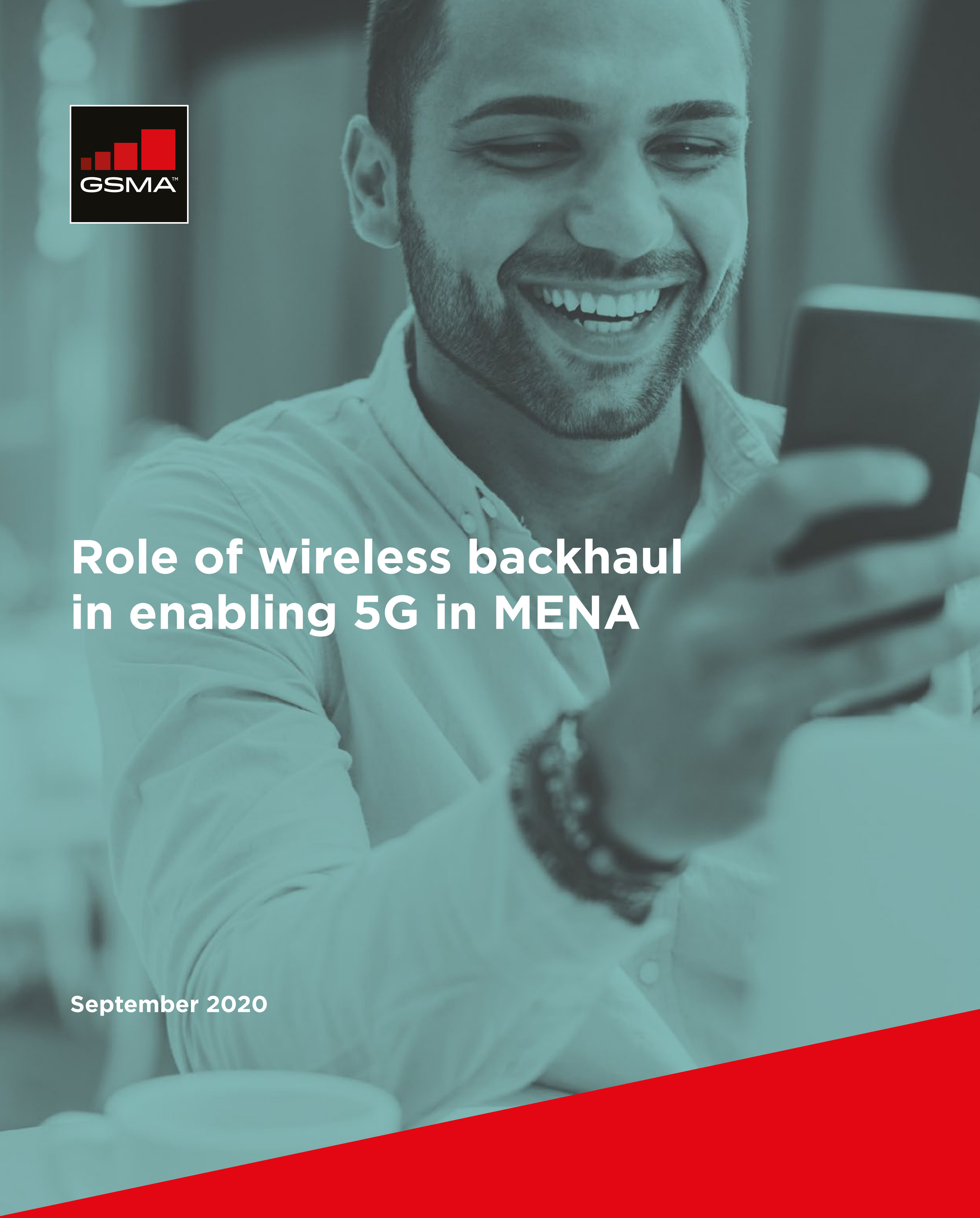

Role of wireless backhaul in enabling 5G in MENA

September 2020

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info@gsmaintelligence.com

Authors
James Joiner, Analyst
Dennisa Nichiforov-Chuang, Lead Spectrum Analyst
Kenechi Okeleke, Director, Social and Regional Research

Contributors
Jawad Abbass, Head of GSMA MENA
Amr Hashem, Technology Director, MENA
Mohamed Abbes, Public Policy Director, MENA
Michele Zarri, Technical Director, Future Networks
Oliver Chapman, Director, Spectrum

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Preface

5G holds the promise of enabling innovative digital services and use cases that can transform society, as technology is seamlessly embedded within social, commercial and industrial processes.

The technology has the potential to deliver a high-speed, reliable, ultra-low latency and secure broadband experience, provide the platform for cloud and AI-based services, and support the massive rollout of intelligent IoT connections for a multitude of scenarios. The improved capabilities and performance will be underpinned by a more advanced core network, increased spectral efficiency and capacity, and further network densification.

This has significant implications for mobile backhaul – the transport network that connects the core network and the radio access network (RAN) of the mobile network. Operators around the world are considering mobile backhaul upgrades from legacy infrastructure to packet-based solutions that can cope with the far higher data throughput and capacity requirements of 5G.

By the end of the last decade, commercial 5G services were available in five GCC Arab States. The 2020s will see widespread 5G deployment across the rest of the Middle East and North Africa (MENA); the technology will account for more than 6% of total mobile connections in MENA by 2025. Consequently, 5G has become central to mobile backhaul planning across the region. In many cases, mobile backhaul improvements will precede access network upgrades, allowing the access network to meet performance requirements of new applications.

To understand the outlook and expectations for mobile backhaul in MENA, GSMA Intelligence conducted a survey of key stakeholders, including mobile operators from across the region and leading transport vendors, to capture on-the-ground perspectives on key mobile backhaul trends and deployment.

Executive summary

The increasing migration to mobile broadband services in MENA is driving a rapid acceleration of mobile data traffic; 4G now accounts for a third of total mobile connections in the region, and this will rise to more than half by 2025. Meanwhile, the transition to 5G is gaining traction in the region, led by the GCC member states. 5G will account for nearly 50 million mobile connections in MENA by 2025, equivalent to 6% of total connections. 5G will play a pivotal role in the development of smart cities and will support the digital transformation agenda of governments across the region.

Mobile backhaul infrastructure is crucial to meeting the increasing demand for data connectivity as well as for achieving the capacity, reliability and performance expectations of 5G. As a result, there will be significant interest in mobile backhaul technologies in the 2020s, as operators seek effective and efficient solutions for their transport requirements. Indeed, investment in backhaul networks will be an early driver of 5G capex in MENA, which is set to accelerate over the period 2020–2025 as pioneer markets extend coverage and commercial launches get underway in other markets in the region.

Wireless backhaul – the use of radio technology to transfer data between the RAN and mobile core – is integral to mobile services in MENA, accounting for more than 80% of the overall mobile backhaul infrastructure. While there is a growing emphasis on the deployment of more fibre infrastructure given its increased capacity for 5G, wireless backhaul will remain the dominant technology in the region – it will account for more than 60% of mobile backhaul infrastructure across the region by 2025. Lower deployment cost and faster time-to-market are among the key factors that will sustain investments in wireless backhaul solutions.

However, wireless backhaul comes with its own dependencies, specifically the availability of the right radio spectrum at the right conditions – quantity, frequency band and pricing – to enable the efficient deployment of wireless backhaul infrastructure. Traditionally, the microwave band (6–42 GHz) has been used for wireless backhaul; however, it will play a more limited role in the 5G era due to increasing saturation, capacity constraints and the refarming of some bands for other uses. The natural evolution is towards higher bands, with wider bandwidth and the capacity to support higher data throughput in the 5G era. The 71–86 GHz spectrum band, commonly referred to as the E-band, is gaining momentum, driven by its ultra-high capacity.

E-band spectrum deployment is likely to gather pace in the coming years as operators step up efforts to densify their networks for 5G and meet the high-capacity demands of mobile networks in general. However, realising the full potential of the E-band requires the right regulatory framework around spectrum licensing and fees to ensure the efficient deployment of wireless backhaul. Spectrum licensing and regulation need to evolve in order to promote innovation and make 5G backhaul economically sustainable. For example, the use of bandwidth as a factor in calculating licence fee results in linear growth with channel width, which is counterproductive to promoting technology advancements, as this effectively punishes operators that are deploying new technologies.

A number of technical solutions are available to help address the limitations of wireless backhaul. For operators in MENA, cross-polarisation interference cancellation (XPIC), adaptive coding and modulation (ACM), and multi-carrier bonding[1] are among the top technical solutions to improve the performance of wireless backhaul solutions. Ongoing investment and research into these innovative solutions underscore the future prospect of wireless backhaul technology and the role it will play in future backhaul solutions, particularly for 5G.

1 Also referred to as band and carrier aggregation (BCA)

1 Mobile backhaul in context

Backhaul plays a central role in the mobile network architecture: it connects the core network and the RAN of the mobile network, providing transport for voice, messaging, data and video traffic between points on the network. Mobile backhaul can be delivered through a variety wireline and wireless technologies, the choice of which depends on several factors, such as capacity, cost, reach, latency and geography.

1.1 Evolution of mobile backhaul

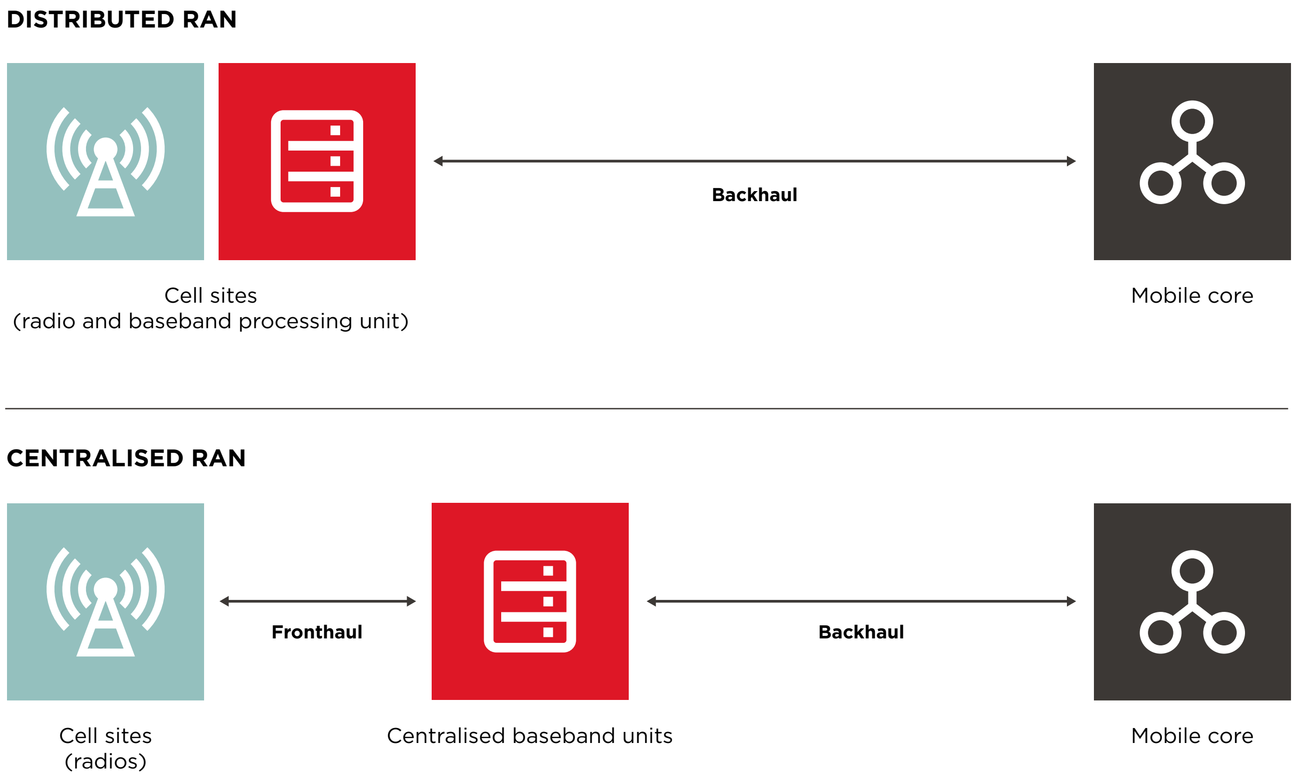
Traditionally, mobile backhaul is part of the network that transports traffic between cell sites and the mobile core network. As the demand for connectivity has exploded, mobile operators have looked for ways to minimise the footprint and cost of their equipment. In recent years, a number of mobile architectures, such as centralised RAN (C-RAN) and small cells, have emerged, with significant implications for wireless backhaul.

In the C-RAN architecture, the transport network connects the mobile core network to centralised hubs, known as baseband units (BBUs), which in turn connects the remote radio unit (RRU) through the mobile fronthaul (see Figure 1). Meanwhile, small cells are low-powered radio access nodes that help improve services in densely populated urban areas that cannot be sustained by macrocells. Broadly, small cells can improve capacity in areas with a high density of users, increase coverage range and available data rates, and extend handset battery life through reduced power consumption.

In both cases, additional transport infrastructure is required beyond the traditional backhaul infrastructure from the mobile core. The term mobile backhaul, as used in this report, generally encompasses fronthaul and backhaul for macrocell and small cell sites.

Figure 1

5G networks will use a mix of distributed RAN and centralised RAN architectures



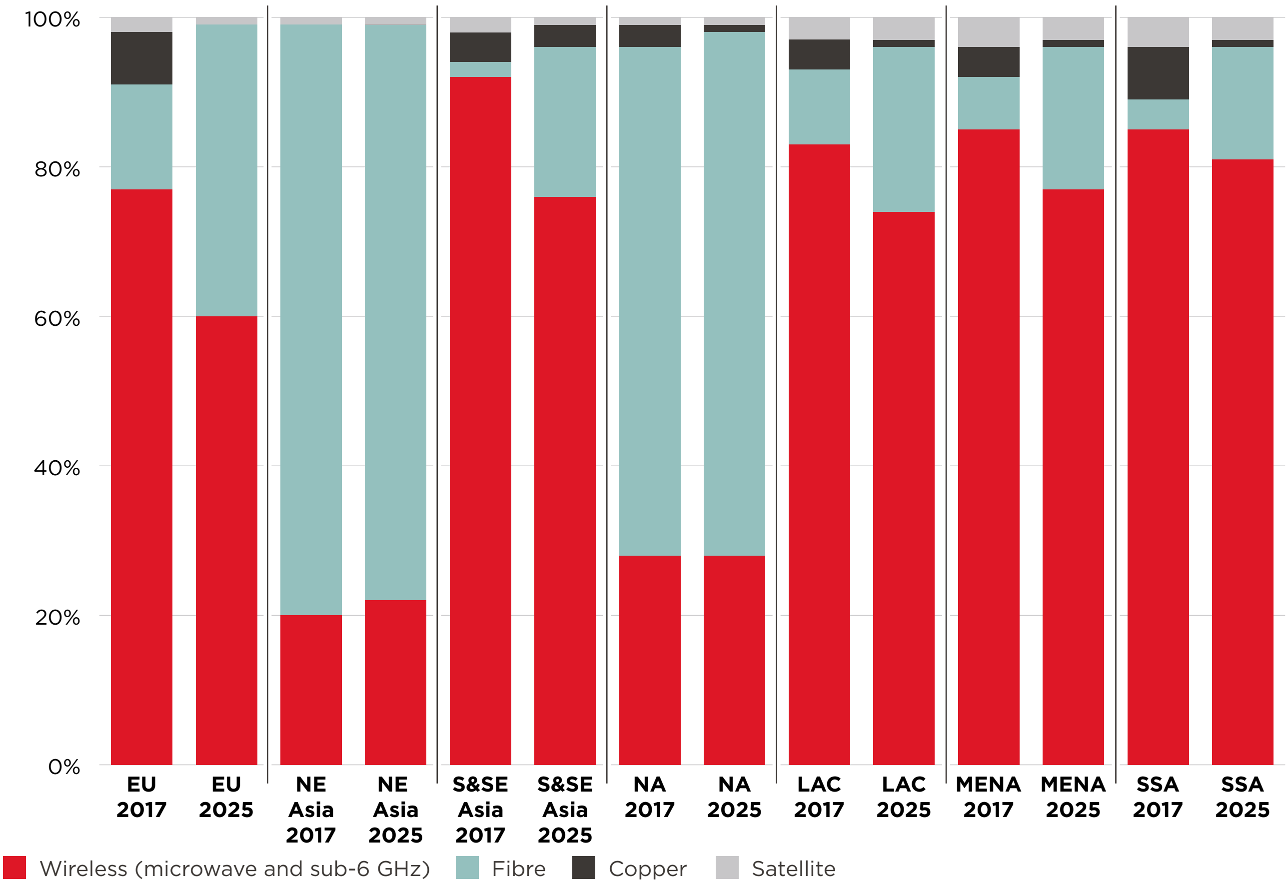
Source: GSMA

1.2 Backhaul technologies

Operators usually select a suitable backhaul technology, or a combination of them, based on several factors, including capacity, reliability, cost, and time to deploy. From a technological point of view, a mobile backhaul network can be based on wireless (microwave) solutions, fibre, copper or satellite. Globally, wireless and fibre-based solutions account for most mobile backhaul links, with significant regional variations, while satellite continues to offer a niche alternative for certain use cases (Figure 2).

Figure 2

Global (macrocell and small cell) backhaul landscape



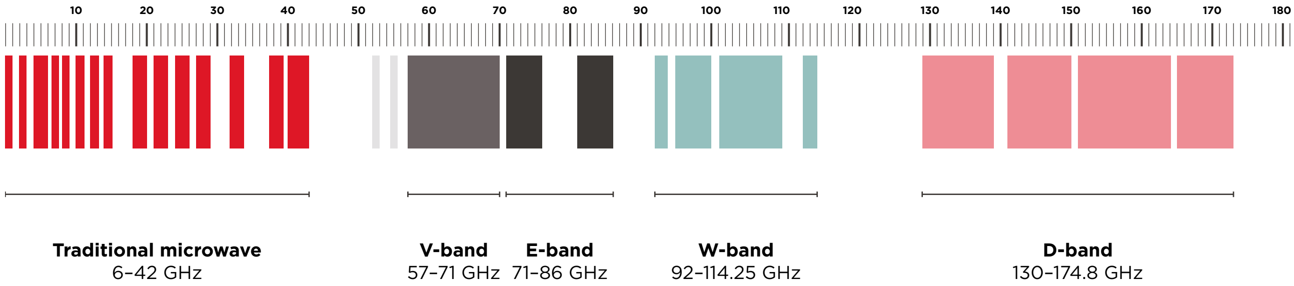
Source: ABI Research

Wireless backhaul

Wireless backhaul uses radio or microwave frequencies to transmit signals between points on a network. Globally, wireless backhaul in the traditional range (7–40 GHz) accounted for nearly 57% of macrocell backhaul links in 2017, although sub-6 GHz licensed and unlicensed have been used in some markets.

Figure 3

Wide channel bandwidth



Provides a good mix of capacity and coverage for mobile backhaul and accounts for the majority of wireless backhaul links

Well-suited to support 4G and 5G networks due to their wide channel bandwidths, allowing 10–25 Gbps data throughput

Significant potential based on availability and capacity, but less mature compared to other bands

Source: GSMA Intelligence, ITU

Fibre backhaul

The performance requirements of 5G has put fibre backhaul under the spotlight, as demonstrated by a growing trend towards fibre densification. Fibre backhaul was used for 26% of global macrocell backhaul links in 2017, but this is expected to rise to just under 40% by 2025. Although deployment costs continue to fall as techniques such as micro-trenching have become best practice, fibre backhaul remains a highly capex-intensive solution. This partly explains the wide variation in fibre density across different countries and regions. Overall, fibre availability tends to be lowest in low-income regions, sparsely populated areas and challenging terrains such as mountainous areas and deserts.

Copper

Copper was the dominant backhaul technology in the 2G and 3G eras, primarily as a bonded digital subscriber line (DSL) solution. In the last decade, however, copper backhaul solutions have become less common as operators turned to fibre and wireless technologies to handle the increasing volumes of traffic generated by mobile networks. This reflects the inherent weakness of copper backhaul: limited capacity over long distances (100+ Mbps can only be guaranteed up to 500 metres) and the inability to scale in a cost-efficient manner.

DSL technologies, such as ADSL2+ and VDSL2, can improve copper bandwidth. However, copper backhaul still requires operators to dig trenches, which is a timely and costly exercise. When operators are required to roll out new fixed networks, it therefore makes more sense to deploy fibre. The one place where copper remains a vital piece of the backhaul landscape is in large public venues. Many of these already have in-building copper networks, which can be leveraged as a backhaul solution for indoor small cell deployments.

Satellite

Satellite continues to serve as a niche alternative (1.9% of backhaul worldwide in 2017[2]) for situations where wireless and fibre-based wireline backhaul solutions are not feasible, such as remote rural areas, or as a temporary solution following natural disasters. The technology can also deliver speeds of 150 Mbps downlink and 10 Mbps uplink, making it suitable for a variety of applications. However, there is a round trip delay of 500–600 ms for a geostationary satellite, making it less suitable for real-time communications applications.

The trend towards low Earth orbit (LEO) constellations moves the satellite industry a step closer to bridging the performance gap to other backhaul technologies. LEO constellations are lower-altitude, higher-density networks that can achieve faster speeds and lower latencies, increasing the value of satellite as a mobile backhaul solution. Despite these improvements, latency will remain a barrier to the widespread use of satellite backhaul for 5G applications. Further, LEO constellations remain commercially untested and it is uncertain when they will provide a credible alternative. Financial difficulties encountered by satellite firm OneWeb in March 2020 underscore the uncertainty around the viability of satellite solutions, at least in the short to medium term.

2 Mobile backhaul options, GSMA, 2018

1.3 Wireless versus fibre

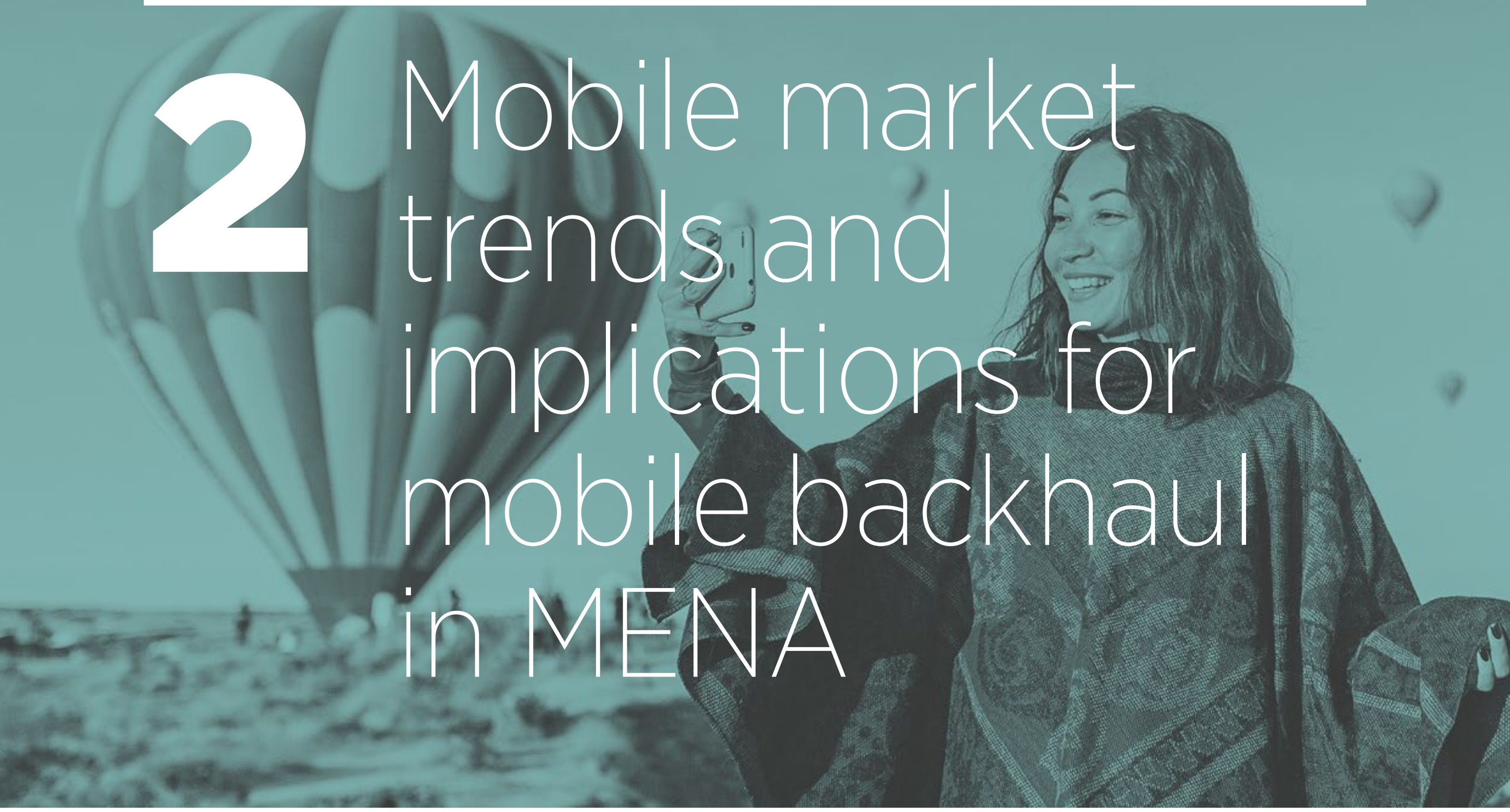
It can be assumed that wireless and fibre technologies will be the two dominant backhaul solutions for future mobile networks, based on ongoing investments and innovations in both technologies. Figure 4 highlights the main areas where wireless and fibre backhaul solutions have noticeably contrasting features. See section 3 for more details.

Figure 4

Key differences between wireless and fibre backhaul solutions

Factor	Wireless	Fibre
Cost	Low initial deployment costs and modest recurring expenses, such as spectrum fees	High initial deployment cost, mostly driven by trenching requirements, but relatively low maintenance costs
Time to market	Can be installed and put into operation quickly	Trenching requirements make fibre time-consuming to deploy, along with the often lengthy processes in obtaining 'rights of way' and work permits
Reliability	Susceptible to interference and adverse weather conditions	Stable and reliable connection speeds, but vulnerable to fibre cuts and damage e.g. during civil works
Capacity	Limited capacity (~1–100 Gbps)	Very large capacity (more than 1 Tbps)
Spectrum	Relies on suitable spectrum	Not applicable
Lifespan	~10 years	~20–30 years
Monetisation	No avenues	Possible by selling dark fibre

Source: GSMA Intelligence



2 Mobile market trends and implications for mobile backhaul in MENA

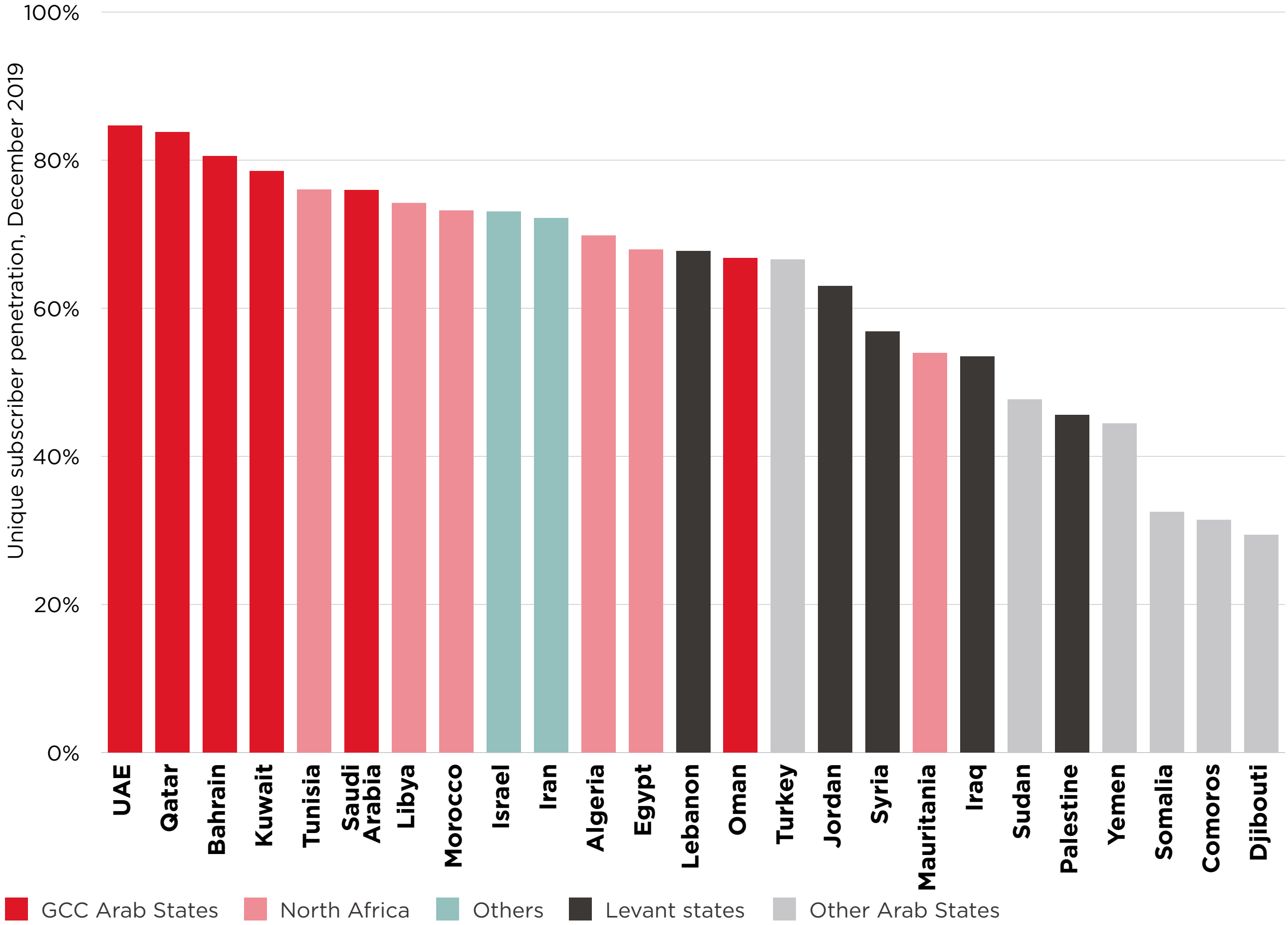
MENA is a diverse region in terms of mobile market maturity and overall telecoms infrastructure development. This is also true for 5G deployment: mobile operators in the GCC Arab States are among the global leaders in 5G commercialisation, but the technology is still many years away in frontier markets in the region. That said, the region as a whole continues its transition away from 2G-centric services to higher-speed mobile broadband services.

2.1 A diverse connectivity landscape

Ten countries in the region now have unique subscriber penetration rates of more than 70%, compared to the global average rate of 66%. However, there still remains a significant connectivity gap in several countries in the region, six of which have unique subscriber penetration rates of less than 50%.

Figure 5

MENA hosts some of the most penetrated mobile markets in the world



Source: GSMA Intelligence

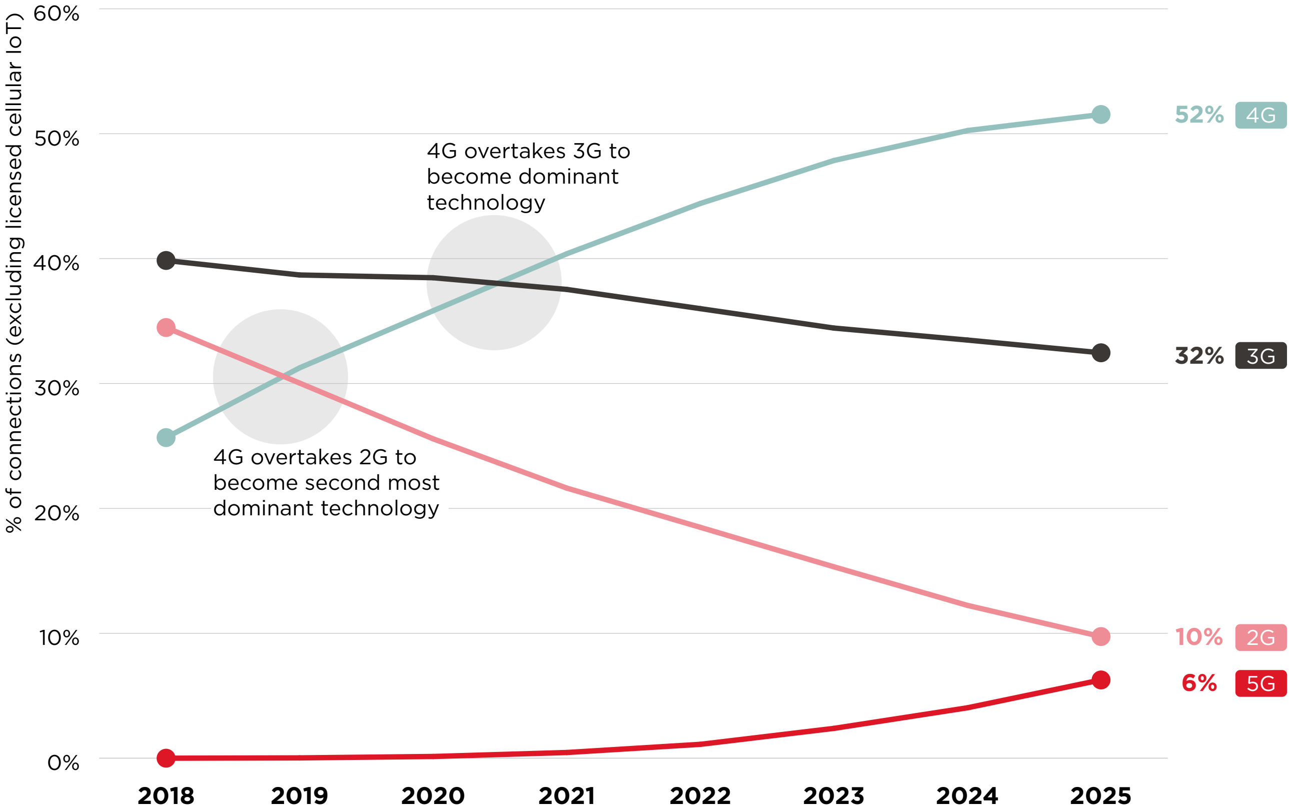
2.2 4G soon to become the dominant technology

Across the region, mobile users are increasingly migrating to mobile broadband services, which have become the primary form of internet connectivity given the underdevelopment of fixed broadband infrastructure networks in many countries in the region.

This is driving a rapid acceleration in mobile data consumption. Among all regions, MENA is expected to record one of the highest growth rates in mobile data traffic between 2019 and 2025, with total mobile data traffic increasing by a factor of almost nine and average data per smartphone expected to reach 23 GB per user per month in 2025.[3]

Figure 6

By 2021, 4G will become dominant technology for the foreseeable future



Source: GSMA Intelligence

3 Ericsson Mobility Report, June 2020

2.3 The 5G era has begun

By the end of 2019, commercial 5G services had been launched in five markets in MENA; a further 11 markets are expected to follow suit between 2020 and 2025.

Figure 7

First wave of commercial 5G launches underway in MENA

2019	2020	2021-2024
Bahrain	Oman	Algeria
Kuwait		Egypt
Qatar		Iraq
Saudi Arabia		Israel
UAE,		Jordan
		Lebanon
		Morocco
		Sudan
		Tunisia
		Turkey

Source: Operator announcements, GSMA Intelligence forecasts based on previous tech migrations

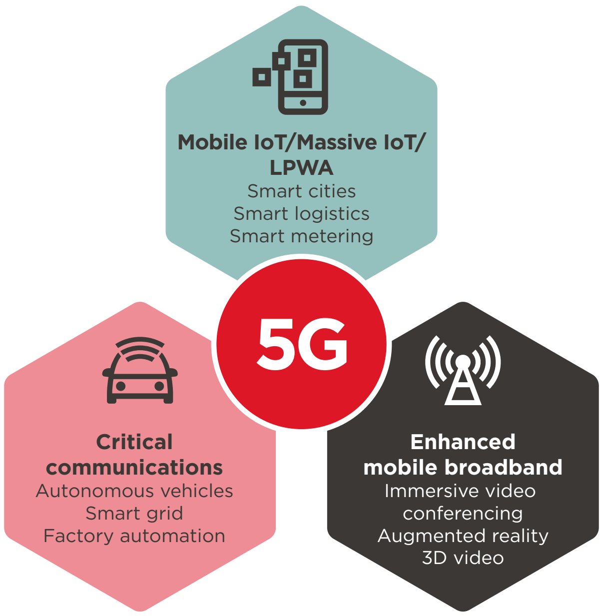
2.4 5G will enable digital transformation across MENA

5G will be critical for the development of smart cities and will support the digital transformation agenda of governments across the region. Bahrain, Egypt, Jordan, Oman, Qatar, Saudi Arabia and the UAE are among countries that are implementing ambitious smart city and digital transformation initiatives to improve the quality of life in fast-growing urban areas, address environmental concerns and maximise the utilisation of scarce resources. These initiatives will rely heavily on the enhanced connectivity that 5G can provide, as well as its potential to enable the application of AI, massive IoT and other transformative technologies for key verticals and public services.

5G will also create opportunities for new consumer and enterprise services. There is already a growing emphasis on immersive services, such as cloud gaming and AR/VR, among operators in the region. In April 2019, Etisalat launched a cloud-gaming service, which could benefit from 5G capabilities such as low latency and high-speed connectivity. In March 2020, STC launched a 5G smart campus to facilitate the development of use cases and service standards for enterprises in different verticals, including energy, education, health and mining.

Figure 8

Key 5G capabilities will enable a variety of enterprise and consumer services



Source: GSMA Intelligence

Edge computing will play a key role in the implementation of new 5G use cases by providing developers an environment to create new 5G applications for enterprises (e.g. mission-critical IoT and flexible manufacturing) and consumers (e.g. cloud gaming and AR/VR). In MENA, Etisalat announced the first major partnership with a public cloud company in February 2020 – a deal with Microsoft to underpin future 5G services and facilitate the evolution of its public-cloud-first strategy. Etisalat plans to build a digital platform on Azure that is capable of incorporating technologies such as automation and AI and that can enable new types of applications related to smart cities, autonomous systems, gaming, AR/VR, IoT, and vision-computing solutions over its 5G network.

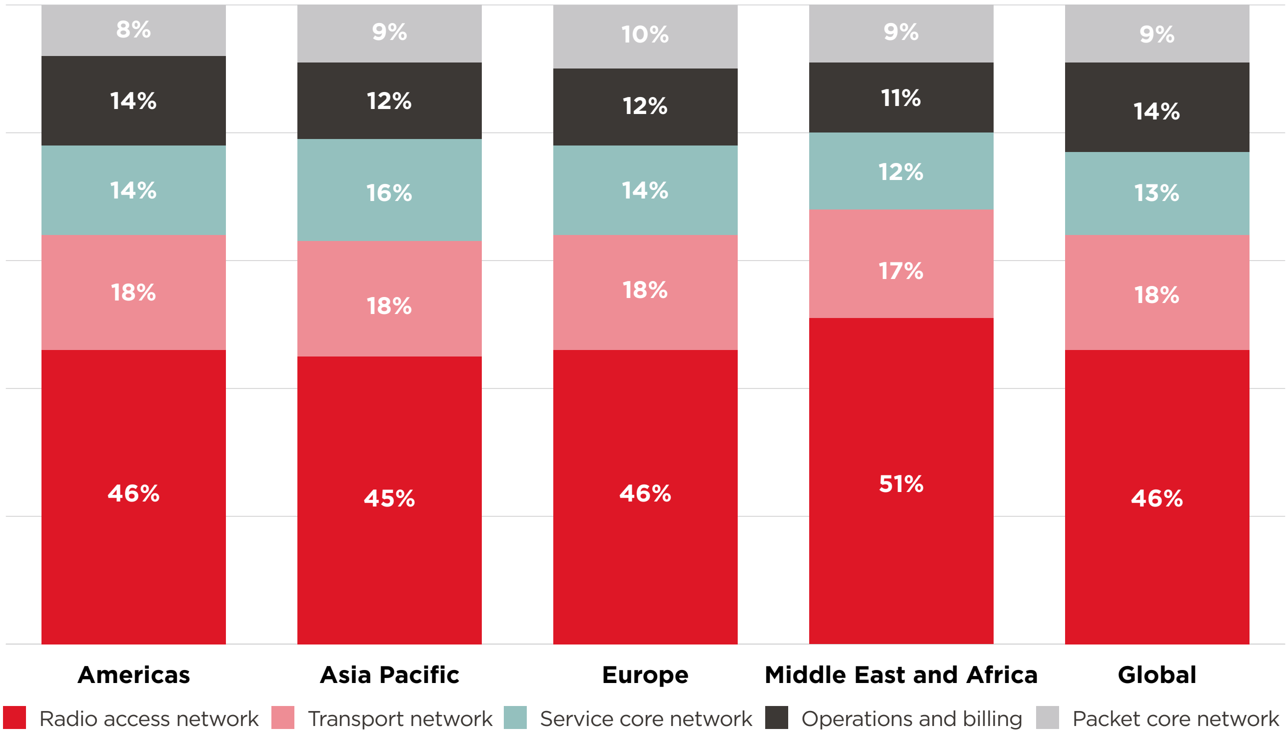
2.5 Implications for mobile backhaul investment

According to a GSMA Intelligence survey,[4] mobile backhaul is the second biggest driver of network costs, behind only the access network, with mobile operators in the Middle East and Africa expecting to spend on average 17% of their total network costs on backhaul in 2020 (Figure 9). While mobile backhaul costs as a proportion of total network spend are relatively consistent across regions, actual spend on mobile backhaul varies significantly depending on the solution chosen by the operator.

Figure 9

RAN dominates spend, but backhaul should not be overlooked

In the next 12 months, what share of your network spend do you expect to support the following?



Source: GSMA Intelligence Network Transformation Survey 2019

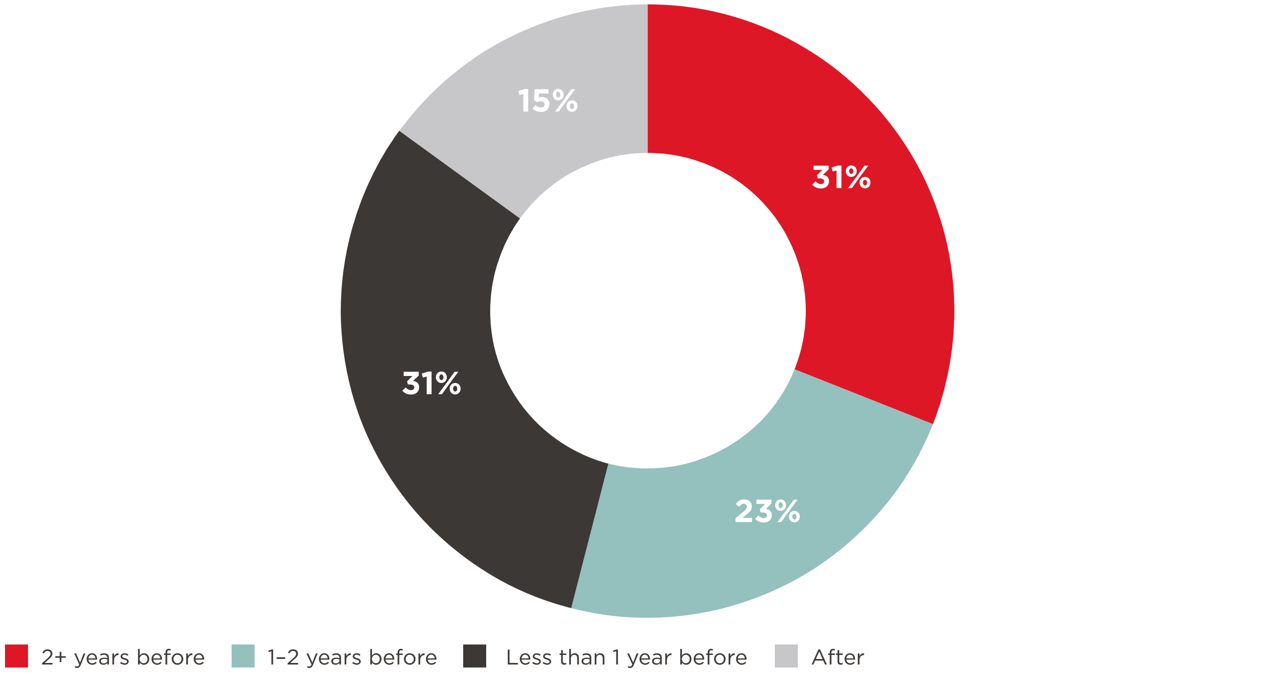
The proportion of investments in mobile backhaul is not surprising: the capacity, densification and latency requirements of 5G will rely on adequate and efficient transport infrastructure to connect the more advanced 5G core network and cell sites. Investment in backhaul networks will be an early driver of 5G capex in MENA, which is set to accelerate over the period to 2025 as pioneer markets extend coverage and commercial launches get underway in other markets in the region. In many cases, enhancements to the transport network will precede access network upgrades as operators lay the foundations for the transition to 5G.

4 Network Transformation 2020, GSMA Intelligence, 2019

Figure 10

5G puts backhaul upgrade on the front burner

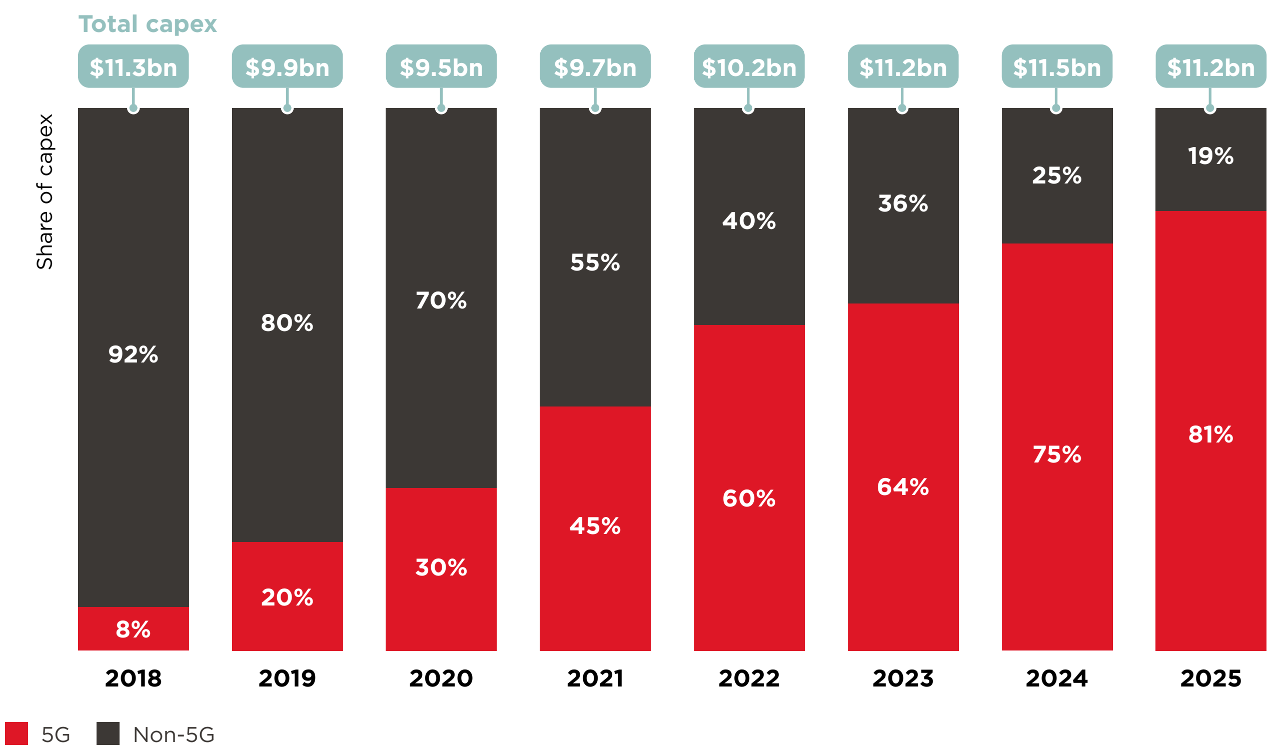
What is your company's timeline for building or upgrading its backhaul network to support 5G rollout? (% of respondents)



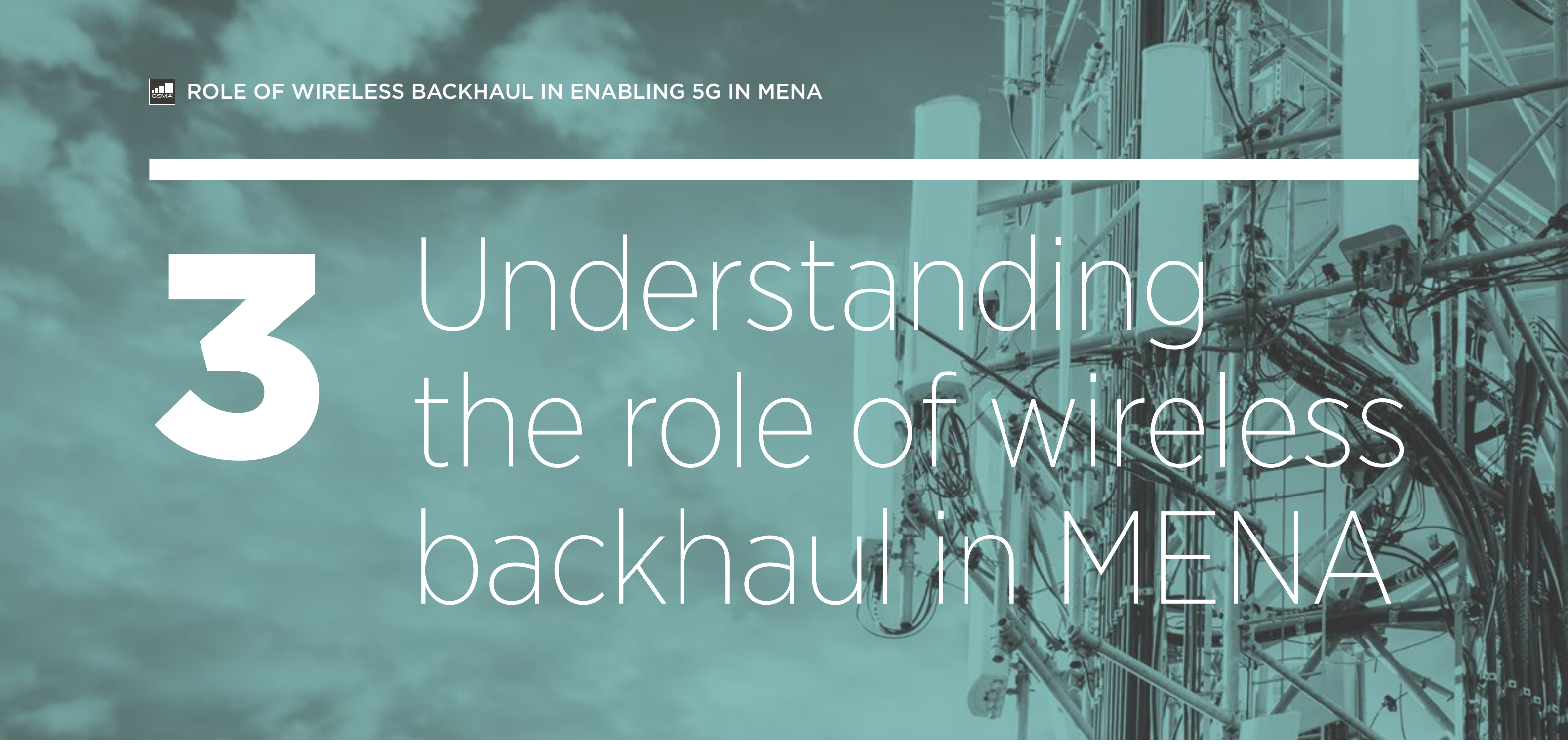
Source: GSMA Intelligence Mobile Backhaul in MENA Survey 2020

Figure 11

Capex in MENA: backhaul investment to drive growth in 5G capex over the period to 2025



Source: GSMA Intelligence



3 Understanding the role of wireless backhaul in MENA

Wireless backhaul is integral to mobile services in MENA, accounting for more than 80% of the overall mobile backhaul infrastructure, on average. This figure is considerably higher in countries with limited fixed network infrastructure coverage. The increasing demand for data connectivity and ongoing transition to 5G highlight the need for adequate and efficient transport infrastructure. A key question then is how the role of wireless backhaul solutions will evolve in the MENA mobile network landscape.

A survey of mobile operators and other ecosystem players conducted by GSMA Intelligence provides some crucial insights on the current and future role of wireless backhaul solutions in the MENA mobile backhaul landscape. These are highlighted below.

3.1 Wireless backhaul will remain a key part of the mobile backhaul landscape despite the growing shift to fibre

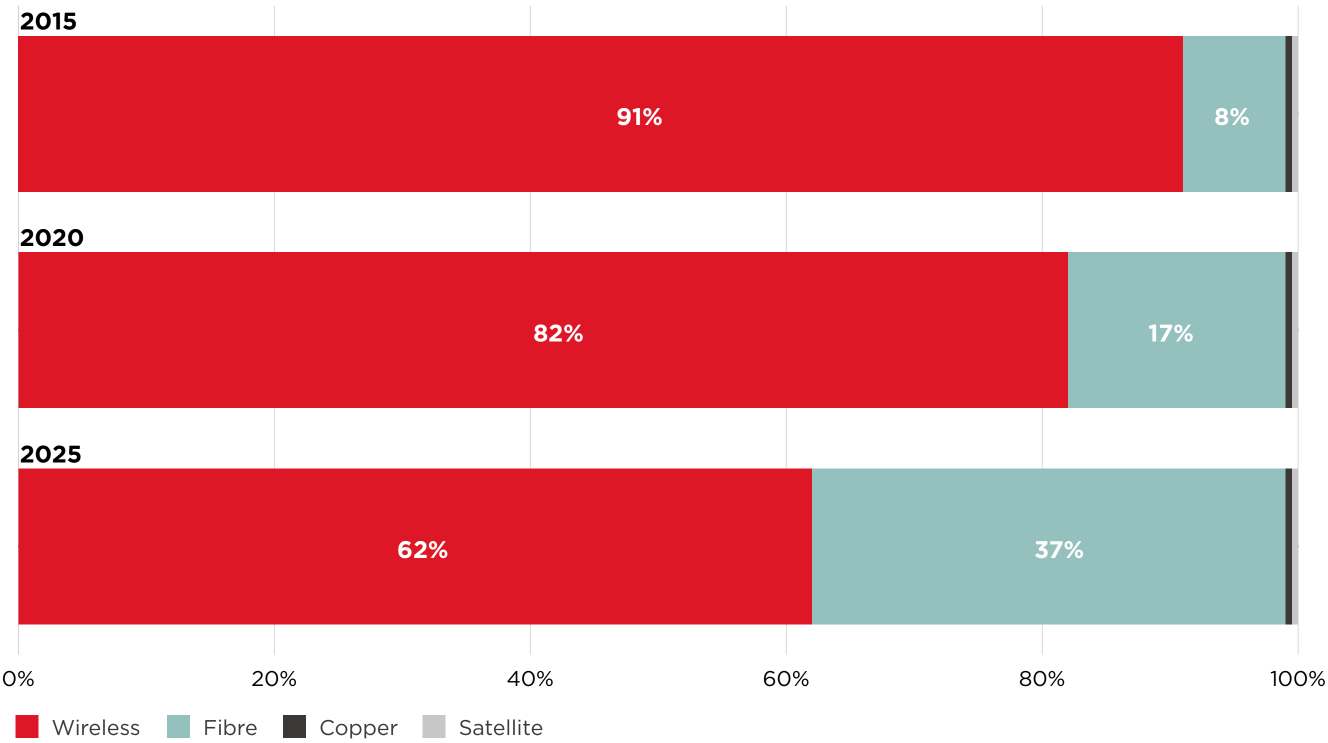
There is a growing emphasis on the deployment of more fibre infrastructure for network densification, given its ability to support increased capacity for 5G.

Respondents to our survey expect the share of fibre backhaul to jump from 8% to 37% between 2015 and 2025. However, wireless backhaul is expected to remain the dominant technology in the region, accounting for more than three fifths of mobile backhaul infrastructure, on average, by 2025.

Figure 12

By 2025 more than 60% of cell sites will still be connected to wireless backhaul

What proportion of cell sites in your network are connected by each of the main backhaul technologies? (% of respondents)



Source: GSMA Intelligence Mobile Backhaul in MENA Survey 2020

Wireless backhaul can be installed and put into operation much faster and more affordably than fibre (which requires trenching), making it a viable alternative for densifying network capacity in situations where fibre backhaul is too expensive or not feasible. This is especially true for deployment in rural communities and regions with challenging topography, such as mountainous areas and deserts. For many operators, time and cost to deploy will be key considerations in their efforts to alleviate the growing pressure on network capacity and the transition to 5G.

3.2 Wireless backhaul investments will remain stable in the medium term

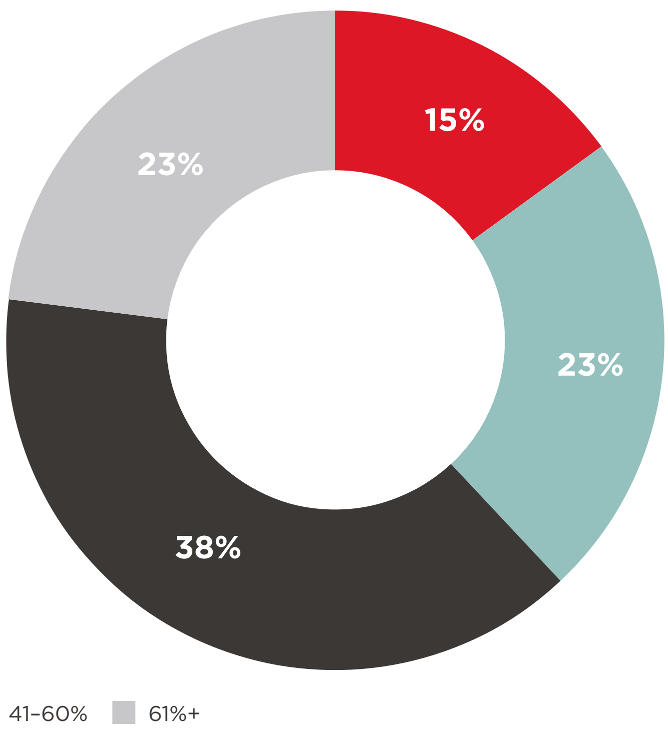
Mobile operators expect spectrum costs and equipment upgrades to be the main drivers of wireless backhaul expenditure over the next five years.

There is a shift towards multi-band antennas that can support two spectrum bands using the same piece of equipment, as opposed to dedicated antennas for each spectrum band. This allows operators to use fewer pieces of network equipment, resulting in both capex and opex savings, as well as more efficient use of cell tower real estate.

Figure 13

Majority of operators plan to spend above 40% of overall mobile backhaul budget on wireless solutions

With regard to your company, what proportion of investments will go into wireless backhaul versus other backhaul technologies in the next five years? (% of respondents)



Source: GSMA Intelligence Mobile Backhaul in MENA Survey 2020

3.3 Capacity is the primary consideration for operators in mobile backhaul planning

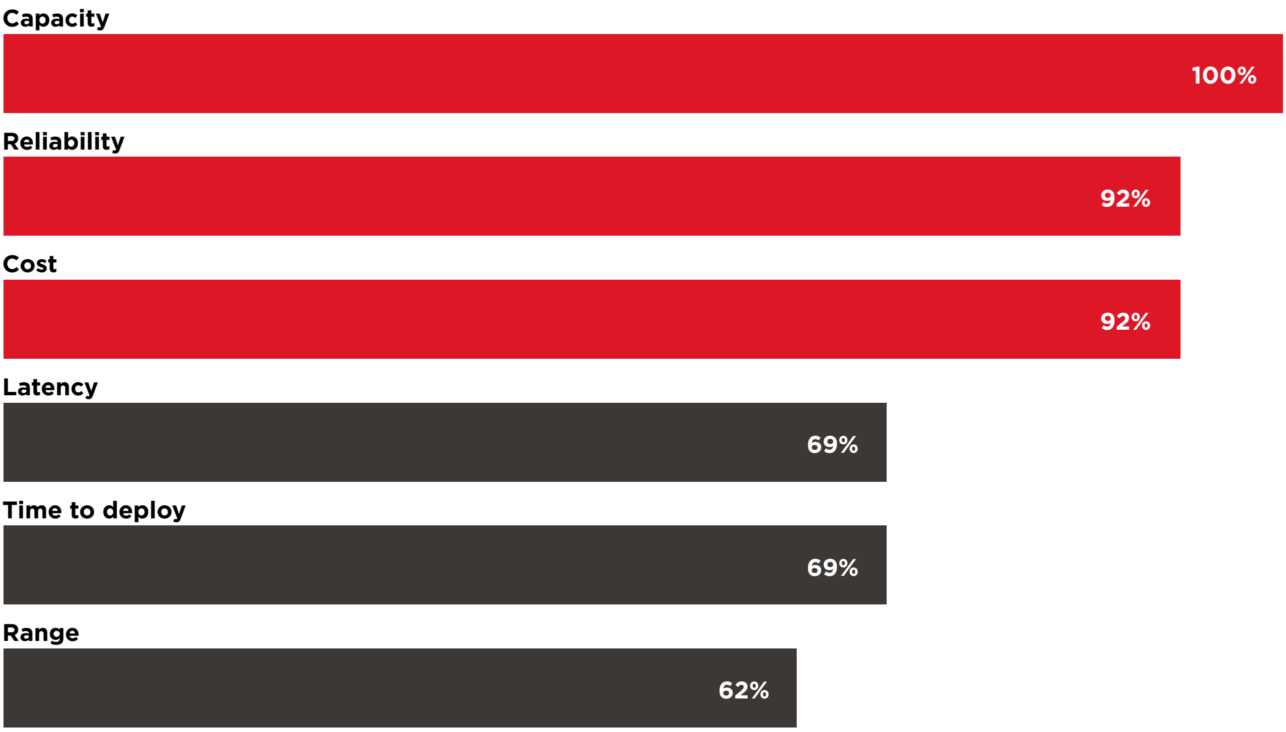
Meeting the capacity requirements of 5G is the most important consideration for operators in selecting backhaul technology, with high-capacity backhaul (10 Gbps and above) required to support an increasing number of cell sites. Capacity is the primary rationale for fibre densification for operators in MENA, along with reliability since network interference is less of an issue. However, these benefits are counterbalanced by the total cost of ownership, which remains an important consideration.

As a result, operators see wireless and fibre backhaul playing complementary roles in the backhaul landscape. Fibre will be mostly deployed to carry data traffic in core and inter-city aggregation networks, while wireless backhaul will support last-mile access in urban and dense urban areas, as well as last-mile access and aggregation in suburban and rural areas, where the capacity demands are reduced.

Figure 14

Capacity is an important consideration for operators in backhaul planning

On a scale of 1 (not important at all) to 5 (very important), how important are the following factors when selecting backhaul technology?



Source: GSMA Intelligence Mobile Backhaul in MENA Survey 2020

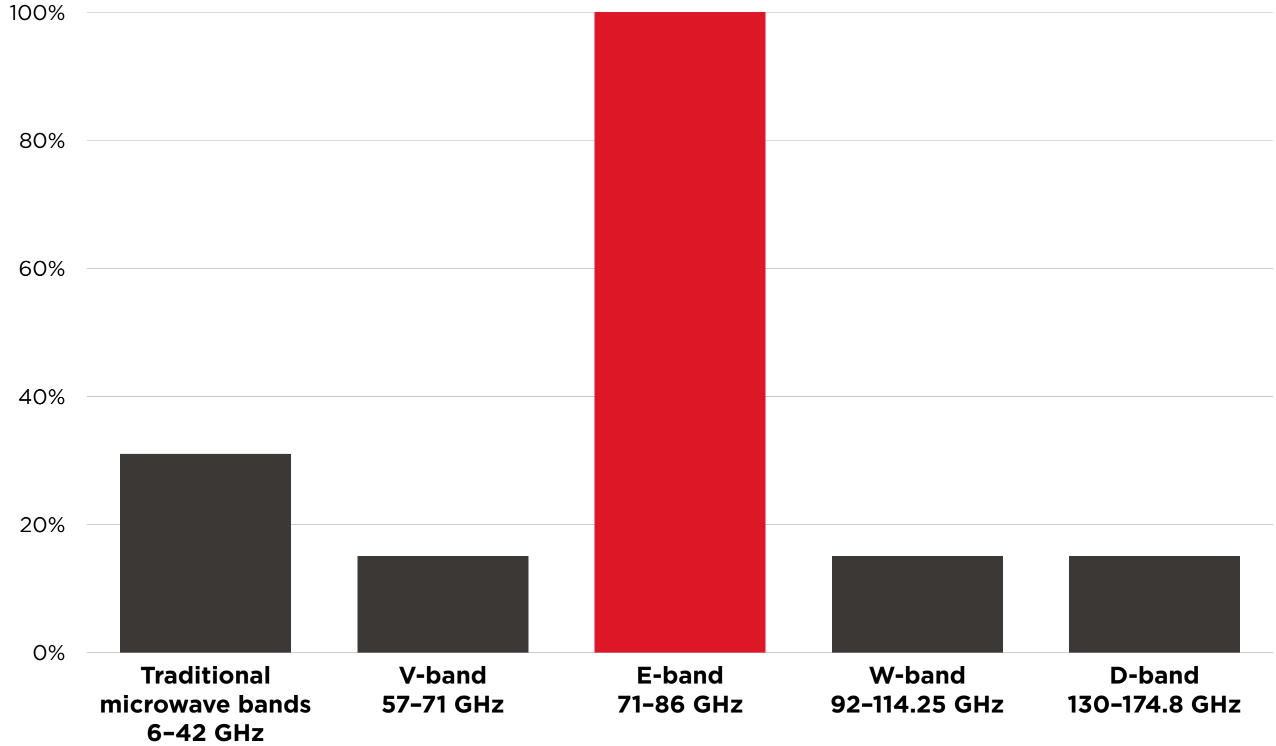
3.4 E-band holds promise to meet capacity requirements over wireless backhaul

Beyond the traditional spectrum ranges for wireless backhaul, operators expect E-band spectrum (71–86 GHz) to be vital for wireless backhaul deployments. Although E-band solutions have been around since the start of the LTE era, the technology only reached maturity in recent years and is now growing in popularity. Beyond the E-band, the W-band (92–114.25 GHz) and D-band (130–174.8 GHz) could also have long-term potential to address the capacity requirements for 5G.

Figure 15

E-band will play a vital role in wireless backhaul deployments

Which frequency bands will become more important for wireless backhaul in your market in the future? (% of respondents)



Source: GSMA Intelligence Mobile Backhaul in MENA Survey 2020

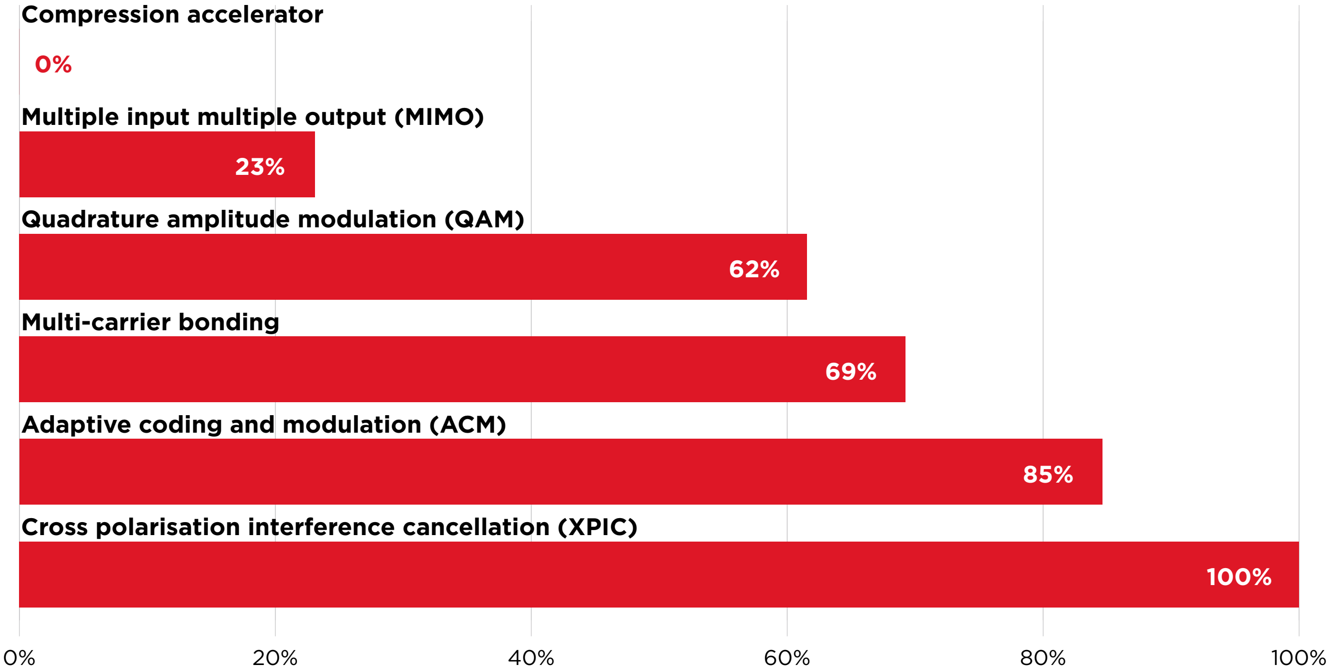
3.5 Operators are exploring technical solutions to improve wireless backhaul performance

A number of technical solutions have emerged to optimise the use of spectrum and enable operators to meet the capacity requirements of 5G. Our survey shows that operators in MENA are increasingly considering some of these solutions, albeit to varying expectations of impact. The widespread consensus among respondents is that cross polarisation interference cancellation (XPIC) has the potential to deliver the most significant impact on wireless backhaul capacity.

Figure 16

Cross polarisation tops market perception for technical innovations

How important will the following innovations be when using wireless backhaul in your market? (% of respondents that classified the following innovations as high importance)



Source: GSMA Intelligence Mobile Backhaul in MENA Survey 2020

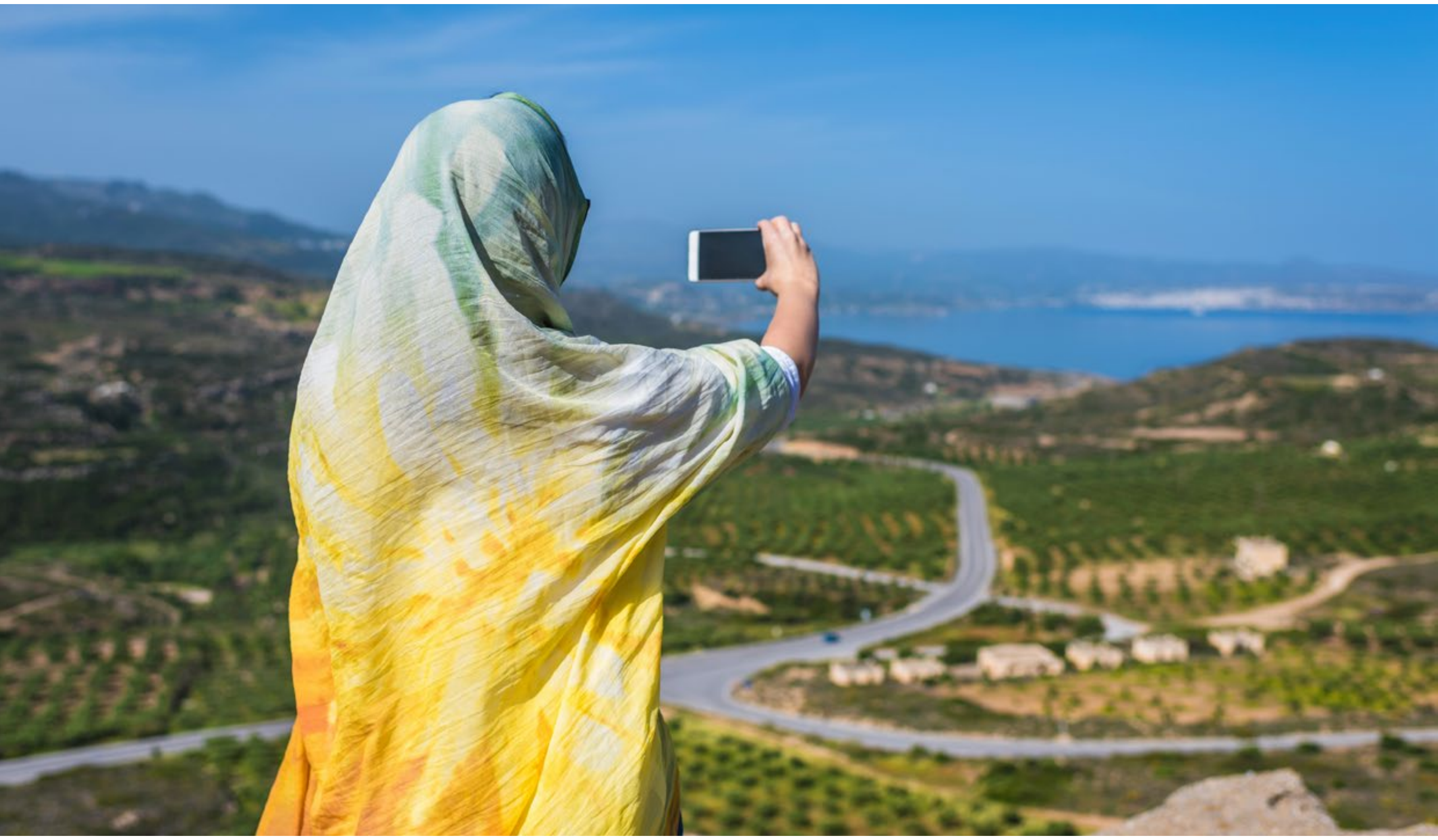
The second-most popular solution, adaptive coding and modulation (ACM), allows the use of a higher modulation scheme to achieve higher capacity and enhance link availability. Multi-carrier bonding and quadrature amplitude modulation (QAM) also increase link capacity by adding further load to existing infrastructure. Despite the general popularity of multiple input multiple output (MIMO), operators took the broad view that the complexity of deploying MIMO solutions limited the additional benefit. This view could change over time as the efficiency advantages of techniques such as MIMO and multi-carrier bonding become increasingly important with the rollout of 5G networks. Compression accelerators received the least acclaim, with operators reporting only a fractional improvement in link capacity and throughput.

Figure 17

Technical solutions to improve wireless backhaul performance

Technical solution	Main function
XPIC	Potentially doubles the capacity of a microwave link by assigning the same frequency to both the vertical and horizontal polarisation.
ACM	Helps manage the modulation, coding, and other signal and protocol parameters to the conditions on the microwave radio link to improve reliability.
Multi-carrier bonding	Combines a low-band microwave link with a high-frequency band. This brings out the best characteristics of both bands, making it possible to boost capacity and improve reliability.
QAM	Enables an analogue signal to efficiently transmit digital information. 1024QAMs are becoming common in microwave links.
MIMO	Allows the use of multiple antennas at both the transmitter and receiver to improve communication performance.
Compression accelerator	Reduces the volume of traffic on the microwave link by compressing and de-duplicating the data payload.

Source: GSMA Intelligence



3.6 Key considerations on wireless backhaul by MENA operators

In practical terms, operators see significant opportunities for wireless backhaul solutions to facilitate cost-effective and timely 5G deployment. The technology is vital for initial 5G deployments, as it will help operators to commercialise 5G more quickly. In Saudi Arabia, one of MENA's pioneer 5G markets, wireless backhaul has played a critical role in enabling operators to launch commercial 5G services at a greater scale than if they had relied entirely on fibre backhaul.

However, there are also limitations that need to be addressed in order to maximise the potential of wireless backhaul and support efficient deployment of the technology. Figure 18 highlights the main advantages and disadvantages of wireless backhaul, as identified by operators in the region.

Figure 18

Main benefits and challenges of wireless backhaul

Benefits	Challenges
Time to deploy – Wireless backhaul has a time advantage over fibre backhaul since it requires less civil work and fewer formal permits for rights of way. This means it can accelerate 5G network deployment, especially in areas with limited or no existing fixed network infrastructure.	**Capacity** – Multi-band systems enable high-capacity wireless backhaul over distances of up to 7 km. Beyond this, wireless backhaul solutions rely on traditional microwave spectrum, which is only capable of handling single-gigabit traffic (or up to 4 Gbps with carrier aggregation).
Cost – Generally, wireless backhaul has a low capex requirement for initial deployment. Given the cell densification requirement for 5G, there is consensus among operators that wireless backhaul is a cost-effective alternative for mobile backhaul, especially for last-mile cells with lower capacity needs. In some cases, the E-band has been used for short distance links in urban areas.	**Spectral attenuation** – The shift to higher-frequency spectrum for wireless backhaul potentially hinders the ability of operators to meet enhanced reliability requirements of 5G. While frequencies below 13 GHz are largely unaffected by environmental conditions, higher-frequency spectrum has weaker propagation characteristics and is more susceptible to atmospheric effects and rain fade.
Practicality – Wireless backhaul can be used in areas where fibre is not viable or possible e.g. in difficult terrains or locations with restrictions on trenching. Additionally, wireless backhaul equipment can be reused in other sites in case of a site replacement/removal.	**Risk of interference** – Wireless backhaul can be prone to interference between cell sites using the same spectrum bands. This could become increasingly problematic as operators densify mobile networks, which puts cell sites in closer proximity.
Remote coverage – Wireless backhaul enables coverage in remote areas where the economics of fibre deployment can be challenging.	**Latency** – Some 5G use cases require sub-10 ms end-to-end latency, which implies a latency of less than 2 ms across the backhaul network. Depending on the spectrum frequency and network design, this is not always possible with wireless backhaul.
Network redundancy – Even where fibre backhaul is available, wireless backhaul can be used as a backup solution to ensure continuous service in cases of fibre cuts.	**Security** – While traffic can be encrypted by AES (advanced encryption standard), the inherent nature of the transmission medium means wireless backhaul is vulnerable and exposed to more security threats and attacks than wired connections.

Source: GSMA Intelligence

4 Realising the potential of wireless backhaul

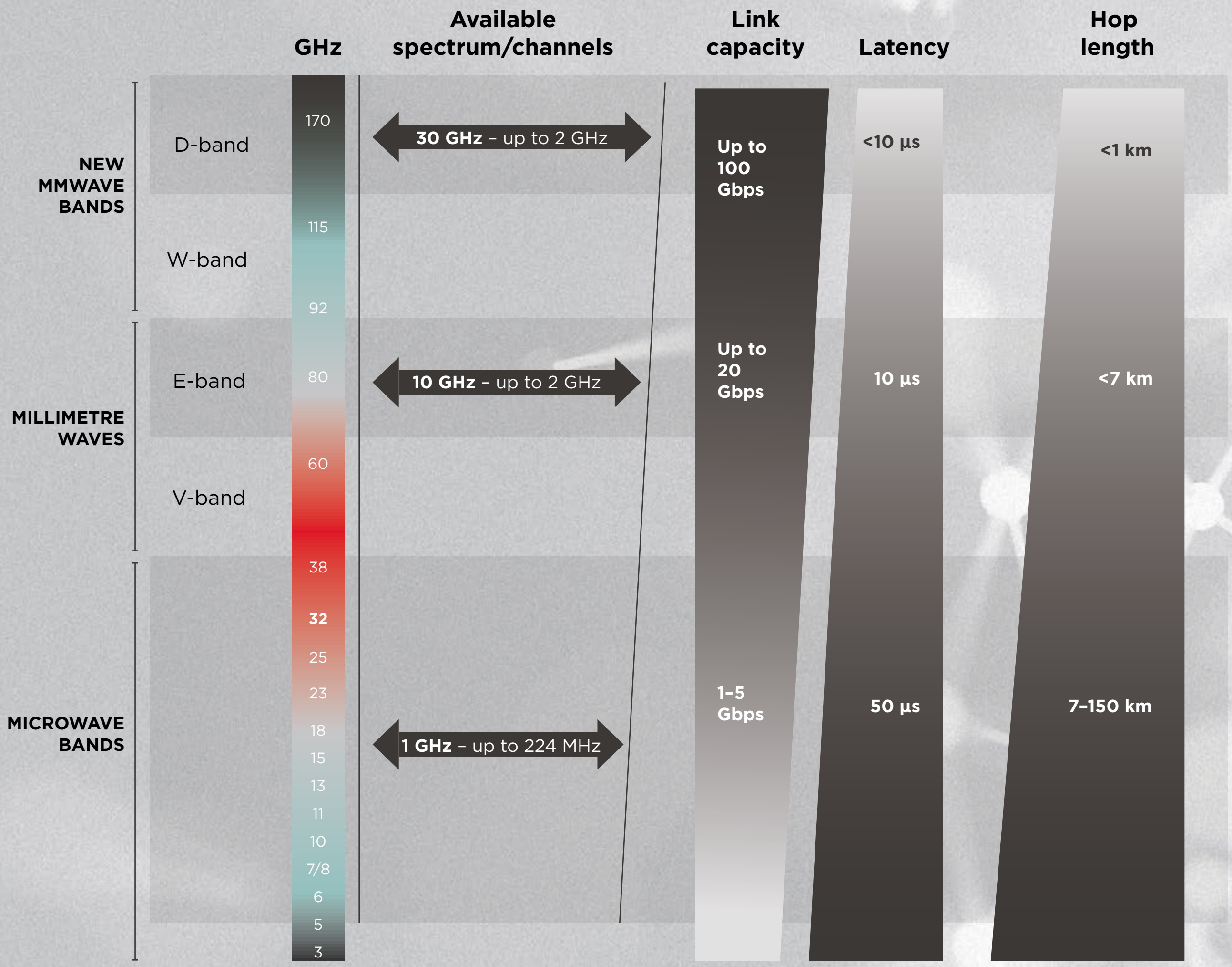
Wireless backhaul is the dominant type of mobile backhaul in MENA today and will remain so for years to come.

Against this backdrop, it is evident that the technology will play a vital role in the transition to 5G and, by extension, support the various digital transformation initiatives of governments across the region. This underscores the need for key stakeholders to address the challenges around wireless backhaul in order to enable the efficient deployment of solutions and ensure sustainable levels of investment in the wider ecosystem.

At a high level, spectrum is at the heart of any wireless network. In particular, spectrum is essential to improving the capacity and performance of wireless backhaul solutions. There is therefore a need for spectrum to be made available at the right conditions – quantity, frequency band and pricing – to enable the efficient deployment of wireless backhaul infrastructure.

Figure 19

Spectrum frequency, capacity and availability



Source: Nokia

4.1 Need for new spectrum bands

Traditionally, the microwave band (6–42 GHz) has been used for wireless backhaul. However, it will play a more limited role in the 5G era because of increasing saturation, capacity constraints and the refarming of some bands (such as the 26 GHz and 28 GHz bands for 5G new radio (NR)).

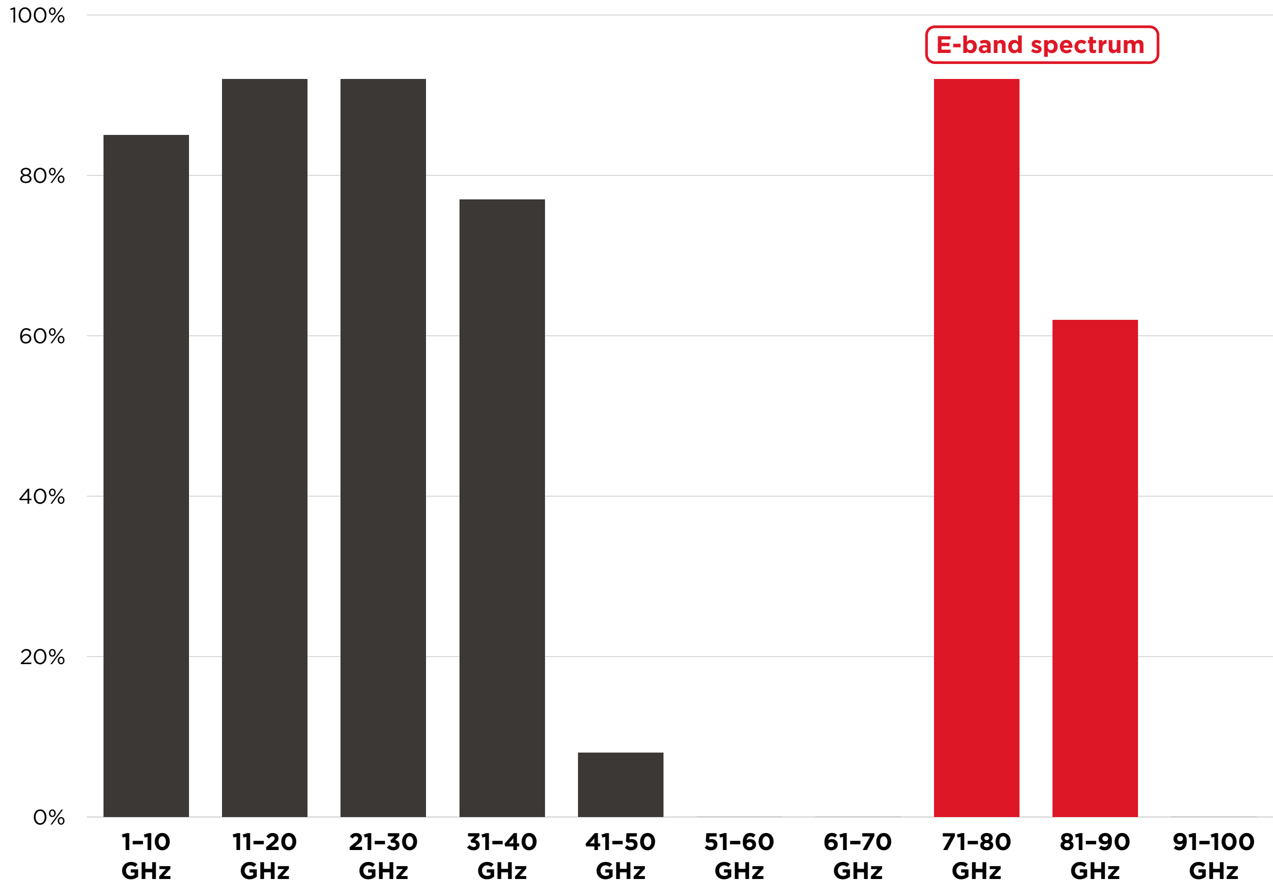
Meanwhile, the sub-6 GHz frequency bands – whose non-line-of-sight (NLoS) properties enable backhaul solutions to work regardless of whether both ends of a link are visible to each other – are increasingly being prioritised for terrestrial mobile services, thereby also limiting their role in future wireless backhaul solutions.

Consequently, there is a growing need for new spectrum bands for wireless backhaul. The natural evolution is towards higher bands, with wider bandwidth and capacity to support higher data throughput in the 5G era. The use of E-band spectrum (71–86 GHz) for wireless backhaul has grown rapidly in recent years, driven by its ultra-high capacity and, in some cases, by enabling regulation around licence fees.

Figure 20

More than 90% of operators in MENA have begun to deploy E-band solutions

Which frequency bands do you use for current wireless backhaul deployments? (% of respondents)



Source: GSMA Intelligence Mobile Backhaul in MENA Survey 2020

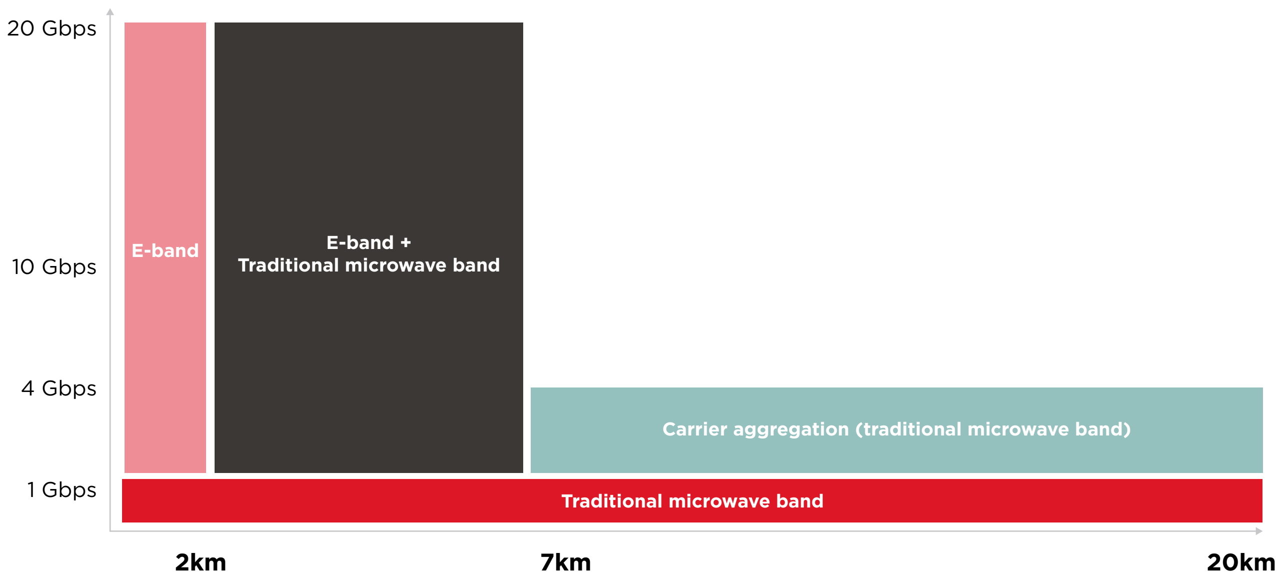
4.2 The E-band is essential for wireless backhaul

As a result of its very large bandwidth (10 GHz), the E-band enables ultra-high capacity backhaul applications over a range up to 3 km. The wide channel sizes on E-band spectrum will be crucial to meeting capacity requirements of cell sites in traffic hot spots, such as busy shopping centres and airports. Its narrow beams have the potential to reduce interference between links and enable dense site deployment.

The E-band is also well suited to small cell deployments, in particular for short link distances, allowing data throughputs of 10–25 Gbps, while multi-band systems, such as band and carrier aggregation, make it possible to use E-band spectrum in conjunction with traditional lower-frequency bands to provide higher capacity and longer links (see Figure 21).

Figure 21

Multi-band systems address the propagation limitations of E-band wireless backhaul



Source: GSMA Intelligence

Deployment of E-band spectrum is set to accelerate in the coming years as operators increase efforts to densify their networks for 5G and meet the high-capacity demands of mobile networks in general. However, to realise the full potential of the E-band, there needs to be a supportive regulatory framework around licensing and fees for the spectrum band.

Spectrum licensing: making backhaul economically sustainable

Spectrum for wireless backhaul is available under a variety of licensing mechanisms, as shown in Figure 22.

Figure 22

Key features of the main spectrum licensing mechanisms

Strengths | Weaknesses | Opportunities | Threats

PER-LINK LICENCE

- Effective for PTP backhaul connections
- Spectrum can be efficiently used
- A tried-and-tested licensing model
- Spectrum is comparatively cheap

- It is a fairly mature licensing model; some regulators and operators would like to move away from the licensing model where possible

- May have to acquire microwave link hardware with different spectrum band configurations
- Can have a heavy licensing administrative overhead

- Licences are often very short duration but usually renewed; operators cannot be 100% certain they have the spectrum for the long term

BLOCK SPECTRUM LICENCE

- Can be used for PTP links, but are particularly useful for PMP application scenarios
- Gives the operator more certainty of operation

- Could grow in use by regulators
- They would need to see that there was substantial demand for it; this would come from small cell deployments

- Licence cost can be significantly higher than per-link licensing

- Speed of license issuing can be a hassle to rollout
- Licensing fees need to be viable for mobile backhaul; operators already pay significant amounts in access spectrum licence fees

LIGHT LICENCE

- Reduces the regulatory/ administrative burden on the operator
- Licence fees can be comparatively low as the licence is not exclusive
- Still quite fast to roll out
- Some moderate guarantees against interference

- Likely to grow in use by regulators
- Operators are keen on it, especially if there is a low probability of interference

- Operator needs to take proactive measures to ensure its backhaul links do not cause interference to any neighbouring existing users
- If there is interference, often the two operators are required to resolve the interference issues themselves

- Unresolved interference conflicts are a possiblity, but usually the regulator can step in as a last resort

SHARED LICENCE

- Has many of the same traits as lightly licensed
- Reduces the regulatory/ administrative burden on the operator
- Licence fees can be comparatively low as the licence is not exclusive
- Still quite fast to roll out

- Regulators are investigating the potential of shared licensing

- Operator needs to take proactive measures to ensure its backhaul links do not cause interference to any neighbouring existing users
- If there is interference, often the two operators are required to resolve the interference issues themselves

- Unresolved interference conflicts are a possiblity, but usually the regulator can step in as a last resort
- Operators have some concerns about quality of service

Source: GSMA Intelligence, ABI Research

The per-block method provides more certainty for operators. However, in many cases the licence cost can be significantly higher than the per-link method and the licence issuing can also take longer, thereby delaying rollouts.

The lightly licensed approach has been used in some markets, with operators paying a comparatively smaller fee for a non-exclusive licence. However, interference has to be managed by operators through link planning and using more advanced interference cancellation techniques. Regulator involvement should be a last resort. To some extent, the shared licensing method is similar to the light licensing approach, the main difference being the explicit requirement to share a block of spectrum with one or more participants.

Unlicensed spectrum can be used for backhaul, but as with any type of service run in unlicensed bands this comes with drawbacks, ultimately impacting quality of service (QoS). While unlicensed spectrum is essentially 'free' for operators and can be utilised quickly, it has technical limitations and is subject to interference, which, due to its unlicensed and therefore non-exclusive nature, can impact the reliability and predictability of the link.

While the per-link method has been the traditional way to license wireless backhaul spectrum, the per-block method has been gaining traction in recent years, especially for the higher spectrum bands (28 GHz and higher), and is increasingly being used for point-to-multipoint (PMP) links. Operators across MENA have access to wireless spectrum through a variety of licensing mechanisms (see Figure 23).

Figure 23

Backhaul licensing model by country

Licensing model	Per link	Block	Lightly licensed	Shared	Unlicensed
Bahrain	●				●
Egypt	●	●		●	
Iraq	●				●
Jordan	●		●	●	
Kuwait	●	●			
Saudi Arabia	●				
Sudan	●	●			
Syria	●	●			●
Turkey	●	●		●	●
Yemen	●				

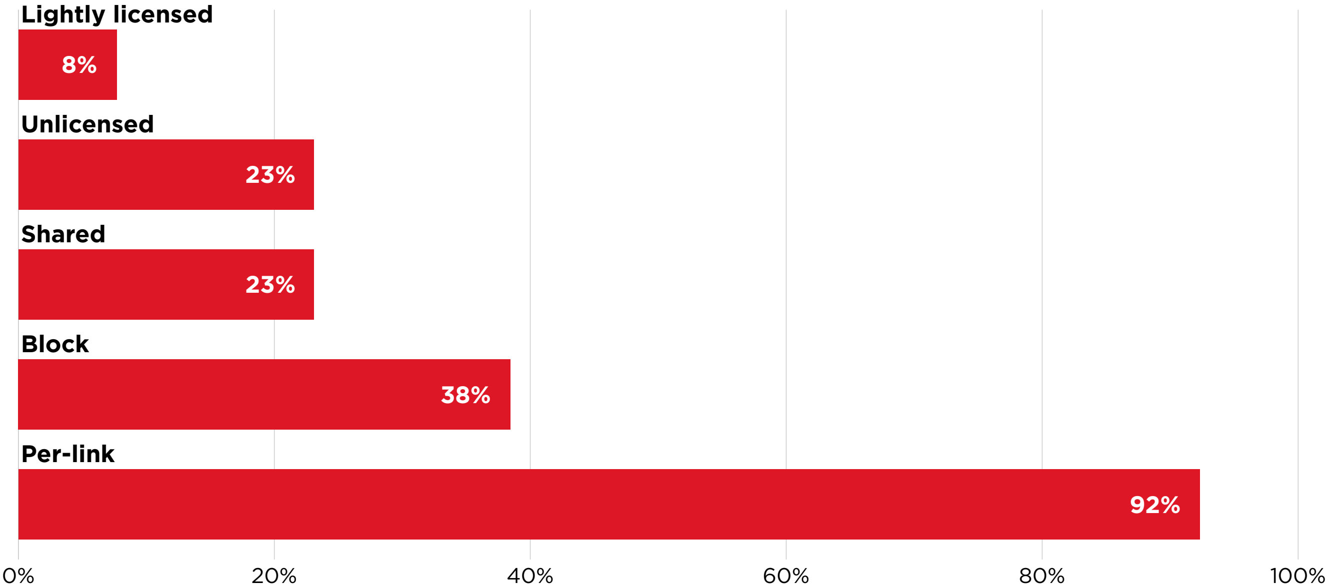
Source: GSMA Intelligence

According to our survey, the per-link method is by far the most common mechanism (see Figure 24). In some countries, there is a mixed approach to licensing, with a growing shift towards the block spectrum method, in line with the global trend.

Figure 24

Near universal application of the per-link method, but growing shift towards block method

Which of these licensing models are used for allocating backhaul spectrum in your country? (% of respondents)



Source: GSMA Intelligence Mobile Backhaul in MENA Survey 2020

While there is no single best licensing approach for any spectrum band in any country, spectrum regulations and licensing schemes should be designed to promote innovation and make backhaul economically sustainable.

The shift towards block licensing is an important regulatory step in this direction. Block spectrum allocation provides much-needed certainty for operators, which can in turn stimulate investments in network infrastructure. It also provides flexibility in deployment and mitigates the risk of interference, which is a big challenge for wireless networks.

Hybrid licensing schemes that combine the features of block and per-link licensing could be considered. This type of licensing enables the protection of large upfront investments from block licensing while also avoiding the spectral utilisation inefficiencies of per-link licensing.

Spectrum licence fees: evolution to promote innovation

Licence fee calculations across the region vary significantly, with formulas taking into account a range of factors, including bandwidth, power, antenna height, spectrum demand density, geographical coverage and frequency range. While some factors are appropriate to promote efficient spectrum management and frequency utilisation, they can also strongly disincentivise investments, the adoption of new technologies and the extension of coverage to rural areas.

The formulas used today for backhaul fees may not be suitable for addressing 5G deployments, as some of the factors used will become limiting. For instance, some calculation methods employed today were created when channel sizes of choice were as small as 3.5/7/14 MHz. In order to support greater capacity for 5G the channel size has been increased to 112–224 MHz. The use of bandwidth as a factor in calculating licence fees results in linear growth with channel width, which is counterproductive to promoting technology advancements, as this effectively punishes operators that are deploying new technologies.

Spectrum licensing and regulation need to evolve to promote innovation and make 5G backhaul economically sustainable. As such, new bands may require new approaches to address 5G economics and enable more innovative technologies.

Spectrum trading and spectrum roadmaps: other regulatory initiatives to support the changing face of wireless backhaul

With a growing shift in backhaul licensing models towards block licensing and an increasing need for additional spectrum, regulators are encouraged to innovate in their management approach. In helping to reduce spectrum shortages faced by some operators, while ensuring valuable spectrum does not remain unused, trading can allow for a country's spectrum resources to be used more efficiently. Voluntary spectrum trading should be encouraged to promote resourceful spectrum use. This supports improved services by efficiently enabling unused, or lightly used, spectrum to be transferred to operators that need it more.

In addition to identifying new spectrum, it is also important to determine the associated timescales for its availability. Predictable and timely spectrum licensing encourages long-term network investment and enables operators to better plan their operations. To support predictability, governments should publish national broadband plans, setting out targets and proposed methods for such plans to be achieved, and spectrum roadmaps that provide a schedule for forthcoming spectrum releases to meet governmental plans and other demands on spectrum.

4.3 Prospects for the over-100 GHz bands

Progress on the E-band has come as a result of extensive trials and an enabling spectrum regulation framework. Similar efforts are now underway for the 92–114.25 GHz and 130–174.8 GHz ranges commonly referred to as the W-band and D-band, respectively. These bands can support capacities in the 5–100 Gbps range or higher, over distances of several kilometres, and potentially meet network densification requirements in ultra-dense urban areas.

The development of the equipment ecosystem for the W- and D-bands, including trials, is still at an early stage. In March 2020, NEC revealed that it had achieved 10 Gbps outdoor transmission at a distance of 150 metres in the D-band with frequency division duplex (FDD). Operators in MENA have yet to start trialling solutions in these bands and less than 20% of respondents in our survey expect the bands to become more important in the future, relative to other bands.

In light of this, large-scale commercial deployment in the W- and D-bands is unlikely in the region in the near term. In the medium to long term, however, there is considerable potential for these to support the deployment of efficient wireless backhaul solutions. To prepare for the inevitable future requirements for additional capacity in the backhaul architecture, it will be necessary to consider the possibility of additional spectrum in the 130–174.8 GHz range (D-band) to complement the use of 70/80 GHz (E-band) and 60 GHz (V-band) spectrum.

Further considerations on creating an enabling regulatory environment for wireless backhaul deployment

Beyond the issues mentioned above, our research showed that there are still areas of concern in the regulatory environment that need to be addressed by policymakers and other ecosystem players to enable the efficient deployment of wireless backhaul infrastructure:

- Some regulators set an upper and lower limit distance for microwave links. Eliminating these limits can enable flexibility and improve efficiency in the use of spectrum, as well as reduce deployment costs.
- Formulas for backhaul fees need to be reviewed in order to eliminate factors such as antenna height, high usage factor, demand density and bandwidth.
- Wider channel arrangements must be allowed and all such channels (250, 500, 750 and 1000 MHz) should be made available.
- The use of time division duplex (TDD) systems for wireless backhaul must be allowed.
- There is a need to review the cancellation mechanism with the view to make it more flexible, in order to optimise the use of spectrum and save costs, and adopt more automation for requesting a new assignment (link basis) or cancelling an assigned spectrum (link basis).
- Regulators must respond to urgent and temporary requirements for additional frequencies during periods of increased demand, such as for major sporting events.
- Where the light licensing mechanism has been implemented, there need to be solutions to deal with cases of interference.

4.4 Ecosystem innovations underscore the long-term potential of wireless backhaul

Wireless backhaul will remain an essential part of a balanced mobile backhaul infrastructure, especially as a means for combatting the digital divide in areas where fibre is not feasible and as a backup to ensure service continuity in instances of fibre outage. The challenge, therefore, for ecosystem players is to build solutions that offer an optimal combination of ultra-high speed, high capacity, low-latency connectivity, effective spectrum usage, easy installation, scalability and reliability at minimal capital and operational cost.

A new deployment technology that could enable future mobile network deployment scenarios and applications is the integrated access backhaul (IAB), which provides support for wireless backhaul and relay links, enabling flexible and very dense deployment of NR cells without the need for densifying the transport network proportionately. Here, the access and backhaul link partially overlap in frequency and could be a future solution for wireless backhaul for 5G when the access network is deployed within the millimetre wave layer. This would allow operators to provide wireless backhaul without any additional equipment, creating cost efficiencies and savings in space. This makes IAB a particularly useful solution for dense urban areas. However, as IAB is still being developed in 3GPP, followed by a work item in Release 16, it is still early days for the technology and some technical issues remain to be worked out.

Despite the trend towards fibre backhaul, the wireless backhaul ecosystem remains vibrant, with increasing investment and research into innovative technical solutions to improve the performance of wireless solutions. This is a testament to the future prospects of the technology and the role it will play in the future backhaul landscape. Innovations by mobile backhaul equipment vendors and other ecosystem players are focused on developing effective transport solutions for 5G, as well as addressing the key limitations of wireless technologies, such as interference and capacity limitations.

Figure 25

Examples of wireless backhaul solutions announced by leading vendors

Aviat Networks	Aviat Networks has introduced the WTM 4800 multi-band solution to improve capacity, which can be achieved over a wireless backhaul network. The solution combines a microwave radio and an E-band radio into a single unit, bypassing couplers, and other ancillary equipment needed to combine two radios into one link. Additionally, the radio uses a dual-band antenna, which further reduces the amount of equipment, resulting in less capex and lower recurring tower costs.
Ceragon	Ceragon's IP-50 is a disaggregated wireless backhaul router capable of delivering 20 Gbps capacity over mmWave. The IP-50 platform aims to support new 5G use cases over one network via simpler 5G network slicing. The use of IP/MPLS or segment routing within the wireless backhaul infrastructure is expected to increase operational efficiency by eliminating the need for additional cell-site or aggregation routers.
Ericsson	Ericsson's MINI-LINK 6000 utilises high modulation, carrier aggregation, multi-band booster and MIMO to support the rapidly increasing capacity demand of mobile backhaul solutions. The MINI-LINK 6000 portfolio delivers 5G transport with E-band and traditional frequencies in both short- and long-haul scenarios, supporting up to 20 Gbps through a 2+0 XPIC solution with the MINI-LINK 6352. The solution also offers hierarchical QoS mechanisms and open SDN interfaces, supporting both network slicing and a higher degree of automation. According to Ericsson, MINI-LINK's power efficiency translates to considerable cost reductions for operators and substantially reduces opex.
Huawei	Huawei's SuperHUB 5G microwave solution uses a simplified architecture to improve spectrum efficiency and enable high bandwidth for aggregation sites. Utilising space division multiplexing (SDM) technology, the solution enables spectrum used only once within a 90° range to be multiplexed three times, thus improving spectral efficiency by 300%. This allows the same amount of spectrum to provide triple the bandwidth for all directions at a hub site, facilitating multi-directional bandwidth upgrade. According to Huawei, the SuperHUB solution provides operators with a tool to solve issues related to spectrum, bandwidth, tower space, and tower bearing at hub sites. Huawei also offers an enhanced MIMO solution to extend transmission distance and reduce antenna separation distance on the same tower. An intelligent beam tracking E-Band antenna is another innovation to allow larger-sized E-band antenna to be deployed and to enable longer transmission distance.
Nokia	Nokia's Wavence utilises carrier aggregation to combine frequency bands in the traditional uWave or mmWave frequencies to achieve 5G-ready microwave throughput beyond 10 Gbps. The 2+0 E-band systems ensure 20 Gbps throughput, as a single radio can provide 10 Gbps with the new 2 GHz channel bandwidth. The Wavence family includes a new compact 5G-ready transceiver called UBT-C for optimal last-mile connections. According to Nokia, the E-band ultra-broadband radios are ready to be deployed in small form factor hardware variants to provide fibre-like backhauling for small cells.

Source: Company announcements, GSMA Intelligence

Outlook for wireless backhaul in MENA

Wireless backhaul already plays a significant role in today's mobile infrastructure landscape, accounting for more than 80% of base station backhaul for 2G, 3G and 4G across MENA. But the ongoing transition to 5G will have significant implications for the backhaul landscape.

New 5G networks bring two challenges to the fore, namely low-latency requirements and the high density of the network. Over the coming years, operators will need to invest in new backhaul infrastructure and upgrade existing ones in order to address these challenges and cope with the growing demand for data connectivity.

There is a growing shift towards fibre technology, given its ability to deliver ultra-low latency and increased capacity for 5G. However, it is also expensive, time consuming to lay and, in some cases, not viable to deploy. For some areas, such as rural communities and regions with difficult geography, fibre is rarely a cost-effective solution. As a result, wireless backhaul will remain a key part of a balanced mobile backhaul landscape in MENA for the foreseeable future. Indeed, it will play a complementary role to fibre, especially as a means to close the digital divide and facilitate the timely and cost-effective transition to 5G.

Against this backdrop, there needs to be regulatory support for the efficient deployment of wireless backhaul solutions. Central to this is access to suitable spectrum for different deployment scenarios. The E-band has demonstrated remarkable potential to help address some of the performance-related limitations of wireless backhaul solutions, highlighting the need for a forward-looking regulatory framework, especially around spectrum licencing and fees. Ecosystem players also have a role to play, with continued innovation in technical solutions to improve spectrum efficiency and the performance of wireless backhaul networks.

gsma.com

GSMA Head Office
Floor 2
The Walbrook Building
25 Walbrook
London EC4N 8AF
United Kingdom
Tel: +44 (0)20 7356 0600
Fax: +44 (0)20 7356 0601