes, 2019	3300-3800 MHz
	Etisalat	5G deployed in network (2018)	Yes, 2019	3300-3800 MHz[15]

11 The existing mobile frequency bands are also identified for 5G NR but as these are typically already used the focus for 5G has been on new frequency bands.

12 Source: Global mobile Suppliers Association (GSA)

13 Formerly Viva, Menatelecom

14 Formerly Viva

15 15 GHz band being evaluated as well.

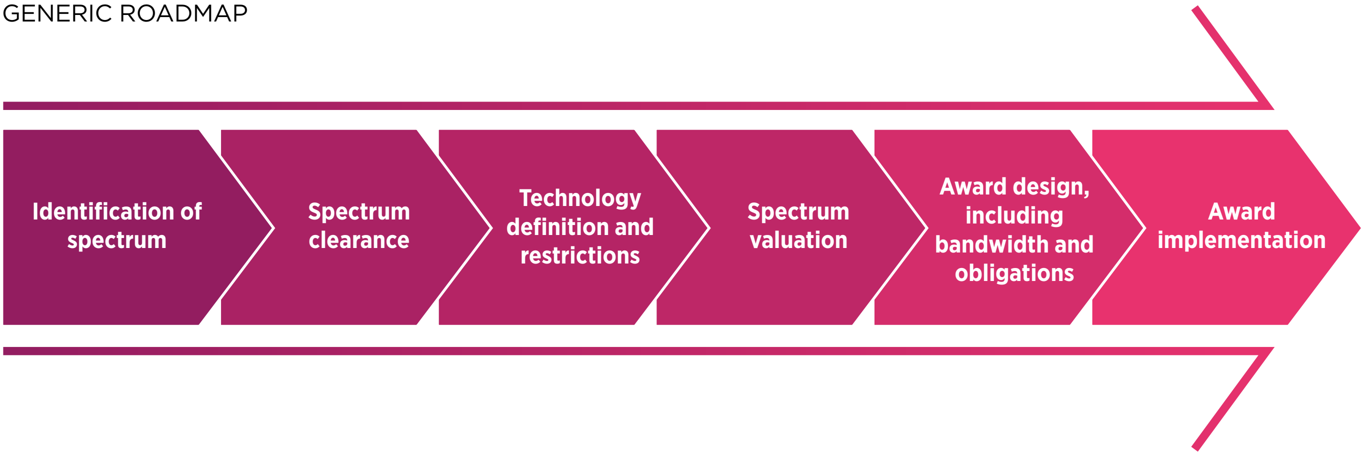
There are a number of steps necessary to release spectrum for 5G services and prepare for the award and these are described in Section 2.2.

2.2 A generic 5G roadmap

Figure 2.4 provides a generic roadmap that can be applied to 5G or the introduction of any other previous generation of mobile technology.

FIGURE 2.4

GENERIC ROADMAP



It is important to recognise that whilst the steps may be the same for each country the detailed activities under each may vary. Consultation with industry is also an important element of any roadmap to ensure the optimum outcome for all.

Identification of spectrum

The first step is to identify suitable spectrum based on key bands being adopted on a world-wide basis and so providing economies of scale. Whilst the key frequency bands for 5G are 700 MHz[16], 3500 MHz range and 26 GHz it may be necessary to consider alternative bands based on spectrum already awarded for mobile. This is highlighted in the approaches adopted for 5G in the Gulf countries shown in Figure 2.3 where in many countries the 3300 – 4200 MHz spectrum is awarded but there are also examples of the 2300 MHz, 2600 MHz and 4400 MHz bands.

Spectrum clearance

In general, there are two main approaches to releasing spectrum for mobile broadband:

1. Clearance and, if needed, relocation of incumbent services; and
2. Sharing with incumbents through the use of appropriate mitigation measures.

The preferred approach will vary depending on incumbents. The feasibility of band clearance and relocation will depend on the type and number of users and whether the existing equipment can be reasonably upgraded or replaced to maintain services or whether there are alternatives for users to maintain their current services and the impact of disruption to services and users.

In some cases, the incumbents may be able to remain through geographic sharing (for example, where there is limited governmental use or existing regional licences). If frequencies are already assigned to mobile network operators and they can implement new 4G or 5G technologies then it may only be necessary to realign the band assignments to provide contiguous frequencies and maximise spectrum efficiency.

Technology definition and restrictions

It will be necessary to define clearly any technical conditions and restrictions that will need to be met when deploying networks. Technical conditions can include, for example, limits on transmitter powers, use of block edge masks and any other obligations that may be necessary to avoid interference. Restrictions may be necessary to allow, for example, geographic sharing with incumbent users that are not being migrated from the spectrum.

16 The 700 MHz bands may already have been awarded and 4G networks deployed so it may be necessary to consider 600 MHz bands as alternatives.

Spectrum valuation

Spectrum fees should promote the efficient use of spectrum and reflect the opportunity cost of the spectrum though this is sometimes difficult to determine in practice, particularly in the case of 5G where use cases and business models are still uncertain. Fees can be set administratively by governments and regulators, or through market-based mechanisms such as auctions. 5G deployment will require significant investment and the business model for 5G is still under development at present. In assessing the appropriate fee levels or reserve prices, it will be important to take account of the impacts of high spectrum costs on the financial ability of operators to invest in network rollout and on consumer outcomes.[17]

Award design

The design of the award will need to take account of policy objectives, available spectrum and the market (for example, the number of operators, or current spectrum holdings). The method of award (auction, beauty contest and direct assignment) is an important consideration as are the licence obligations that may be applied, such as spectrum caps, coverage or rollout requirements and spectrum leasing and trading.

Award implementation

The final step is the actual award process as defined in the award documentation. It should be noted that it may not necessarily be a single award but a number depending on spectrum release timings and market demand. This is demonstrated in the Saudi Arabia case study in Section 2.3.

2.3 Example case study: Saudi Arabia

The Kingdom of Saudi Arabia is one of the first countries in the Middle East region to assign key mid-band spectrum for 5G, with auctions of the 2.3 GHz, 2.6 GHz and 3.5 GHz bands which were completed in early 2019. Low-band spectrum (700 MHz and 800 MHz bands) was awarded earlier primarily for 4G, but operators can use it for 5G as well as the licences are technology neutral.

One of the KSA's strategic objectives in the National Transformation Program (NTP) 2020 was to make available more spectrum for the provision of mobile broadband or IMT services. In the last three years the Communications and Information Technology Commission (CITC) has carried out four auctions including existing and new IMT bands, namely:

- June 2017: 700 MHz and 1800 MHz
- February 2018: 800 MHz, residual spectrum in 700 MHz and 1800 MHz bands
- January 2019: 2.3 GHz and 2.6 GHz
- March 2019: 3.5 GHz

As a result, operators in the KSA today have access to more than 1000 MHz of licensed spectrum for IMT use in the low- and mid-band ranges. This is on a par, or higher than, most of the leading countries in Europe, Americas and the Asia Pacific.

17 GSMA. The impact of spectrum prices on consumers. September 2019. https://www.gsma.com/spectrum/wp-content/uploads/2019/09/Impact-of-spectrum-prices-on-consumers.pdf

In planning for the release of the 2.3 GHz, 2.6 GHz and 3.5 GHz bands, the CITC had to take account of a number of incumbent users. They included existing assignments for fixed wireless broadband, fixed links and other government uses. To ensure efficient use, in particular for 5G deployments, the following steps were taken by the CITC:

Discussions and consultations with operators;

- A reorganisation of the bands, including revocation of assignments which were not being utilised;
- Retention of some 3.5 GHz range spectrum to allow existing fixed wireless providers to continue to provide services;
- Coordination measures to ensure IMT use does not impact on with government users; and
- Reserved spectrum for existing mobile network operators to ensure sufficient contiguous bandwidths to facilitate 5G use.

As part the CITC's objectives to promote 5G deployment and improve mobile service quality, the licence conditions for these bands included obligations for the operators to meet coverage and rollout targets within five years and to achieve specific quality of service requirements.

CITC has also planned to release more spectrum for 5G as detailed in its "Spectrum Outlook for Commercial and Innovative Use". CITC is planning to auction 600 MHz, 700 MHz and 3.8 GHz for IMT use in 2022. This will make Saudi Arabia the number one country in the world in the amount of IMT spectrum in the sub-1 GHz bands, with a total of 1,420 MHz. CITC is also planning to auction the 26 GHz band and 1.5 GHz in a separate auction.

3 Current status of markets in MENA region

This section provides an overview of mobile networks and spectrum awards in the MENA countries considered in this study. Where available predictions are provided on expected market growth and information on plans for award of spectrum for 5G. The data has been sourced from the GSMAi, inputs from regulators and operators and web sources. Further details for each country are provided in Figure 3.2.

In this table, demand forecasts are labelled according to the following convention.

FIGURE 3.1

KEY TO DEMAND FORECASTING SYMBOLS

Symbol	Meaning
↓↓	Significant decrease in connections
↓	Noticeable decrease in connections
–	Little change in number of connections
↑	Noticeable increase in connections
↑↑	Significant increase in connections

FIGURE 3.2

COMPARISON OF COUNTRIES

Country	No. of operators	Total spectrum (MHz)	Frequency bands awarded (MHz)	Demand forecasts (2018 to 2025)	4G introduction & 5G forecast	5G status	Comments
Algeria	3	247	900, 1800, 2100	2G↓↓ 3G ↑ 4G↑↑	4G 2016 5G 2023	5G tests and trials undertaken. New regulatory framework to be established	5G development is not an immediate national priority, as the government is instead focused on improving 4G mobile services for the population
Djibouti	1	-	900, 2100	2G↓↓ 3G ↑ 4G↑↑	4G 2018 5G > 2025		3G commenced in 2011. Aiming to extend LTE coverage. Annual growth in mobile traffic threefold. State-owned operator is being privatized
Egypt	4	360	700, 900, 1800, 2100, 2600	2G↓↓ 3G ↑ 4G↑↑	4G 2017 5G 2024	Considering 3800 – 4200 MHz for 5G 5G trials undertaken. Still significant demand for further 4G frequencies. Legal framework for the frequencies and licences for 5G is being prepared.	LTE @ 700 MHz
Iraq	3	193.2	900, 1800, 2100	2G↓↓ 3G↑ 4G↑↑		5G not pressing concern as lack 4G connectivity. 3G main technology. Reviewing FWA spectrum. Have been examining the use of spectrum at 450 MHz, 1500 MHz, 2300 MHz, 2600 MHz and 3500 MHz, taking into account the need for spectrum for 4G and 5G services. A virtual 5G-ready network launched by Zain in June 2021	
Jordan	3	340	900, 1800, 2100, 2600, 3500	2G↓ 3G↓↓ 4G↑↑	4G 2015 5G 2021	Plans for 5G but will take a while to adopt plans. Consultations started on multiple 5G bands 3600 MHz spectrum identified for trials. Frequencies in the 3500 MHz band provided to conduct experiments. 3500 MHz currently used for FBWA and expire end of 2022. 2.6 GHz assigned for LTE. 26 GHz for pt.– pt. links to be migrated to other bands over next 2 years. FiberTech licensed in 2019 to provide 5G infrastructure.	BWA @ 2.6 & 3.5 GHz Umnia to shut down its 2G network to upgrade and invest in 3G and 4G

FIGURE 3.2

COMPARISON OF COUNTRIES

Country	No. of operators	Total spectrum (MHz)	Frequency bands awarded (MHz)	Demand forecasts (2018 to 2025)	4G introduction & 5G forecast	5G status	Comments
Lebanon	2	210	800, 900, 1800, 2100	2G↓↓ 3G↓↓ 4G↑↑	4G 2013 5G 2023	Trials of 5G in C-band in 2018. Fibre roll-out to support 5G	LTE @ 800 MHz
Libya	2 MNOs 1 BWA	328.4	800, 900, 1800, 2100, 2600	2G↓↓ 3G↓ 4G↑↑	4G 2017 5G > 2025	Discussions on key strategic initiatives and projects aimed at developing Libyan ICT sector held in 2018. Cooperation agreements are being discussed with various foreign governments and telecom groups. 4G services are being extended.	WiMAX @ 2500 MHz LibyaPhone assumed to be a BWA operator
Mauritania	3	-	800, 900, 1800, 2100	2G↓↓ 3G↑↑ 4G↑	4G 2021 5G > 2025		CDMA @ 800 MHz 3G commenced in 2011.
Morocco	3	562	800, 900, 1800, 2100, 2600, 3500	2G↓↓ 3G↑ 4G↑	4G 2014 5G 2023	Evaluating, testing and trialling 5G. Telecom legal and regulatory framework revised. Launch of study to set terms for allocating 5G licences. Frequency consultation (including for 5G)	CDMA @ 800 MHz BWA @ 3.5 GHz
Palestine	2	18	900, 1800	-	-		Understand 3G commenced in 2018 but no information on frequency band.
Sudan	3	329.2	850, 900, 1800, 2100	2G↓↓ 3G↑ 4G↑↑	4G 2016 5G >2025	Ongoing consultations for 700 and 800 MHz. 700 MHz expected to be for 5G.	CDMA @ 850 MHz
Tunisia	3	359	800, 900, 1800, 2100	2G↓↓ 3G↓↓ 4G↑↑	4G 2016 5G 2023	5G bands identified are: 700 MHz band not currently used. 3.4 – 3.6 GHz. Current allocations to Orange (49 MHz) & Ooredoo (40 MHz) to remain and operators already transitioned from WiMAX to LTE TDD. 20 MHz for OMPP will remain but only used for 3 ports. 3.3 – 3.4 & 3.6 – 3.7 GHz not currently used so possibility for 5G. 26 GHz band currently used for fixed links. Technology neutrality needs to be implemented in legislation. Public consultation on the allocation strategy for 700 MHz and 3500 MHz. Public consultation on 5G use cases	LTE @ 800 MHz Mobile providers were most interested in the 26GHz spectrum for 5G services
Turkey	3	549	800, 900, 1800, 2100, 2600	2G↓ 3G↓ 4G↑↑	4G 2016 5G 2022	Live trials at 3.5GHz and field trials at 3.5 and 26 / 28 GHz. New Generation Mobile Communications Technologies Turkey Forum (5GTR Forum) was established in 2016 to coordinate activities of industry and academia on 5G. Report identifies the bands 470-694 MHz, 694-790 MHz, 1427-1518 MHz, 2300-2400 MHz, 2500-2690 MHz,[18] 3400-3800 MHz, 24.25-27.5 GHz, 40-43.5 GHz and 66-71 GHz for mobile broadband systems in the short (before 2023), medium (2023 – 2028) and long (beyond 2028) term.	LTE @ 800, 2100, 2600 MHz 2G & 3G forecasted to support limited number of connections. 4G is the main technology deployed.

18 Parts that are not already assigned.

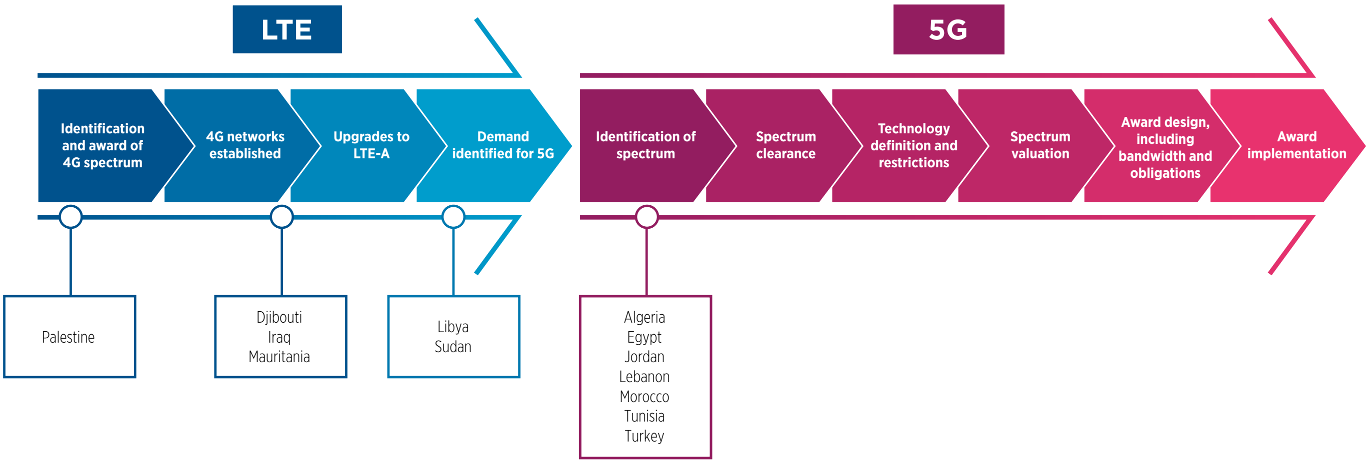
4 Roadmaps

This section looks at how the generic roadmap in Section 2.2 can be applied to each of the countries studied.

In Figure 4.1 the current status of each country on the road map to 5G award is identified based on available information shown in Figure 3.2 and Error! Reference source not found..

FIGURE 4.1

ESTIMATED CURRENT STATUS ON ROAD MAP



The steps recommended are based on the grouping of countries above. Tunisia has been included in more detail as an example case study. In addition, some general recommendations are provided based on international best practice.

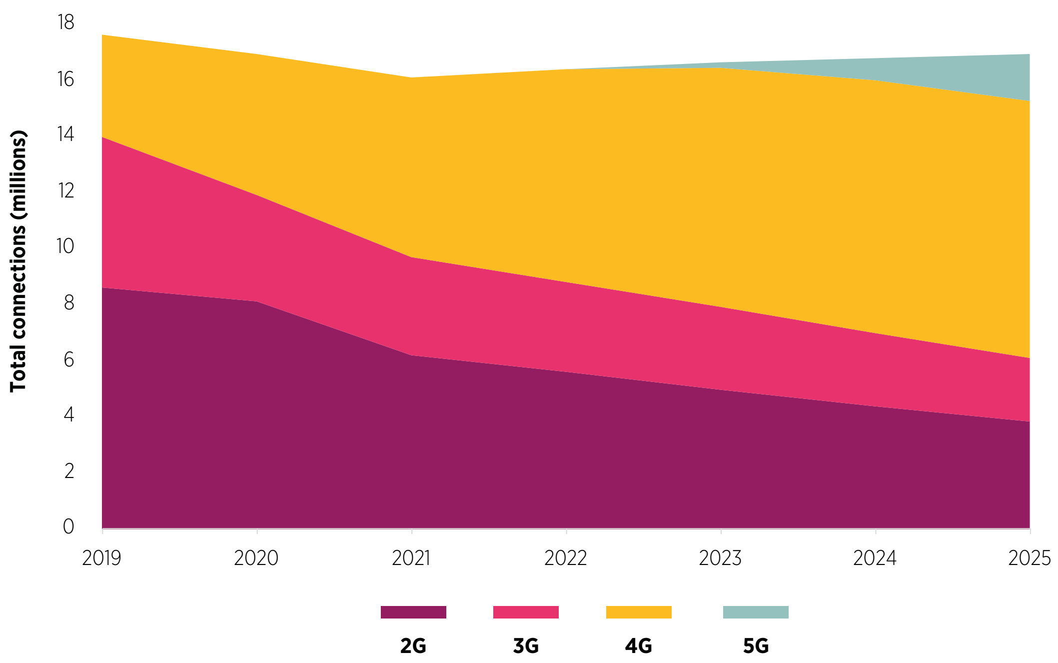
19 Source ANF

4.1 Roadmap for Tunisia

In Tunisia it is forecasted that there will be a significant increase in 4G connections to 2025 and the expectation that 5G will be deployed in 2023[19]. As shown in Figure 4.2, connections using 2G and 3G technologies will decline. If the aim is to meet the 2023 forecast date for 5G, then it will be essential to award the spectrum in the first half of 2022. In the following sections we discuss the necessary steps.

FIGURE 4.2

PROJECTIONS FOR CONNECTIONS BY TECHNOLOGY IN TUNISIA (MILLIONS)[20]



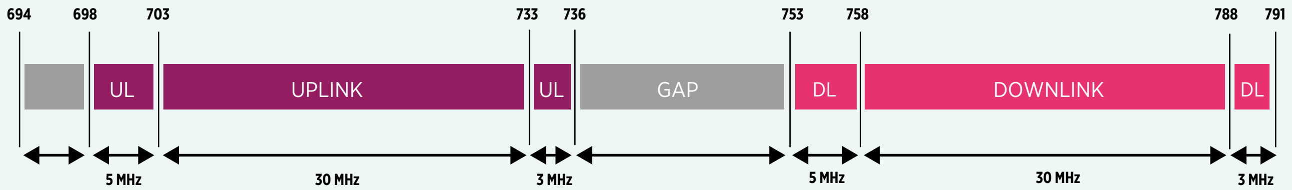
4.1.1 Steps 1 and 2: Identification of spectrum and clearance

The regulator, ANF, has already identified low, mid and high bands for 5G, namely 700 MHz, 3400 – 3600 MHz and the 26 GHz band respectively and their current availability. It does not appear there is any specific need for clearance of any of the bands as considered below but further studies are required to fully define the frequency bands and any associated technical conditions.

20 Source: GSMAi

700 MHz

It is understood that this band is not used and has been available since analogue TV switch off in May 2016. The proposed band plan is in line with the European band plan for 700 MHz, with one main band of 2×30 MHz to be assigned (and smaller bands for potential PPDR or other use).



The basis of this band plan is not known but does not appear to be aligned with 3GPP 700 MHz band plans. The 3GPP band 28 is 703 – 748 MHz (uplink) and 758 – 803 MHz (downlink) but in Europe the paired band that has been adopted is 703 – 733 MHz paired with 758 – 788 MHz. In the UK Ofcom has proposed to award 2 blocks of 30 MHz in the paired band 703 – 733 MHz with 758 – 788 MHz and 20 MHz of the centre gap, 738 – 758 MHz, as supplementary downlink.

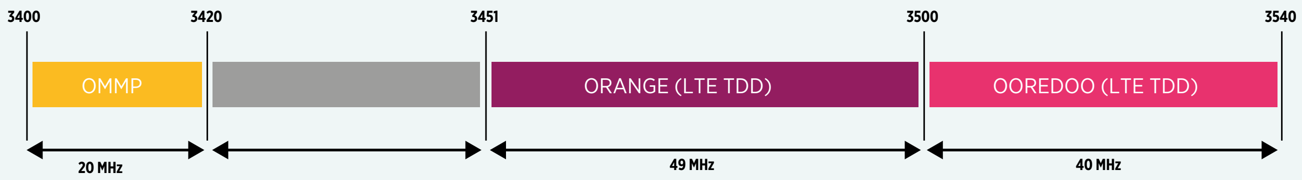
It is important to ensure that an appropriate band plan is adopted that will co-exist with other 3GPP bands. In addition, ANF should coordinate with neighbouring countries to understand their current use of the spectrum with the aim of reducing the risk of interference and any limitations on spectrum use in border regions.

The use of frequencies below and above the band plan should also be considered to ensure there are no adjacent channel coexistence issues that would require licence conditions to be implemented such as transmitter power limits, block edge masks etc.

3400 – 3600 MHz

There are existing users of the 3400 – 3600 MHz band. In the bottom 20 MHz the spectrum is used by the OMMP (Office des Marines marchandes et des ports) in a limited geographic area at three ports (Bizerte ; Radès et la Goulette) and will not be migrated from the band. It will be necessary to define the cochannel and adjacent channel coexistence requirements. For example, this could be a power flux density limit at a defined geographic border around the ports.

The two mobile operators, Orange and Ooredoo, each have access to unpaired frequencies (49 MHz and 40 MHz respectively.



It will be necessary to consider options to defragment the band and provide contiguous allocations depending on the outcome of the award. ECC Report 287[21] provides useful advice to administrations on defragmenting the 3.4 – 3.8 GHz band for 5G introduction. This can include one or more of the following:

- Early termination of incumbent licences which would expire after the planned date for award.
- Moving incumbents to alternative frequency bands or technologies (e.g. wired).
- Amend existing licences to allow them to be used for 5G services if technology migration path is 5G.
- Implement trading and leasing between licensees which allows spectrum to be re-allocated without the revocation and award of licences.
- Move incumbent licences into one part of the band to provide contiguous spectrum.

ANF need to consider whether to revoke these licences and award all the spectrum or whether to allow Orange and Ooredoo to retain part or all of their spectrum, noting the licences have been updated to support LTE TDD and are compatible with 5G. It would be feasible to allow them to retain all or some of their frequencies on the basis that they can be moved within the band to ensure contiguous allocations depending on the outcome of the award.

ANF should also investigate the potential to extend the frequencies available to include, for example, 3600 – 3800 MHz to provide larger contiguous bandwidths of around 80 – 100 MHz per operator.

26 GHz

The 26 GHz band is currently used for fixed links with Ooredoo being licensed to use 2×112 MHz and the Douane Tunisienne assigned 4 off 56 MHz channels. The potential for the incumbents to remain in the band should be investigated especially as 5G deployment in the 26 GHz band is expected to be concentrated in urban areas and the locations for fixed links transmitters are typically known so it may be possible to coordinate between the two services.

Also, at this stage, if it has not already occurred, spectrum should be made available for the operators to undertake initial testing or trials. It should be made clear that access to spectrum for this does not imply any guaranteed continued access.

21 https://www.ecodocdb.dk/document/category/ECC_Reports?status=ACTIVE

4.1.2 Step 3: Technology definitions and restrictions

The tasks identified above will feed into the definition of technical licence conditions and any restrictions on use. It is important to understand if any of the spectrum that will be awarded will be restricted compared with other frequencies in the same band, for example due to incumbent fixed link use, as this might have an impact on the approach to the award and also spectrum valuation.

In the case of the OMMP use in the bottom 20 MHz of the 3400 – 3600 MHz band, as noted above, it will be necessary to define the technical conditions necessary to protect the port usage. This could be by the definition of power flux density levels that must not be exceed by operators in a defined geographic area or through exclusion zones around the ports. This will potentially limit the deployment of base stations near ports and limit transmitter powers that can be used for both co-channel and adjacent channel mobile operators.

In addition to co-existence other important technical considerations are the use of guard bands, block edge masks and synchronisation between networks (in country and cross border) to avoid base station to base station interference. The use of synchronisation requires all operators to use a specific downlink to uplink transmit ratio and frame length[22].

Step 4: Spectrum valuation

Spectrum valuation is an important element of the road map. If spectrum fees or auction reserve prices are set too high it can lead to spectrum not being awarded and slow roll-out of 5G. It is noted that there is an increasing number of 5G awards, particularly in the lower and mid-bands, to inform spectrum valuations if they are based on prices paid at auction. Further information is provided in Section 2.2 and Appendix A.

Step 5: Award design

It is important that the policy objectives associated with the award of 5G spectrum are taken into account in the design of the award and associated licence obligations. Further information is provided in Section 2.2 and Appendix A.

The award design needs to be considered carefully based on the aims of the Government and Regulator. These objectives may influence decisions on a number of policies:

- The duration for spectrum licences (longer licences can provide greater market certainty and encourage investment),
- Promotion of, or greater openness to, network sharing including spectrum sharing in those countries where there is more than one operator. This approach has the potential to increase coverage in rural areas where the business case for a new base station is marginal,
- Introduction of measures to reduce administrative and regulatory barriers to network deployment (for example, site planning and approval processes) to help speed up network deployment,
- Incorporating measures in spectrum award design to ensure equitable distribution of spectrum and to reduce uncertainty for operators (for example, spectrum caps and floors),
- Introduction of spectrum leasing and trading to facilitate migration of incumbents.
- Need for specific obligations such as network coverage and the balance against roll-out investment costs.

The method of award will also need to be decided – direct award, beauty contest or auction are options and the advantages and disadvantages of each are provided in Appendix A. The 5G spectrum can be awarded separately or as part of a multiband process depending on timescales for spectrum availability, substitutability of frequencies and inputs from operators. If the spectrum is awarded separately it is important that information is made available on when further spectrum (frequency bands and amount of spectrum) will become available to allow operators to determine their award strategies.

Finally, the relevant licensing and associated obligations need to be considered. These are in part determined by the policy objectives as well as market and competition objectives.

The output of this step will generally be award documentation detailing the award process Including:

- Spectrum to be awarded,
- Technical obligations,
- Licence conditions,
- Fees, and
- Award process.

22 ECC Report 296 provides options for synchronisation.

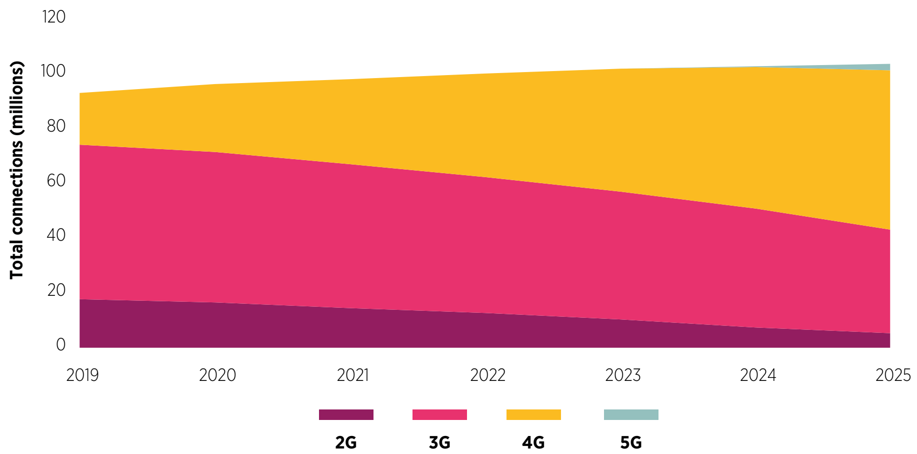
4.2 Roadmaps for Algeria, Egypt, Jordan, Lebanon, Morocco and Turkey

It is understood that in Algeria, Egypt, Morocco and Turkey the operators have been undertaking testing and trials of 5G and that in Lebanon at least one operator has been planning their 5G network. In Jordan plans for 5G are being developed and frequency bands identified while Egyptian authorities are currently developing the legal framework for awarding 5G spectrum. The COVID-19 pandemic has caused delays in some of these countries timetables for introducing 5G. Based on GSMA latest forecasts it is expected that all these countries will have commercial 5G services (BWA and mobile) between 2022 and 2024.

It is noted that in Egypt and Turkey there have been awards of spectrum for LTE in bands that could also potentially be used for 5G This is not an issue as indicated by Figure 2.2 and Figure 2.3, as a range of different bands have been identified for 5G – in particular for the mid-frequencies. In all these countries there is significant growth in 4G connections anticipated to 2025 since the services were available and there is expected to be a decline in 2G and 3G connections, see Figure 3.2 and Figure 4.3.

FIGURE 4.3

PROJECTIONS FOR CONNECTIONS BY TECHNOLOGY IN EGYPT (MILLIONS)[23]



In Morocco we would recommend that current use of the 800 MHz (CDMA) and 3500 MHz (BWA) bands is examined to determine the potential for releasing the spectrum for 5G although we understand from ANRT that the 3700 MHz is already one of the first bands that will be studied for 5G award along with 700 MHz, 1400 MHz, 3500 MHz and 26 GHz.

As well as identifying spectrum for 5G it will be important to identify the associated timescales for its availability as this may impact on the award process and whether there is a single multi band award or several separate awards over time as more spectrum becomes available. For example, in Jordan the BWA licences for the 3500 MHz band are due to expire in less than 2 years and fixed links in the 26 GHz band can be migrated to other bands in a similar timescale allowing both bands to be awarded at the same time. In Morocco the bands that will need to be redeveloped support fixed links, radio local loop as well as mobile.

Then assuming all these countries have identified 5G spectrum and any associated technical constraints have been identified and can be specified in technical obligations the next steps will be to undertake the spectrum valuation to inform spectrum fees and spectrum reserve prices, determine the method of award and all details of the process including licence obligations. The final step will be the actual award process. It may be that spectrum is awarded in a single process or separately depending on the timing for access to the spectrum and market demand. For example in Saudi the 26 GHz band has not yet been awarded, see Section 2.3 Further information on these steps is provided in Section 2.2 and Appendix A.

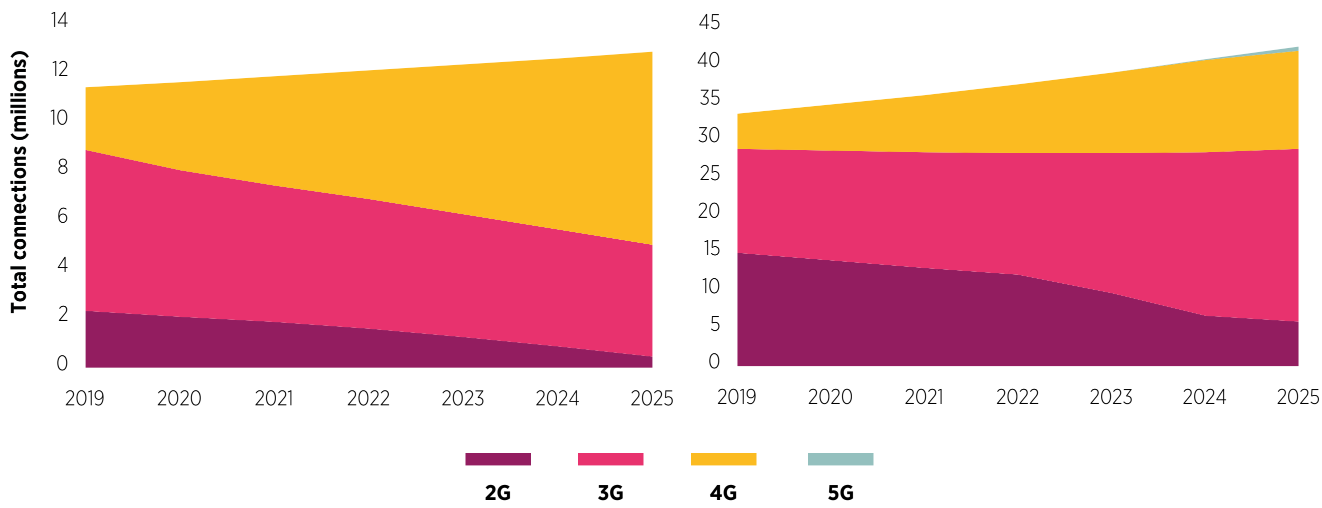
23 Source: GSMAi

4.3 Roadmaps for Libya and Sudan

In Libya and Sudan spectrum was awarded for 4G technologies in 2017 and 2016 respectively, and operators have launched LTE-Advanced services in both countries. While there is currently no indication of likely demand or rollout of 5G before 2026 in Libya (see Figure 4.4) it is forecast that demand for 5G will emerge (in a limited way) in 2024 in Sudan. In both countries demand for 4G connections are forecast to increase significantly by 2025 and in Sudan there is also predicted to be an increase in 3G connections. In both countries demand for 2G is expected to decrease significantly.

FIGURE 4.4

PROJECTIONS FOR CONNECTIONS BY TECHNOLOGY IN LIBYA AND SUDAN (MILLIONS)[24]



Frequency bands awarded to mobile operators are:

- Libya: 900, 1800, 2100 MHz; and
- Sudan: 850, 900, 1800, 2100 MHz[25].

In addition, in Libya it is understood that the bands 800 MHz and 2600 MHz are awarded with LTE technology being deployed to provide fixed wireless access.

The starting point for mobile roadmaps in both Libya and Sudan should be ensuring there is sufficient spectrum to support the forecast increases in 4G connections. Both countries have awarded around 100 MHz of 1800 MHz spectrum. In Libya there are two mobile operators and Sudan three, and it is assumed that the operators are refarming this spectrum as 2G connections decrease.

After consolidating the position of LTE, the next steps are to prepare for the award of spectrum for 5G. Libya and Sudan should follow the steps outlined in Section 2.2 and Appendix A. Step 1, as shown in Figure 2.4, will be to identify potential spectrum for 5G in prime bands of 700 MHz, 3500 MHz range and 26 GHz as well as investigate other potential bands in case there are issues with releasing this spectrum due to incumbents. In the case of Libya, it will be important to consider the spectrum used by, but not necessarily awarded to, LibyaPhone in the 800 MHz and 2600 MHz bands and how this sits with future mobile market plans. This process should be started as soon as possible and potential 5G spectrum consulted on and clearance process determined as well as any spectrum use restrictions before addressing the details of the award process.

The subsequent steps will depend on the spectrum that is identified and associated timescales for availability, technical constraints and decisions on spectrum award.

24 Source: GSMAi
25 Note that the 850 MHz band uses CDMA technology

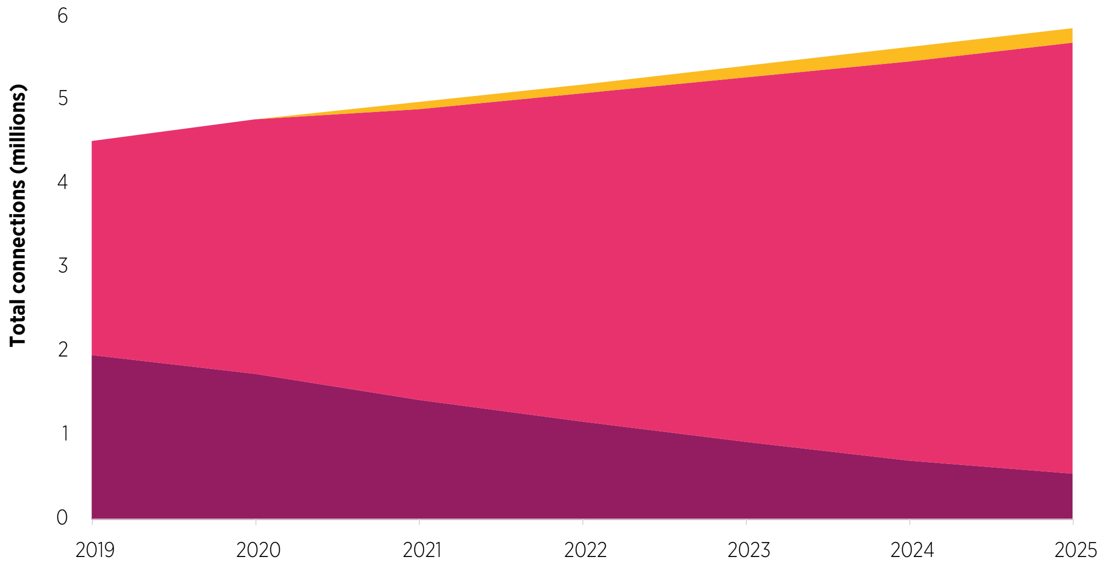
4.4 Roadmaps for Mauritania, Djibouti and Iraq

4G services were launched in Iraq and Mauritania in 2020 and 2021 respectively, so 5G is not a pressing concern in these countries. Iraqi operator Korek argued[26] that it will take some time before 5G becomes economically feasible given the need to establish solutions and regulations and provide the necessary infrastructure to deploy it, and noted the relevance to all types of enterprises as well as subscribers. We note that a review of spectrum allocated to FWA services has been undertaken as an initial public consultation was launched in December 2018, with a second expected to follow; this has been examining the use of spectrum at 450 MHz, 1500 MHz, 2300 MHz, 2600 MHz and 3500 MHz, taking into account the need for spectrum for 4G and 5G services[27].

In Mauritania, 2G services were introduced in the 900 and 1800 MHz bands, with 3G services in the 800 and 2100 MHz bands, starting in 2007. 2G connections are expected to decrease while the number of 3G connections is expected to significantly increase in the next years. 4G adoption is forecast to be slow and the technology is not expected to be dominant in the market by 2025.

FIGURE 4.5

PROJECTIONS FOR CONNECTIONS BY TECHNOLOGY IN MAURITANIA (MILLIONS)



Regarding Djibouti, there is very little information on the telecommunications market available in the public domain. It can be seen however from Figure 4.6 that 2G services were introduced in 2001 in the 900 MHz bands, 3G services in 2011 in the 2100 MHz band and 4G services in June 2018.

26 https://www.telecomreview.com/index.php/articles/exclusive-interviews/2999-korek-providing-global-services-with-an-iraqi-twist
27 http://comitatomcs.eu/wp-content/uploads/2019/08/190730-GSA-5G-spectrum-report-July.pdf

FIGURE 4.6

TECHNOLOGIES DEPLOYED BY OPERATOR BY BAND IN DJIBOUTI[28]

Technologies	Bands (MHz)	Generation	Djibouti Telecom
GSM	900	2G	Dec 2001
WCDMA HSDPA	2100	3G	Dec 2011
WCDMA HSPA+	2100	3G	Jan 2013
LTE	-	4G	June 21018

In Djibouti, Iraq and Mauritania, the introduction of 4G is still recent in these markets and its adoption by consumers is still in its early stages. The mobile roadmaps of these countries should first focus on keeping enough spectrum ready to use to support a surge in 4G connections. The next step would be to anticipate network upgrades and prepare to a demand-shift from 2G services to 3G and 4G services.

The regulators' priorities will depend on the spectrum that is identified and associated timescales for availability, technical constraints and decisions on spectrum award. Further information on these steps is provided in Section 2.2 and Appendix A.

4.5 Roadmap for Palestine

In Palestine there have been no awards for spectrum for 4G or introduction of 4G technology in current frequency bands. It is therefore premature to consider the requirements for 5G and more appropriate to roll out 4G that can meet the requirements of many applications, except those requiring very large bandwidth and low latency, and potentially stimulate the market for new services not supported by 2G and 3G technologies. 4G equipment and devices are currently lower cost than 5G due to economies of scale. Expectations of industry are that new 5G networks will co-exist with the existing 4G ones for a long period of time.

5G stand-alone new radio solutions as defined in 3GPP Release 19 are not currently available and not expected to be readily available until 2025[29]. 5G will also require the adoption of a new 3GPP defined network architecture (service-based architecture) and new network functions built on cloud native technology. This all supports the view not to make a technology jump (3G directly to 5G) and instead develop a roadmap for 4G.

All licencing in Palestine is carried out by the Israeli regulator, who allocates spectrum between Israel and Palestine ensuring there is no potential for interference. We note that 2G services were first introduced in 1999 in the 900 and 1800 MHz bands; 3G services were launched in 2018 but it is understood the operators were required to refarm some of their existing spectrum.

As mentioned before, 4G licences are yet to be awarded and it can be seen in Figure 4.7 that there is no demand identified before 2025. However, in November 2021 it was announced[30] that the Israeli regulator had met with Palestine operators to discuss the rollout of LTE networks, but no firm details of spectrum awards have been made public. With technical discussions due to take place during 2022, it is unlikely there will be any significant availability of LTE systems until 2024 at the earliest.

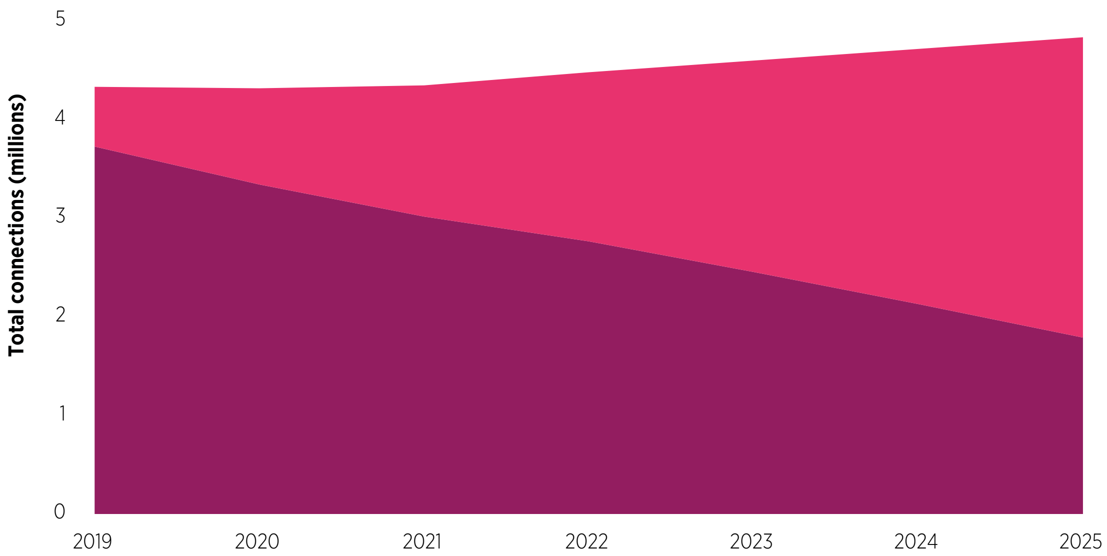
28 Source: GSMAi

29 3GPP Release 15 for 5G NR completed in June 2018 and is stable. Release 19 should be finalised by September 2021.

30 See https://www.commsupdate.com/articles/2021/11/26/israel-plans-to-allow-palestinian-operators-to-launch-4g/

FIGURE 4.7

PROJECTIONS FOR CONNECTIONS BY TECHNOLOGY IN PALESTINE (MILLIONS)



The roadmap for 4G for Palestine is based on the following steps.

Step 1. The first step will be to identify suitable frequency bands for 4G. The main choice for LTE around the world is 1800 MHz. Other bands that have been licensed include 2600 MHz, which is a major capacity band, 800 MHz which is widely licensed in EMEA countries, 700 MHz and 2100 MHz. TDD bands at 2300 and 2600 MHz are also licensed[31]. It is noted that in regards the prime 1800 MHz band, the two operators in Palestine have limited 1800 MHz spectrum which makes refarming impossible as ideally both require 2×10 MHz or in the worst case 2×5 MHz for LTE.

Step 2. The next step is to consider the potential to clear frequency bands for award. The aim should be to identify a minimum of 2×10 MHz or 1×20 MHz contiguous spectrum per operator – this may take into account the possibility of refarming part of the 1800 MHz band as explained above or other suitable 4G bands. Ideally coverage and capacity bands should be made available. It will be important to consider the options for removal of incumbents as described in Section 2.2 and Appendix A as it is the same process for the release of any frequency band – it is just the incumbents that may differ.

Step 3. It will be important to identify any technical restrictions that may need to apply to the spectrum for award. This may be technical conditions, such as maximum transmitter powers and block edge masks that apply to protect services in adjacent frequency bands or geographic restrictions to protect incumbents that cannot be migrated from the band.

Step 4. Regardless of the award process it will be necessary to value the spectrum to allow annual spectrum fees and auction reserve prices to be determined. As noted in Section 2, fees can be set administratively determined by governments and regulators, or through market-based mechanisms such as auctions. With auctions, governments and regulators determine the auction design and set the reserve prices which will have an important influence on the award outcomes and the spectrum prices. As for 5G, 4G deployment will require significant investment and to allow the introduction of new faster data services and the benefits thereof it is important to take account of the impacts of high spectrum costs on the financial ability of operators to invest in network rollout and on consumer outcomes.[32]

31 https://gsacom.com/paper/lte-fdd-frequency-bands-worldwide-november-2019/ and https://gsacom.com/paper/lte-frequency-bands-april-2019/

32 GSMA. The impact of spectrum prices on consumers. September 2019. https://www.gsma.com/spectrum/wp-content/uploads/2019/09/Impact-of-spectrum-prices-on-consumers.pdf

Step 5. The award design needs to be considered carefully based on the aims of the Government and Regulator. These objectives may influence decisions on:

- The duration for spectrum licences (longer licences can provide greater market certainty and encourage investment),
- Promotion of, or willingness to allow network sharing including spectrum sharing in those countries where there is more than one operator,
- Introduction of measures to reduce administrative and regulatory barriers to network deployment (for example, site planning and approval processes),
- Incorporating measures in spectrum award design to ensure equitable distribution of spectrum and to reduce uncertainty for operators (for example, spectrum caps and floors), and
- Need for specific obligations such as network coverage noting that this will impact on roll-out investment costs.

The method of award will also need to be decided – direct award, beauty contest or auction are options and the advantages and disadvantages of each are provided in Appendix A. In the case where there is only one or two operators and no expectation of new mobile players and sufficient spectrum then a direct award may be most appropriate. If there is more than one frequency band identified for award, then it will be necessary to decide whether to offer them separately or as part of a multiband process. This may be determined based on, for example, timescales for spectrum availability, substitutability of frequencies and inputs from operators.

Finally, the relevant licensing and associated obligations need to be considered. These are in part determined by the policy objectives as well as market and competition objectives.

The output of this step will generally be award documentation detailing the award process, description of available spectrum and any constraints on use (such as timescales, geographic sharing), licence obligations including technical conditions and fees.

Step 6. The final step is implementation of the award process as provided in the award documentation.

5 Recommendations

In this section we identify a number of general recommendations based on the current status of spectrum award in the MENA countries and international best practice.

5.1 Existing spectrum

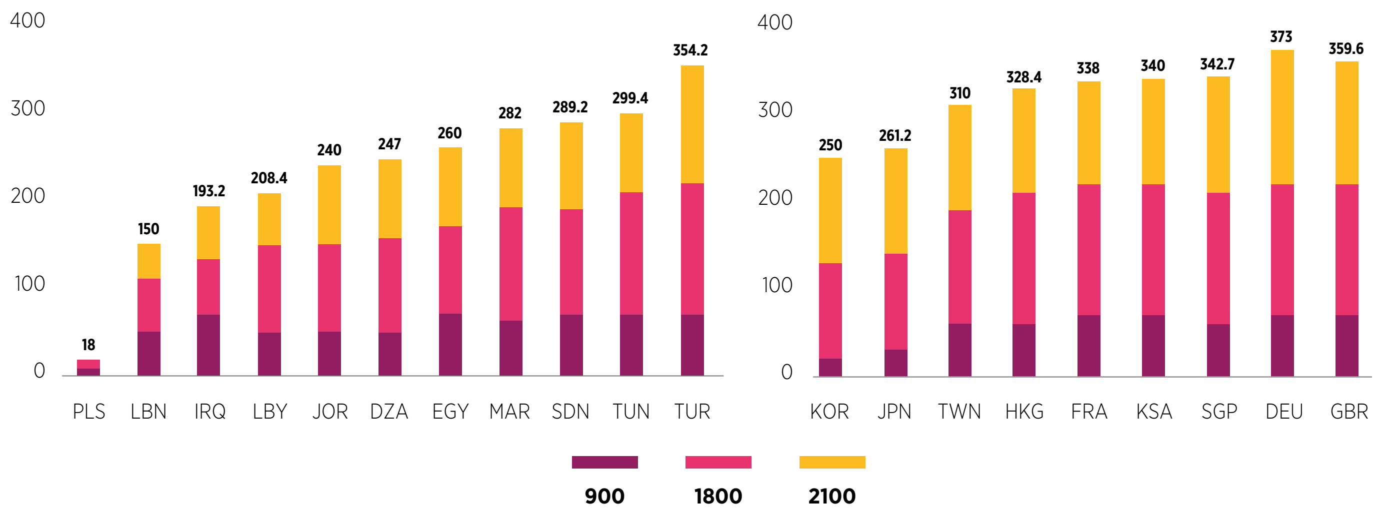
The current level of spectrum availability varies considerably by country, but most states have released spectrum in traditional IMT bands for 2G and 3G services.

5.1.1 900, 1800 and 2100 MHz

It can be seen from Figure 5.1 that the amount of paired spectrum awarded in a number of the MENA countries to support 2G, 3G and 4G technologies is substantially less than that awarded in other countries such as Saudi Arabia, Germany, UK, and Singapore.

FIGURE 5.1

900, 1800 AND 2100 MHZ PAIRED SPECTRUM COMPARISON (MENA AND OTHER ITU-REGION 1 AND 3 COUNTRIES)[33]

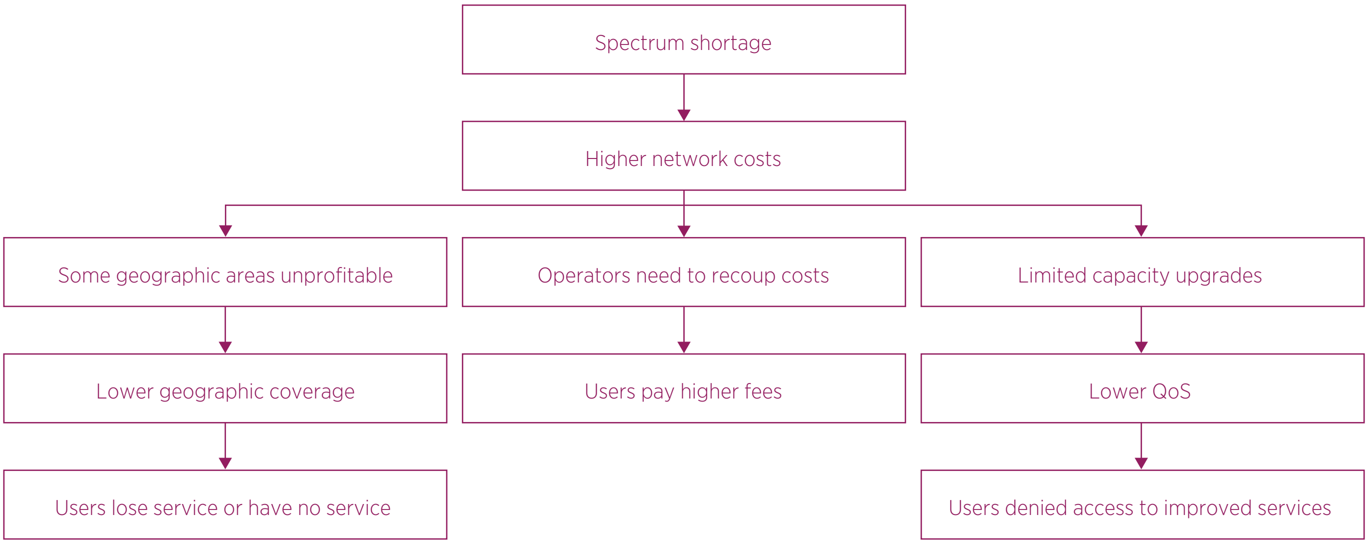


It is important that operators can minimise deployment costs by having access to sufficient spectrum to enable countries to benefit from the potential growth in GDP afforded by mobile services. Limited spectrum will require operators to deploy additional base stations to meet traffic demand and this can have an impact on further investment in geographic roll-out, grade and quality of services and prices as shown in Figure 5.2.

33 Source: GSMAi and Plum analysis. For this chart, Palestine has been abbreviated as PLS.

FIGURE 5.2

IMPACT OF SPECTRUM SHORTAGES



We recommend that those countries with limited spectrum already released should investigate the potential to release further spectrum in the existing frequency bands of 900, 1800 and 2100 MHz, and the timescales for release and award. There is potentially a total of 2×35 MHz available at 900 MHz, 2×75 MHz at 1800 MHz and 2×60 MHz at 2100 MHz; a total of 340 MHz.

- Steps involved in identifying and releasing spectrum are as follows.
- Discuss with existing users the potential to release further spectrum. Important considerations are how they can be migrated from the band and associated timescales and migration costs.

As necessary discuss with mobile operators the options to rearrange the bands once additional spectrum is available to provide contiguous spectrum. In particular for the 1800 MHz band these should ideally be in 10 MHz blocks, which can support LTE (4G) technology.

5.1.2 700 and 3500 MHz

The 700 MHz band and in particular the 3500 MHz range are the preferred frequencies for 5G and should be the main focus for award wherever feasible. The 3500 MHz range (3300 MHz – 4200 MHz) has quickly become the prime option for commercial 5G deployments worldwide. Its ability to provide coverage and capacity combined with spectrum availability makes it that ideal candidate. This initial focus on one range is also resulting in a quickly developing ecosystem, with the launch of increasingly affordable devices.

5.1.3 850 MHz

It is noted that a few countries (Mauritania, Morocco and Sudan) have awarded the 800 / 850 MHz bands for CDMA 2000 technology. Depending on the band plans the use of CDMA 850 can lead to potential interference into the 900 MHz (E-GSM) bands within the country or cross-border to neighbouring countries. It is recommended that all countries should adopt the Region 1 allocations and associated band plans and identify how to cease the current use of CDMA as soon as possible and ideally within the next 2 to 3 years to take account of 5G network roll-out and the potential to refarm 2G frequency bands as demand decreases..

5.1.4 Removing WiMAX from 2300, 2600 and 3500 MHz

A number of countries (Jordan, Libya and Morocco) have awarded the 2500, 2600 and 3500 MHz bands for wireless access using technologies such as WiMAX. These bands are potentially suitable for deployment of 4G and 5G and provision of mobile services, as well as wireless access; see Section 2.1 and Figure 2.3. We therefore recommend that the following should be considered to determine whether the licences should be revoked, and spectrum re-awarded or the current allocations retained.

- Are the assignments being used and if not, can they be revoked?
- Are the licences technology and service neutral so the licensees can upgrade to 4G and 5G technologies as they consider necessary based on market developments?
- Does the current licensing provide sufficient spectrum to support 4G or 5G deployments i.e. a minimum bandwidth of 10 MHz and 80-100 MHz contiguous spectrum for each licensee for 4G and 5G respectively?
- Are the current spectrum allocations spectrally efficient or could it be improved by moving licensees within the band or to alternative spectrum?
- Are there competition concerns if licences are not revoked and allowed to be used for mobile?
- Is the current use of the spectrum such that the existing licensees would take part in any award procedure? This would enable the spectrum to be allocated on a market basis to those that would maximise the economic and technical efficiency through an appropriate award process.

Answers to the above and consultation with interested parties should provide a way forward for these bands to be unlocked for mobile and so significantly increase the capacity of mobile networks and enhance user experience.

5.2 Technology neutral licences

It is important that technology neutral licensing is adopted to provide the necessary flexibility to operators to deploy new technologies based on market demand and their own service and network roadmaps.

Uncertainty and delays can lead to reductions in network investment and impact on roll-out, quality, cost and availability of services. This approach should apply to existing and new licences and may require changes to a country's underlying legislation.

Appendix A Roadmap considerations

This Appendix provides further information on the considerations for the steps shown in the generic roadmap in Section 2.2 that are based on international experience and best practice.

A.1 Spectrum clearance considerations

In general, there are two main approaches to releasing spectrum for mobile broadband:

1. Clearance and, if needed, relocation of incumbent services; and
2. Sharing with incumbents through the use of appropriate mitigation measures.

The feasibility of band clearance and timescales involved are dependent on a number of factors, including

- The type of service and number of users – for example in the C-band the number of consumers using DTH satellite TV is likely to be many times that of enterprise users of VSAT data communications.
- The possible impact on consumers and how this can be managed if there is a need to replace or upgrade equipment to maintain services (e.g. for DTH users, what are the other forms of receiving TV services)?
- The availability of alternatives for users to maintain their current service output, e.g. through alternative frequencies or wired technologies
- The cost of migration to alternatives identified above and measures which need to be put in place to address potential disruption to services.

Typically, a cost benefit analysis will be undertaken to assess if clearance of the band is the optimum approach or if other options such as mitigation and coexistence measures are more appropriate. The feasibility of coexistence measures will also depend on the nature and extent of incumbent usage. For example, sub-1 GHz bands (e.g. 600 MHz, 700 MHz) are typically used for broadcast TV services over wide geographic areas which means coexistence with 5G is impractical. On the other hand, usage by incumbents in other bands, such as fixed links and fixed satellite, may be highly localised which increase the opportunities for shared use.

The types of coexistence measures which can be considered include:

- Protection of existing users (e.g. FSS or FS) through methods such as
  - Shielding or use of exclusion zones
  - Using improved FSS receivers
  - Addition of filters to FSS receivers
- Restrictions on IMT deployments such as
  - Limitations on locations deployed
  - Antenna down-tilt or pointing, taking account of the location of existing users
  - Reduced transmitter power
- Detailed coordination between new and existing users
- Use of guard bands to separate new and incumbent users into different sub-bands.

More novel techniques for sharing spectrum such as licensed shared access (LSA) and dynamic spectrum access (DSA) could also be potential solutions. These involve active control of interference through the use of geolocation databases and sensing technologies. Examples of initiatives involving such techniques include the Citizen Band Radio Service (CBRS) in the 3.5 GHz band in the US and the LSA framework in the EU. Depending on specific local circumstances, a combination of coexistence measures and clearance can also be considered, if clearance is not feasible.

A.2 Timing for 5G spectrum release

For governments and regulators planning for their 5G spectrum roadmaps, the prioritisation and timing of release of specific bands depend on two main factors, namely

The ecosystem around specific 5G bands which will drive economies of scale in the availability and cost of devices and equipment; and

The challenges in clearing the band or in implementing the necessary mitigation measures.

The three main priority bands being considered for 5G to date are the 700 MHz[34], 3.3-3.8 GHz and the 26/28 GHz bands. The timing for the release of these bands and the potential amount of spectrum available in each band is contingent on the spectrum clearance considerations and the mitigation measures discussed above.

Some countries, particularly those where there is extensive use of C-band satellite services, have faced difficulties in releasing the 3.3-3.8 GHz band.[35] Potential alternatives to mid-band spectrum include the 2.3 GHz and 2.6 GHz bands,[36] although the feasibility of using these bands for 5G depends again on the extent of current deployments which may include broadband wireless access (BWA) and multichannel multipoint distribution systems (MMDS). Ensuring a timely and orderly transition of incumbent services will be necessary to the efficient release of these bands for 5G.[37]

A.3 Objectives of award

Radio spectrum is a public resource and is an essential input into the provision of communications services as well as an enabler of various functions performed by both private and public sector entities across different sectors of the economy and society. Thus, the first and foremost objective of spectrum management is to ensure the efficient use of spectrum, particularly in situations of scarcity which hitherto has been the case when it comes to spectrum for IMT use. In addition, many governments are putting 5G as a core aspect of industrial policy and see it as a key enabler of digital transformation across different industry sectors and as an engine for economic growth. As a result, promoting investment in 5G infrastructure and facilitating network deployment have also become important policy objectives.

One of the main challenges of 5G is the need for denser networks at the RAN level with a significantly higher number of small cells being introduced. Mobile operators are keen to deploy 5G to tap into new revenue streams, including new consumer applications such as multimedia, augmented reality and virtual reality services, and industrial and enterprise applications related to massive Internet of Things (IoT) and ultra-reliable low latency communications across different sectors such as manufacturing, logistics, utilities, transport, and healthcare. At the same time, they are also concerned about the associated costs and the risks that the investment will not pay back. The responses from policymakers and regulators to these concerns have been reflected in a number of ways including:

- Longer duration for spectrum licences,
- Promotion of, or greater openness to, network sharing including spectrum sharing,
- Introduction of measures to reduce administrative and regulatory barriers to network deployment,
- Reduction in licence fees in some cases, and
- Incorporating measures in spectrum award design to ensure equitable distribution of spectrum and to reduce uncertainty for operators (for example, spectrum caps and floors).

The suitability of these measures varies according to the specific market conditions and policy objectives. The design of the spectrum award and the licence conditions will need to take account of pressures on the current market structure and consider appropriate measures to mitigate risks and facilitate investment in 5G.

34 The 700 MHz bands may already have been awarded and 4G networks deployed so it may be necessary to consider 600 MHz bands as alternatives.

35 These include countries in South-east Asia. See Plum. Roadmap for C-band spectrum in ASEAN. Report for GSMA, August 2019. https://plumconsulting.co.uk/roadmap-for-c-band-spectrum-in-asean/

36 The 2.3 GHz and 2.6 GHz bands have been earmarked for 5G in countries as China, Saudi Arabia and Thailand.

37 Plum. It is all down to timing – spectrum transitioning. Insight paper, January 2020. https://plumconsulting.co.uk/it-is-all-down-to-timing-spectrum-transitioning/

A.4 Method of award

There are three main approaches to award spectrum – auction, beauty contest and direct assignment. Direct awards are suitable in situations where there is no scarcity, supply exceeds demand, but this tends to be rare for harmonised IMT bands with well-developed ecosystems. For 5G spectrum, some administrations (such as Hong Kong, UK) have chosen to use direct assignments for high-band spectrum due to the relative abundance of the mmWave frequencies and the uncertainty of the use cases and value of these bands at present. Direct assignments are also sometimes used for reassignments or renewal of spectrum as they are most simple to administer.

Auctions have been widely used globally for the award of mobile spectrum, and a well-designed auction would be able to address policy objectives and ensure that the spectrum is assigned to the bidder who values the spectrum the highest (and is thus likely to use it most effectively and efficiently). For 5G spectrum, particularly that in the low and mid bands, where there is supply is scarce, many administrations have continued to adopt auctions as the preferred mechanism for assignment.

Beauty contests or comparative tenders are an alternative option for awards where there may be other policy objectives beyond the pure economic value of spectrum. This was adopted by Japan in their 2019 multiband 5G award and has been proposed in Malaysia (700 MHz, 3.5 GHz, 26 GHz) as well. Factors which are used in the evaluation process may include coverage, quality of service, rollout plans, financial viability, technical experience and service pricing. A hybrid, involving a beauty contest with financial bidding, is also possible, for example, this has proposed by France (3.5 GHz) and Singapore (3.5 GHz and 26/28 GHz).

Figure A.1 provides a comparison of the general aspects of the three types of awards and the situations in which they are suitable.

FIGURE A.1

FIGURE A.1: KEY FEATURES OF DIFFERENT TYPES OF AWARDS[38]

Features	Auction	Comparative tender	Direct award
Design aspects (efficiency, competition, cost)	Allows for greater freedom and flexibility for bidders to express their demand for spectrum. Delivers an economically efficient outcome with spectrum sold at market clearing price. Spectrum caps can be used to address competition issues but intervention reduces economic efficiency. High costs of implementation but can vary depending on auction format and spectrum lots sold.	Less freedom and flexibility as bidders are required to abide by set evaluation criteria. Risk of inefficient allocation if evaluation criteria too subjective. Price of spectrum may not reflect opportunity cost. Cost can vary but typically lower than auction. Regulators have better opportunities to influence awards to meet their economic objectives.	Risk of inefficient allocation in cases where there is excess demand. Price of spectrum may not reflect opportunity cost. New entry either prohibited or enforced, without full consideration of business case reality. Simple, quickest and least costly process to administer.
Public policy objectives	Policy goals can be incorporated but requirements or obligations (e.g. coverage) need to be formulated upfront.	Allows regulator more flexibility to include elements relating to policy goals such as coverage, deployment and quality of service. Bidders can make bids in accordance to their ability and willingness to take on specific obligations. Subjective criteria harder to evaluate.	Can be addressed through imposition of obligations. Potentially less say for licensees but there could be extensive consultations in advance. Results in minimal disruption to operators and end users (in case of renewals).
Situations where these are used	Supply is less than demand (number of lots exceed number of bidders) and where there is uncertainty over efficient allocation Newly released bands (where there are no incumbent users).	Control of the assignment process is necessary (e.g. in the case of distorted markets or where there is a preference for more focus on non-price aspects and specific policy objectives). Appropriate when the number of licences is limited.	No scarcity of supply, or demand is unclear. Renewal of existing spectrum (e.g. 1800, 2100 MHz) which is being utilised efficiently. Appropriate when there are no market distortions that could jeopardize long term interest of end-users.

38 See also GSMA Public Policy Position on Auction Best Practice, May 2019. https://www.gsma.com/spectrum/wp-content/uploads/2019/05/Auction-Best-Practice.pdf

A.5 Licensing and obligations

Government policies on spectrum management usually involve allocation decisions and related matters, such as access by different users or uses, market competition, public safety and security needs, industry development and social objectives (e.g. digital inclusion). Spectrum awards provide a good opportunity for regulators to address and promote specific policy objectives and outcomes.

Public policy objectives are usually taken into account in the design of the award process and the obligations or conditions placed on the spectrum licences. In administrative awards or comparative tenders, these objectives can also be reflected in the evaluation criteria and the commitments made by the bidding parties. These can be related to aspects such as

- network coverage, in terms of geographic or population covered, indoor or outdoor, transportation links (for example, road or railway);
- service quality, in terms of average or minimum data throughput;
- network rollout, in terms of deployment timescales; and
- access requirements (for example, wholesale or interconnection for MVNOs).

Spectrum awards can also be a mechanism for promoting competition by facilitating market entry by new players or to address potential issues of market power and enable more effective competition between players in the market.[39] While the incorporation of public policy goals in spectrum award processes is increasingly common, it is important in designing the award and obligations to take into account the local market context and ensure that the measures are appropriate and do not place undue burden on businesses.

Another important aspect of 5G is that unlike previous generations of mobile technology, 5G is envisaged to serve a multitude of applications with heterogenous performance and spectrum requirements. Techniques such as Software Defined Networking (SDN) and Network Function Virtualisation (NFV) will allow 5G connectivity to be much more flexible, simultaneously addressing different use cases. From the regulatory perspective this is likely to require new approaches to spectrum award and authorisation.

With the variety of frequency bands identified for 5G – low, mid and high , this form of geographic licensing may no longer be appropriate for the types of use cases in the 5G era. New users (industry verticals) and applications will not necessarily require spectrum access on a wide geographic scale. Often these will be on a limited, highly localised basis and may involve a range of frequency bands. For example, agriculture uses may require wide area coverage in rural areas and so require spectrum below 6 GHz, but other industrial applications, such as those in indoor environments may be better suited to mmWave bands.

The range of options being considered by regulators to address these industrial sector uses include:

- **Spectrum leasing** – where the mobile network operator (MNO) leases some of their spectrum which they have identified will not be required in the short to medium term at a specific location, generally on a commercial basis, to another user.
- **Spectrum sharing solutions** – this is similar to leasing but in this case the regulator will issue a licence for the specific spectrum and location, and the conditions to be met by the new user. For example, Ofcom has adopted this approach in the UK for already licensed bands (3.8-4.2 GHz, 2.3 GHz, 1800 MHz) to support innovative use.40 Another option is Dynamic Spectrum Access (DSA) where the usage of a band at a location can be determined through use of a geo-location database, possibly with beacons or sensors, before being utilised and so avoid interference to the primary or other licensed users.[41]
- **Identifying spectrum specifically for new users.** There is currently no single approach adopted but there are proposals for licence exemption or light licensing in the mmWave bands.[42]

With 5G, there is no 'one size fits all' licensing solution. Instead, a range of licensing approaches, including licence exempt spectrum, will be considered. As new 5G use cases, not just eMBB, are starting to emerge, it will be timely for regulators to review existing licensing approaches and consider new forms of spectrum access to cater to innovative uses in new 5G bands.

39 These are usually done through spectrum set-asides or spectrum caps.

40 Ofcom. Statement: Enabling wireless innovation through local licensing. 25 July 2019.

41 Examples include TV White Spaces and the Citizens Broadband Radio Service (CBRS) in the 3.5 GHz band in the US.

42 For example, Australia has proposed to make the band 24.25 – 24.7 GHz available for class licensing for indoor use and 24.7 – 25.1 GHz for outdoor and indoor use.

A.6 Fees

The primary economic objective of spectrum management is to ensure an efficient distribution of resources to maximise the benefits to society. Spectrum fees are an important mechanism to promote the efficient use of spectrum in cases where there is excess demand. In principle, fees should reflect the opportunity cost of the spectrum though this is sometimes difficult to determine in practice, particularly in the case of 5G where use cases and business models are still uncertain.

Fees can be set administratively by governments and regulators, or through market-based mechanisms such as auctions. With auctions, governments and regulators determine the auction design and set the reserve prices which will have an important influence on the award outcomes and the spectrum prices. As discussed above, 5G deployment will require significant investment and the business model for 5G is still under development at present. In assessing the appropriate fee levels or reserve prices, it is important to take account of the impacts of high spectrum costs on the financial ability of operators to invest in network rollout and on consumer outcomes.[43]

With the award of 5G spectrum, governments are increasingly aware of the challenges faced by mobile operators and the potential role of 5G in transforming industries and enabling the delivery of national policy objectives. This has led to some regulators either opting for more conservative fees or adopting comparative tenders or hybrid awards with a focus on non-price criteria. For example, in Qatar there were no upfront fees and the annual fees for the 3500 and 3700 MHz bands awarded to Vodafone and Ooredoo are QAR 624,000 (US$ 171k) for 100 MHz of spectrum44. Japan allocated the 5G spectrum licences at no cost to MNOs (including mid-range spectrum in 3.7 GHz) via a competitive tender. Instead of auctioning the spectrum, the tender process awarded the spectrum licences based on a number of criteria including the best 5G investment proposals45. Additionally, in China, where there is no upfront spectrum charge, 5G spectrum usage fees for the first three years are waived, followed by a staged reduction of 25%, 50% and 75% for years four, five and six respectively. Full fees apply from year seven onwards. It is also vital that the regulator awards long-term (e.g. 25 years) with the expectation of renewal[46].

43 GSMA. The impact of spectrum prices on consumers. September 2019. https://www.gsma.com/spectrum/wp-content/uploads/2019/09/Impact-of-spectrum-prices-on-consumers.pdf

44 Source CRA Qatar and Decision on radio spectrum fees.

45 chrome-extension://bocbaocobfecmglnmeaeppambideimao/pdf/viewer.html?file=https://www.soumu.go.jp/main_content/000613734.pdf

46 http://www.gov.cn/fuwu/2018-04/28/content_5286546.htm

Appendix B
Country abbreviations

Acronym	Full form
DEU	Germany
DZA	Algeria
EGY	Egypt
FRA	France
GBR	United Kingdom
HKG	Hong Kong
IRQ	Iraq
JOR	Jordan
JPN	Japan
KOR	South Korea

Acronym	Full form
KSA	Saudi Arabia
LBY	Libya
LDN	Lebanon
MAR	Morocco
PLS[47]	Palestine
SDN	Sudan
SGP	Singapore
TUN	Tunisia
TUR	Turkey
TWN	Taiwan

47 For this report, Palestine has been abbreviated as PLS

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