



# B5G Technology White Paper

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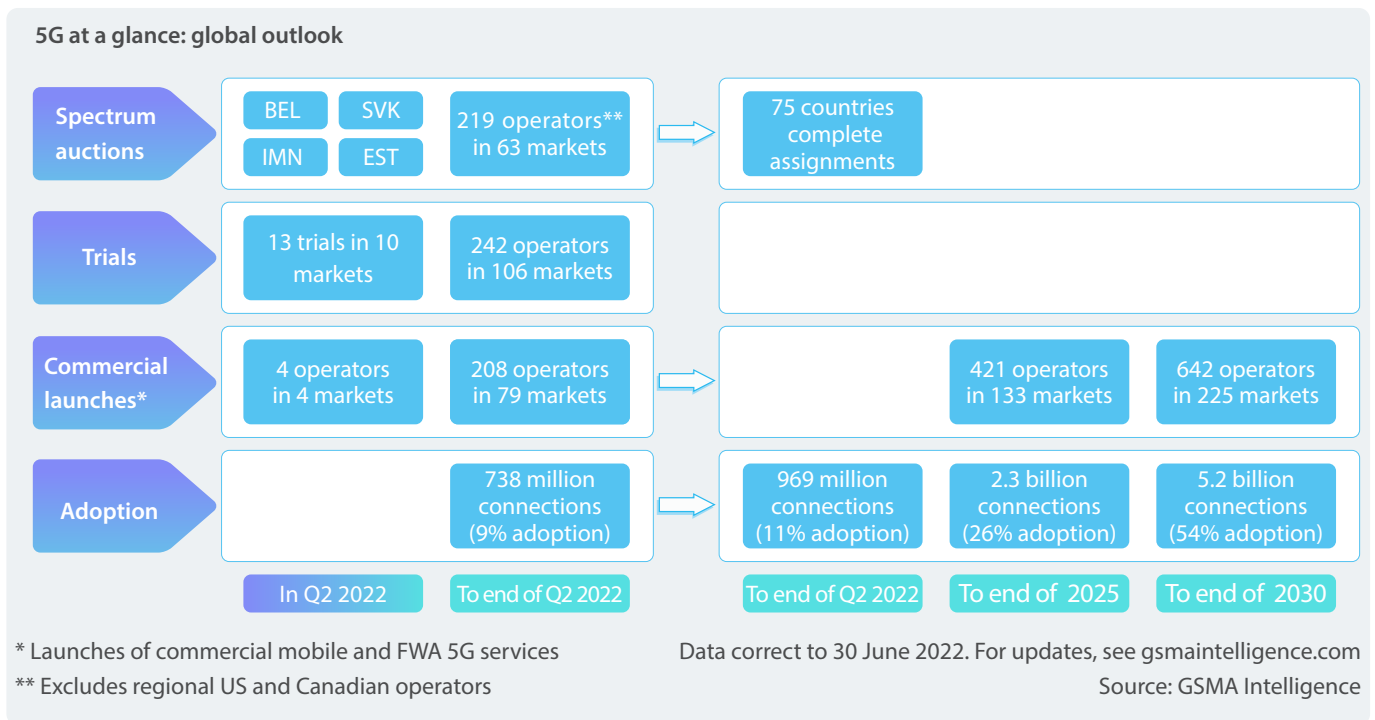
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## Welcoming the beyond-5G era: from 5G-Advanced through to 6G



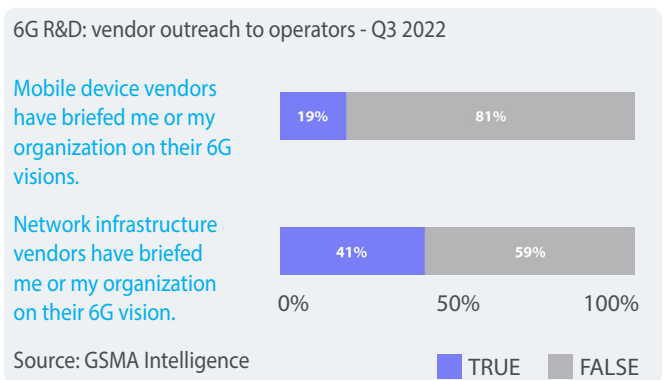
At GSMA Intelligence, our analysts spend their days working closely with operators to understand and guide their business strategies, demands and direction. As part of this remit, we have been talking about the state of the 5G market for several years already.

We have tracked 5G trials and commercial deployments, enablers such as 5G spectrum deployments, and the impact of 5G on operators' supplier decisions. We have carried out this work because 5G is the latest generation of mobile broadband technology, but also because of the high hopes around 5G in terms of addressing ever-increasing demand for data and helping operators enable (and create value from) the digital transformation of enterprises.

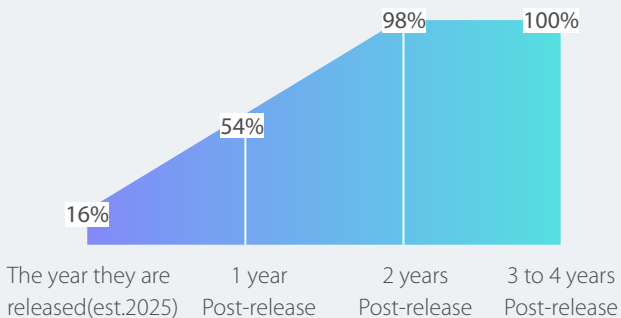


After years of planning for 5G's arrival and working through its early phases, we are now firmly in the 5G era. Yet, as is often the case, when one milestone is achieved, the industry begins to ask what is next.

5G-Advanced standards, for example, have progressed to the point where there is line of sight to what the next major iteration of 5G may deliver within the next few years. Vendors and operators have been busy releasing 5G-Advanced and 6G messaging, communicating their visions, expectations and R&D plans for beyond 5G (B5G). Meanwhile, network infrastructure and mobile device suppliers have been communicating B5G visions and R&D roadmaps to their customers – the mobile operators that will eventually deploy these technologies.



5G-Advanced timelines: how long following standards release do operators expect deployment?



Source: GSMA Intelligence

Industry messaging efforts are about more than just sales and marketing. They are a very real consequence of operator interest, customer demand and network deployment plans. Interest from operators around 5G-Advanced can only be categorised as intense, with more than half of those surveyed expecting to deploy the technology between one and two years following the release of standards. This isn't particularly realistic. Regardless, it points to the recognition of – and extreme focus on – B5G technologies by operators as they look to continue the momentum of 5G but also achieve the business gains that 5G promised. For many operators, after all, 5G deployments have not resulted in real revenue uplift.

Vendor messaging, combined with over-eager operator interest, does not necessarily mean that B5G technologies are important in the here and now. However, market trajectories and trends make the value and importance of B5G technology very clear.

**While we may take them for granted, today's realities all point to the critical nature of 5G, as well as the need to seriously plan for what's next. These dynamics include the following:**

- **Unending data demand:** more data, in more places, supporting more services
- **6G use-case development timelines:** a long-term proposition
- **5G in support of B2B:** the core industry promise requiring added support
- **5G in a 6G world:** an enduring legacy
- **The three S's:** security, sustainability and spectrum.

Against this backdrop, B5G technologies are more than something it would be nice to begin thinking about; they represent fundamental enablers of the industry's health and its ability to continue delivering critical, life-changing services. This means it cannot be too early to begin exploring their potential and thinking about them holistically, asking what we hope to achieve and how to think about them as part of a broader technology evolution.

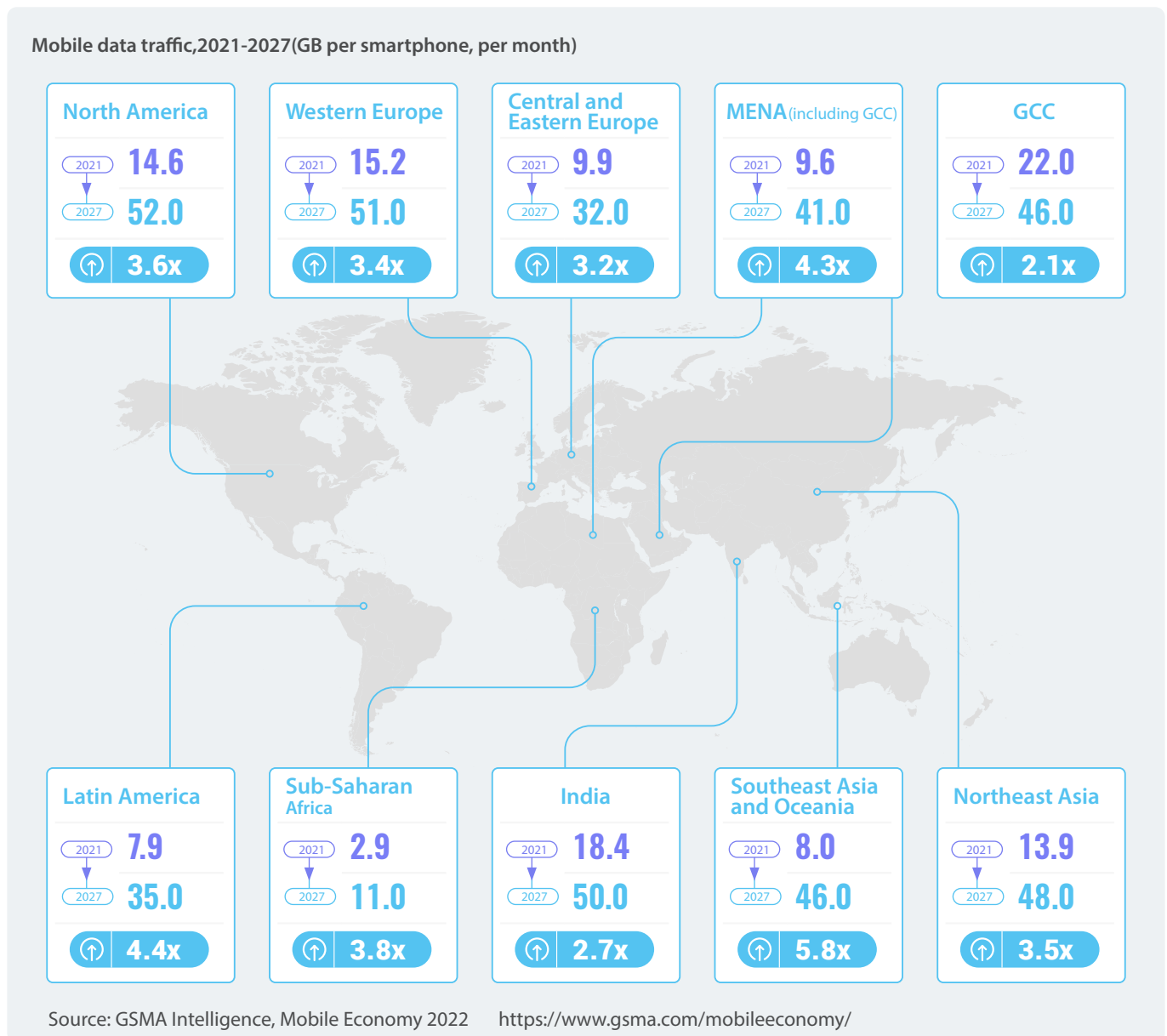
ZTE's research and whitepaper is an important part of that process. With myriad potential B5G candidate technologies, the work helps to explain how some of the key technologies operate and what they promise. Just as importantly though, taking a step back to ask what we hope to achieve in the B5G era is critical and part of making sure we exploit the full potential of new B5G technologies.

## 1.1 Why B5G matters

Mobile broadband technologies will continue to evolve. They will need to evolve in order to meet increasingly demanding enterprise, consumer and societal requirements. Why do B5G technologies and innovations matter in the near term then? The market dynamics outlined earlier provide a solid foundation for explaining why B5G matters today and why it is not too early to begin thinking about and planning for it.

### 1.1.1 Unending data demand

Between 2021 and 2027, mobile data usage across the globe will grow by 3.6x to reach 41 GB per smartphone, per month. Growth dynamics will vary between markets, but every operator in every country will need to deal with incredible demands on their networks and service infrastructure.







That mobile data traffic will continue to grow over the mid-term is not a new insight; demand for data has been on an inexorable climb since the introduction of mobile data services.

However, the evolution of mobile data demand over the next decade will be about much more than traffic demand and data usage.

Just as the mobile email and web browsing services that drove early data usage gave way to interactive video, gaming and user-generated content, tomorrow's dominant mobile broadband services will bring new requirements. For example, if expectations around the success of the metaverse come to pass, it will require massive data capacity improvements but also latency, coverage quality (cell edge, in particular) and uplink bandwidth improvements over the capabilities of today's 5G networks.

If the only material change in requirements involved added data traffic, it might be reasonable to expect operators to meet customer demand by simply doing more of the same. 5G rollouts, combined with legacy network decommissioning and radio access network (RAN) densification, could allow network capacities to scale incredibly. But, putting aside the costs involved and their impact on end users, current technologies will simply not accommodate the new latency, coverage and uplink-versus-downlink realities – along with other requirements we have yet to even realise.

These requirements demand new technologies and mobile network innovations. And, since tomorrow's use cases will be arriving sooner than many people think, we need to begin planning early.

### 1.1.2 6G use-case development timelines

The term 'killer app' has been around for decades, cited over the years by tech luminaries including Steve Jobs and Bill Gates. However, in many ways, the concept is something of a fallacy. For new technology generations at least, there is rarely a single, novel application that drives the industry's success. Just as importantly, few people have ever been able to accurately predict the new 'killer app' that eventually went on to drive traffic and usage of the next mobile generation.

Consider some of the potential 6G use cases being discussed today. The NextG Alliance outlined an impressive set of them in its '6G Applications and Use Cases' report from earlier this year:

- field robots for hazardous environments
- immersive gaming
- mixed-reality telepresence and immersive education
- untethered wearables
- remote data collection powered by terrestrial and non-terrestrial network synergies.

In a 6G world (2030 or later), fully executing on these use cases will require support for stringent performance criteria in terms of bandwidth (uplink in particular), network capacity, latency, coverage, security, costs and more. However, much of this feels very familiar in the near term.

Robots are already being used in industrial environments, supported by 5G private networks. Gaming is already shifting from consoles to mobile devices, thanks to mobile network innovation. Interactive, immersive communications took a huge leap forward thanks to the Covid-19 pandemic and are now attracting attention as part of metaverse aspirations. Meanwhile, multi-network connectivity integrating terrestrial and non-terrestrial networks is garnering plenty of attention as mobile device vendors, and mobile device software vendors, rush to integrate direct-to-device satellite support into their solutions.

This isn't to imply that 6G won't bring new capabilities and amazing new applications. Rather, it is a reminder that tomorrow's use cases will build on what we have already developed and are planning for in the near and medium term. That means we can gain insight into what is needed from B5G technologies well before those technologies and use cases arrive. The fact that we can see the seeds of B5G use cases in today's applications signals that we will need today's 5G networks to evolve in order to meet market demand.

Recent GSMA Intelligence research suggests operators were 31% more likely to see 6G as 10+ years away in 2022 than they were in 2021. This underscores a realization that 6G may take longer to arrive than once expected, and that 5G networks must continue evolving as the run-up to 6G's arrival extends into the long-term.



### 1.1.3 5G in support of B2B

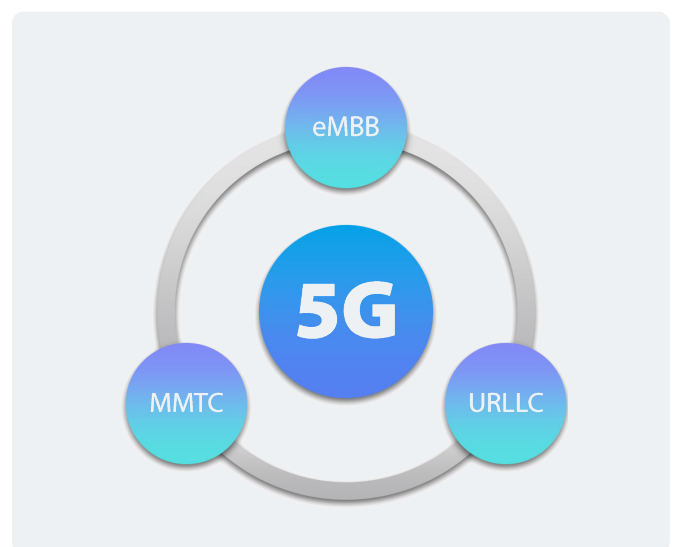
From the earliest days of 5G (well before it was even commercialised), simultaneous support for mass-market consumer applications along with more demanding enterprise use cases was the major technology and business innovation.

Enhanced mobile broadband (eMBB) would offer higher speed connections with lower latencies, which would benefit consumers and enterprises alike. But massive machine-type communications (MMTC, or scaled IoT) and ultra-reliable, low-latency communications (URLLC, or mission-critical communications) would provide operators with an opportunity to target new market segments in the business-to-business (B2B) space – and help them to grow their revenues in the process.

5G was never just about faster data or more network capacity. It was about serving very demanding and less demanding performance requirements from a common network. This is why 83% of operator CEOs in a GSMA survey claimed that enterprise and government segments were the most likely source of 5G revenue upside. That shouldn't be surprising when you recognise that the consumer segment accounts for about 70% of revenues across the market's top operators, and it helps to explain why so many conversations around 5G still reference those three core use cases.

To their credit, operators are making steady progress in expanding their revenue base beyond the traditional consumer demographic. However, if operators are to execute on the broad array of enterprise demands and support a diverse set of enterprise requirements, there is still more to be done.

Some of this is simply about continuing on the journey that 5G began and improving the performance of mobile networks: higher network capacity and connection speeds, along with further latency improvements that open up new use cases. But it also means extending coverage while improving uplink and cell edge connection performance to provide enterprise users with the confidence that networks can meet the demands of myriad devices, regardless of where they are operating. An evolving enterprise service environment embracing cloud environments, new security



architectures and advanced network slicing business models will only add further demands on today's networks. Finally, some new requirements have nothing to do with individual device, service or business requirements but rather the fate of the world. That might sound like hyperbole, but GSMA Intelligence estimates that digital transformation driven by mobile broadband technology can support 30–40% of the decarbonisation goals of critical, energy-intensive industries such as transport or power & energy.

To execute on the foundational enterprise digital transformation promise of 5G, driving operator and societal goals in the process, an evolution beyond today's 5G is necessary.





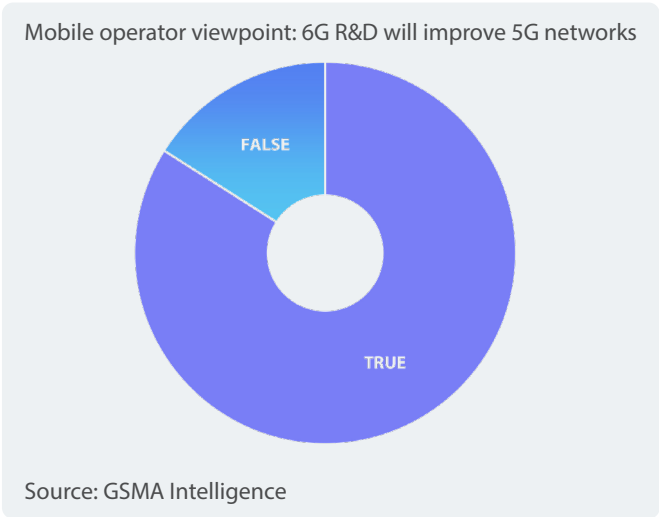
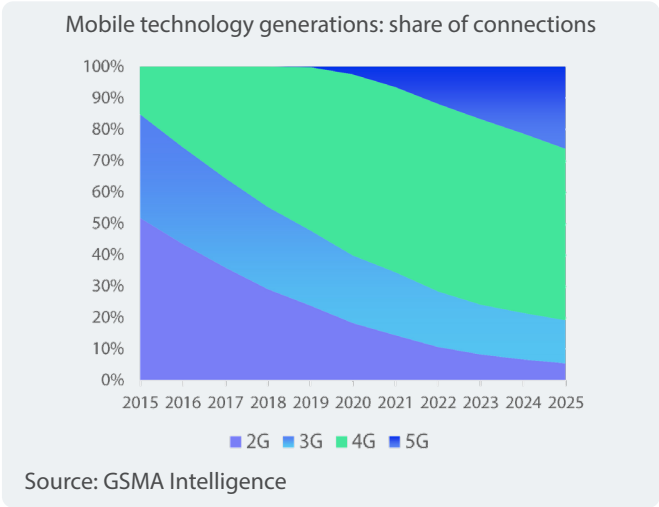
### 1.1.4 5G in a 6G world

In 2015, 2G and 3G accounted for nearly 85% of global cellular connections. Five years later, that figure fell to about 40%, with 4G having scaled to take 58% of the market. Yet, in 2025, 2G and 3G will still account for about 20% of global connections, with 4G maintaining a relatively constant share of connections and 5G growing steadily.

While legacy technology generations will naturally decline in use as new ones scale, there is an important implication here. 4G delivered a critical set of mobile broadband capabilities, giving birth to an app economy that drove mobile technologies and smartphones to be a part of everyday life. As a result, 4G now dominates mobile broadband and will continue to do so in the near term. Yet, legacy technologies continue to live on; phasing out older networks and usage is difficult and time-consuming.

It is therefore natural to expect that a decade from now (after 6G should have arrived), 5G will still be a dominant technology for delivering mobile broadband.

Against that backdrop, there are two realities to consider. First, we need to continue focusing on how 5G will evolve and how its performance will improve over the medium term. Second, given the importance of 5G, we need to ask how 6G technology innovations and visions can support 5G networks and services in the interim. This is a large part of what B5G technologies promise. Indeed, per GSMA Intelligence research from mid-2022, this is exactly what many operators expect.



### 1.1.5 The three S's: security, sustainability and spectrum

Addressing the importance of B5G technologies, we've already discussed the key aspects of an operator's business and the way they will be looking at their business going forward, including:

- new business models built on enterprise digital transformation and the financial, as well as societal, gains to be had by addressing them
- new network and service capabilities – including capacity, coverage and latency improvements – that will be required to support customers old and new
- the pace of network innovation which dictates that the 5G technologies operators are investing in today will need to continue evolving and serving users well into the 2030s

Moving past these basics, three cross-cutting network and service dynamics are front of mind for operators today and need to play a role in how they think about, and plan for, B5G technologies: security, sustainability and spectrum.

When GSMA Intelligence asked operators in mid-2022 about their most important network transformation priorities, sustainability and security dominated the top three positions. Sustainability (and energy efficiency) was highlighted as very or extremely important for 84% of operators around the world. Network security saw 72% of operators make the same claim, with end-user security being very or extremely important for 69% of operators around the world. These ranked ahead of oft-cited strategic focus areas such as automation, open networking technologies, supply-chain diversity and the upskilling of staff.

Spectrum, though, might not capture operator attention in the same way. New spectrum allocations, mmWave deployment and spectrum refarming were actually near the bottom of operator 5G RAN investment priorities per our survey. Yet, the attention given to spectrum allocations, ongoing network sunset activity and the amount of money spent at spectrum auctions all highlight how important spectrum truly is to operators.

And what do spectrum, sustainability and security all have in common?

They represent a foundational set of priorities that transcend the marquee business initiatives that drive tectonic network shifts. At the same time, they are fundamental to those business initiatives. Success in the enterprise, for example, will require secure networks. Profitably supporting increased data demands, in turn, will require energy efficient, spectrally efficient networks. This is why, in one way or another, operators have been clear that the three S's are critical to how they view the future of their networks.

A focus on security, sustainability and spectrum was core to the way 5G technologies were developed. Security was baked into 5G standards from the outset. Sustainability has been a central component of the 5G value proposition to the extent that 5G can deliver more data for a given amount of energy than previous technology generations. Like every new mobile technology, 5G was also designed to be more spectrally efficient than previous generations, as well as more spectrally flexible and capable of supporting diverse spectrum bands.

As 5G evolves and gives way to 6G, the need to be secure, sustainable and spectrally efficient will not wane. In fact, today's operator priorities suggest the need will only intensify. 6G will play a role in meeting those needs, and we should begin exploring how. 5G, in turn, will continually evolve in order to execute on these needs and improve on existing network capabilities.

## 1.2 How to think about B5G: efficiency, extension, enhanced capabilities

One major complication in looking forward to future mobile technology generations, as well as the evolution of existing technologies, is where to focus our attention. There are many aspects that help to characterise a given 'G' and determine its development trajectory:

**technology innovation** – the new air interfaces, antenna technologies, transmission protocols, architectural revolutions (and more) that enable a new generation of network and service capabilities

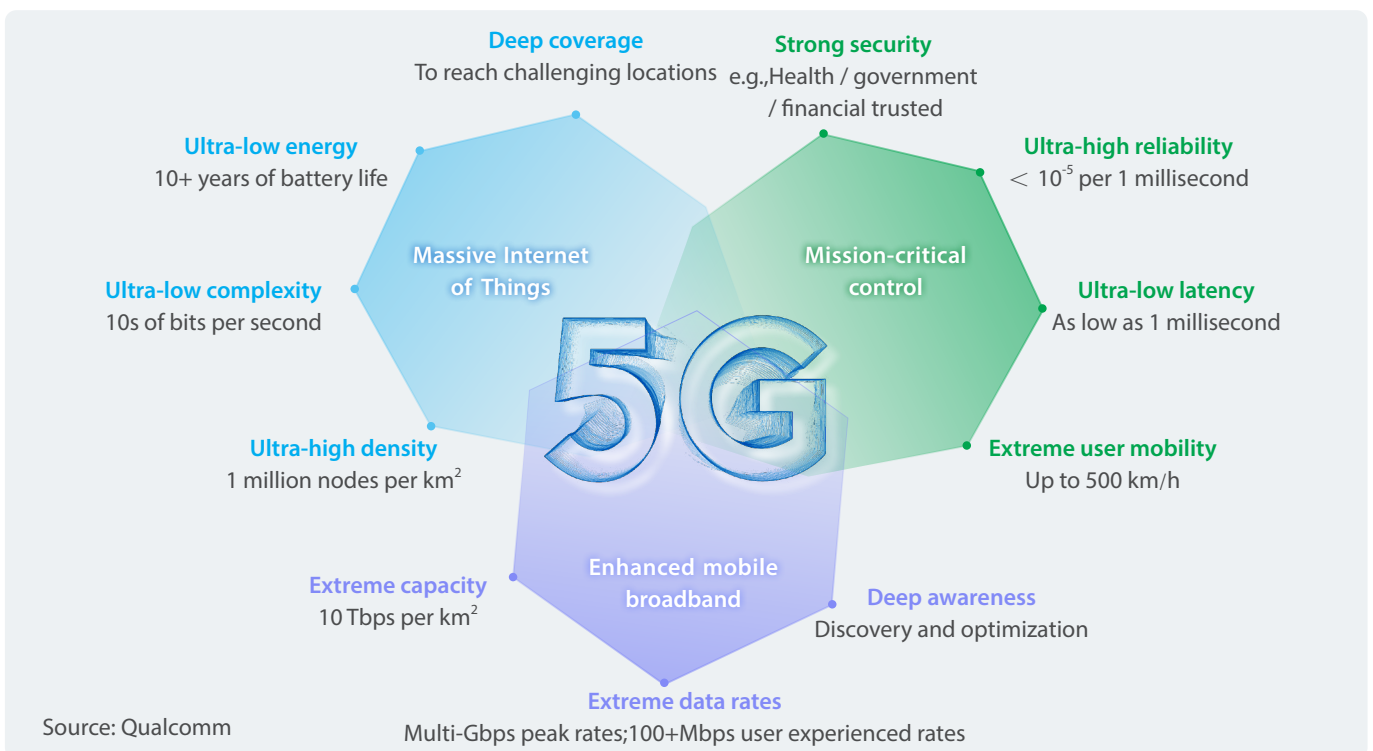
**standards** – the technical specifications adopted by standards development organisations which turn technology innovations into scalable, interoperable solutions

**organisations and study groups** – national and international research groups that bring together operators, suppliers, academics and governments to drive innovations which often feed into industry specifications and standards

**use cases** – the applications, services and specific situations in which the technologies could be put to use, and which will define their performance requirements

**societal demands** – the broader goals for a new mobile technology that stretch beyond network or service performance, such as security, sustainability and inclusion

You can see this dynamic in how some industry leaders and innovators have tried to capture the multiple dimensions of 5G use cases, breaking down each use case into performance requirements and even the technologies or standards that enable that performance. Adding specific business or consumer applications to be supported can add another layer of completeness – and complexity.

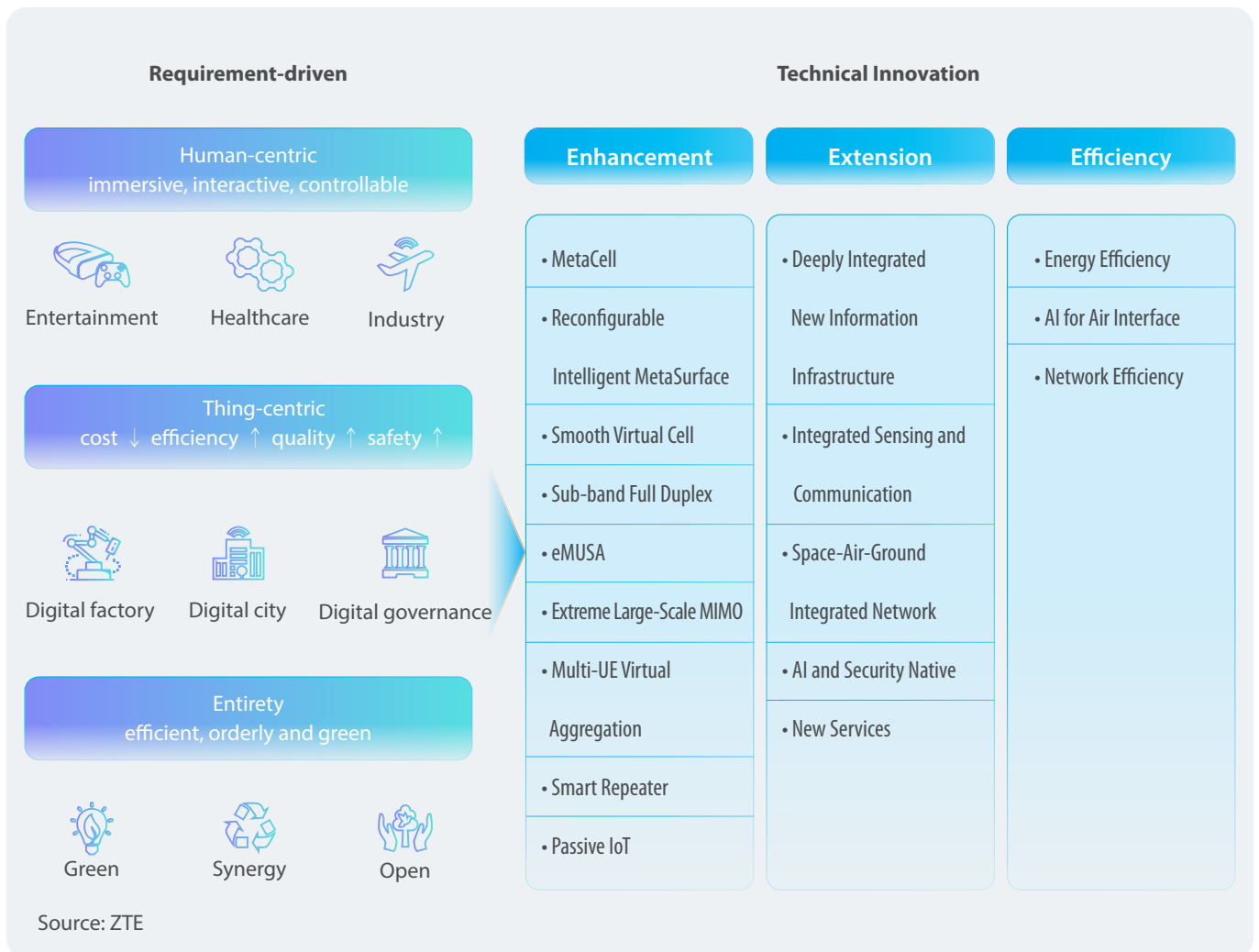




On top of this, national and regional dynamics add a layer of complexity and completeness in the search to understand future technologies, because so much of what goes into creating a new technology generation will differ across markets. The spectrum allocations and regulatory regimes in Europe may differ from those in Asia or North America. The services and applications driving uptake in pioneering markets such as Japan, South Korea, China or the US will differ from those in Latin America or Sub-Saharan Africa. User behaviour patterns; societal demands; market structures impacting fixed-mobile service convergence; deployment maturity and whether operators in some regions will be able to begin their 5G journey with 5G-Advanced or will look to deploy it tactically. All of this will vary by market – across and within regions – impacting technical choices that go into the creation of new technology.

In reality, all of these are important considerations; R&D innovations, use cases, standards, study groups, societal demands and regional differences all feed into the shape of tomorrow’s 5G and 6G technologies. No attempt to characterise this development with a single vision will be perfect.

Against this backdrop, ZTE’s Beyond 5G Vision attempts to represent some of these varied realities in a clear, logical manner.





Beginning with the notion that future use cases will need to address both human-centric and thing-centric application requirements (no different from today's 5G use cases), ZTE reminds us that societal and network requirements must also be taken into account. Whether that means a focus on sustainability, security, open networking or synergies across use cases, it's clear how this future B5G vision carries forward today's operator demands and 5G thinking.

Building on these requirements, ZTE's discussion of enhancement, extension and efficiency lays out the innovations that could help support B5G requirements. Enhanced network and device capabilities deliver on future coverage, capacity and quality demands. The extension of wireless networks to new architectures and domains ensures they benefit from innovations taking place across communications ecosystems. Focusing on efficiency – including AI and automation tools required to drive efficiency gains – recognises that new use cases, technologies, networks and services will still need to be rolled out in a cost-effective manner while delivering solid user experiences. The process by which specific technology innovations and vendor R&D translate into standards and future technology generations is not a simple one; standards organisations do the difficult work of building specifications from innovation, balancing user demands with the capabilities of technology. We are currently seeing that as the 3GPP continues work on Release-18 and 5G-Advanced while already beginning early work on Release-19.

ZTE's contribution to the discussion, via its in-depth and technical whitepaper, is both an attempt to frame a way of thinking about B5G technologies and a menu of technical innovations and advancements that could bring those technologies to life. More importantly, it highlights questions we need to be thinking about. Which technologies will enable in-demand capabilities and which need to be prioritised? Where will we see connections between disparate parts of the communications industry? How should operators connect themselves into new revenue sources? To this end, the whitepaper is an important component in planning for what comes next in mobile – what lies beyond today's 5G networks and services.

## 1.3 Why beyond 5G tech matters now

ZTE's whitepaper may be a valuable contribution to the discussion of what future mobile networks and services will look like. To understand why it is worth our attention we must answer one last question.

### Why now?

With 4G and 5G networks continuing to support mobile broadband demands in the here and now, and 6G not expected until 2030 or later, why should we be focusing on beyond 5G in 2022? The fundamental question we need to answer before turning the first page of any B5G whitepaper is why B5G technologies matter today. Luckily, we've already laid out the parts of an answer:

**5G is mature.** While 5G networks and services have not yet come to every country around the world, we can no longer consider 5G to be in its infancy. As of mid-2022, some 200+ operators had launched commercial 5G services in almost 80 markets. Bolstered by rapidly falling device prices, uptake has been solid, with 1 billion connections forecast by year-end.

**Network and service demands are not abating.** Many of today's mobile services and use cases require capabilities that networks from a decade ago would not support. Tomorrow's services and use cases will require capabilities that today's networks may struggle to keep up with. Metaverse visions and business models provide a strong example. They have the power to transform societies but will require new capabilities that touch on network performance as well as broader goals in terms of security, sustainability and societal goals such as inclusivity.

**6G represents a long-term solution.** Recognising that new technology generations arrive with roughly a 10-year cadence, 6G marketing and thought leadership activity began gaining momentum in 2020. Underscoring these efforts was an acknowledgement that developing a new technology generation would take many years and the support of operators, governments and solution suppliers alike.

### Operators need long-term and mid-term solutions.

Whether or not commercial 6G solutions arrive in 2030 (and operators are beginning to express doubts), evolving market demands mean today's 5G networks will need to evolve if they hope to keep pace. As enterprise digital transformation moves forward, metaverse business models take shape and operators attempt to balance commercial priorities with a focus on sustainability, security and spectrum, mid-term solutions need to arrive sooner rather than later.

Summing up these dynamics is a well-worn quotation: "With great power comes great responsibility".

Of course, the assertion that power and responsibility are linked is not a novel concept. In the context of the 5G era, however, it provides a critical reminder.

The 5G era has demonstrated how mobile broadband technologies have the power to transform business, society and daily life. The expectations of them going forward are therefore bound to be high. They will need to execute on their promise and continue to meet increasingly demanding requirements. Against this backdrop, we need to ask what we want from tomorrow's technologies, how we will put them to use, and which innovations to prioritize. It is the responsibility of the industry to ask, and answer, these questions.

GSMA Intelligence has not written this study or conducted any of the analysis included herein. Regardless, we know that messaging and positioning papers from industry leaders like ZTE are an important part of driving the industry to think about its future and believe you will find it insightful.





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