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Sectoral Systems of Innovation and the UK's Competitiveness:

The UK Telecommunications Sector 2024

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Executive Summary

We have explored the impacts and outlooks of key transformational drivers across the telecommunications sector in the UK: (1) the impact of 5G and 6G at both the **business model** and technology level; (2) the convergence in technology, data and platforms **beyond the vertical** telecoms sector; and (3) the regulatory context that **enables new entrants and industry dynamics to evolve.**

We analyse 5G's growth potential and identify the most promising areas and disruptive implications of 5G while acknowledging other communications technologies. The economic impact of the telecoms sector in the UK is more significant than that of other Organisation for Economic Co-operation and Development (OECD) countries, with a strong positive relationship between broadband investments, speed, and economic growth. Consequently, due to its profound impact on the performance of other sectors, such as healthcare, manufacturing and entertainment, the telecommunications sector needs to be viewed holistically as part of the digital sector at large. One of the major novel sources of growth identified is the emergence of new location-specific operator concepts that require and rely on entirely different economic logic and business models than traditional public nationwide telecommunications networks. It is also important to acknowledge that despite its focal impact on national economic performance, the sector is also a dynamic, global industry.

We identify three key principles that should be relied upon when thinking about the further development of the telecoms sector:

- Focus on the development of new telecommunications innovation ecosystems
- Embrace convergence of the digital domain
- Imagine the role of data, platforms, and analytics beyond the vertical telecoms sector

Introduction

This sectoral innovation study on telecoms focuses on identifying the critical elements with the most significant potential that can improve the productivity and competitiveness of the UK economy. Essentially, these elements concern the understanding of (1) the implications of 5G and 6G at both the business and technological levels, (2) the role of data, platforms, and analytics, and (3) the importance of the regulatory context.

We identify recommendations for policymakers and industry representatives based on our analysis of the UK telecoms sector. These recommendations address, for instance, the UK's role in developing future 6G networks, how regulations should respond to the sector's changing needs, and the convergence of telecommunications technologies with other technologies, such as artificial intelligence (AI). We call for support for the development of an agile and open environment through new forms of public-private collaboration in 5G deployment, as well as research and development (R&D) and industry-academia collaboration.

We emphasise the need for the UK's telecoms sector to invest in capabilities to offer and operate communications networks in different sectors central to economic growth. We also identify the most promising areas and disruptive implications of 5G and, eventually, 6G. One of the expected sources of growth and competitiveness is the emergence of new location-specific operator concepts at the service level and private mobile communications networks at the infrastructure level.

There is an ongoing convergence of mobile communication networks with digital platforms, such as cloud service providers and satellite communications. This has triggered the need to consider the sector's transformation from vertical and hierarchical structures to horizontal platforms. Further sources of competitiveness and growth can be identified from the 'convergence' of telecoms with other sectors. Within the next ten years, the adoption of 5G technology will accelerate, creating opportunities to boost local businesses and ecosystems to new growth areas in the UK, along with investments in 6G research and standardisation. AI, cybersecurity, and low-orbit satellite communications have been discussed on the technology front, but sustainability and green telecommunications have also garnered attention during 2023-2024. Regulatory and policy bodies need to consider how to support start-ups stemming from these technology domains to foster competitive national innovation policies and new market developments nationally and support their internationalisation aspirations.

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Section 1: Sector background

Status of the UK's connectivity landscape

The sector includes various kinds of telecoms services, devices, and infrastructure providers such as mobile network operators, dedicated technology/chipset manufacturers, infrastructure equipment providers, device manufacturers, operating system software providers, application developers, content providers, Internet service providers, mobile virtual network operators and fixed-line service operators.

Telecoms services can be further categorised as wired, wireless, satellite and other communications activities. Retail fixed (wired) and mobile services generated 75% of industry revenues and 25% of wholesale services in 2023, consistent with recent years. Significant differences exist between fixed and mobile telecoms markets, but increased convergence is also occurring in the sector. The UK market is highly consolidated, with a few major players in mobile and fixed telecommunications and broadband: BT (biggest at £30bn), Vodafone (the most valuable brand), Sky, Virgin Media O2 and EE.[1]

There are approximately 8000 companies classified as telecoms companies in the UK[2], including:

- Medium- and high-tech manufacturing, e.g., dedicated technology/chipset manufacturers, infrastructure equipment providers, device manufacturers, and
- Knowledge-intensive service providers, e.g., mobile network operators, operating system software providers, application developers, content providers, internet service providers, mobile virtual network operators, and fixed-line service operators.

We acknowledge that as telecommunications consists of various types of companies in several inherently different sub-sectors, this also impacts how and if we are able to measure the economic performance of the sector reliably. Moreover, categorising the companies broadly into wired, wireless, satellite and other (mainly hybrid) communications does not take into account that many of these companies actually provide their services to several other specialised sub-sectors or even other industries outside telecommunications (for example, geolocation, which utilises GPS, Wi-Fi access points and mobile base stations to track an individual device's location). Therefore, defining what constitutes a telecommunications company is challenging, directly impacting on our ability to build an accurate picture of the UK's connectivity landscape. This is also reflected in the actions of the UK government. In February 2023, responsibility for the digital sector, including Telecommunications, moved from the Department for Culture, Media and Sport (DCMS) to the newly created Department for Science, Innovation and Technology (DSIT). In their definitions, the 'Telecommunications Sector' is based on Standard Industrial Classification 2007 (SIC) codes, as it enables nationally consistent sources of data and more reliable international comparisons. Although telecommunications is considered a sector in its own right, it is wholly contained within the 'Digital Sector' as defined by SIC codes.[3] Hence, telecoms could alternatively be referred to as the 'digital infrastructure'. The OECD definition of digital infrastructure includes communications buildings, including cell-towers and data centres; network base stations; broadband access and internet connectivity systems; software to run IT and communications-related networks; permits for the use of radio spectra; cables and lines - coaxial, copper, aluminium, optical fibre and other communication construction.[4] This kind of expanded definition of digital infrastructure in the UK would also include selected intellectual property (IP) products and permits for the use of radio spectrum as a type of infrastructure asset.

The UK telecoms market is experiencing positive annual growth. However, with its 3.7% compound annual growth rate, the sector overall is considered a low-growth industry in advanced economies. This is even though telecoms infrastructure is crucial to every sector of the economy and has played a significant role in the country managing and surviving the COVID-19 pandemic. Telecoms has, for instance, contributed to intra-industry productivity growth effects of Information Communications Technologies (ICT) in the Southeast of England (73%) and the Northeast (56.9%), according to the UK Innovation Report 2023.[5] 5G mobile telecommunications, especially, is expected to be the next "big thing" in the UK. DSIT has anticipated that "if adopted at scale, 5G could enable productivity gains that add £159 billion in cumulative Gross Value Added (GVA) between now and 2035, reflecting a potential annual GVA increase of £37 billion by 2035". [6]Furthermore, they consider that 5G can transform the UK's public services and grow the economy, making factories and workplaces more productive, resulting in better paid jobs. 5G is also considered the key to helping sectors across the economy maintain their international competitiveness. In the last few years, the estimated GVA of the telecoms sector has shown some fluctuations, with positive growth from £34.4 billion to £35.2 billion in 2020-2021, but a notable decline in 2022, when GVA dropped to £32.9 billion. Despite its slow growth rate, the sector can still be considered both adaptable and resilient, as the GVA rebounded to approximately £34.6 billion in 2023.

Consequently, benchmarking telecommunications performance to others using measures such as GVA without knowledge of the sector's characteristics does not capture the actual value of telecommunications as an enabler, and how this sector contributes to the overall economy's performance and productivity. Moreover, we also acknowledge that modern telecoms is a global industry when it comes to technology, even though consumer service provisioning is done in local, national markets. The UK has several advantages that can contribute to future growth, such as a wide knowledge base, a proven history of innovation, good regulatory practices, and a thriving and mature service industry that has stimulated the design of telecoms infrastructure:

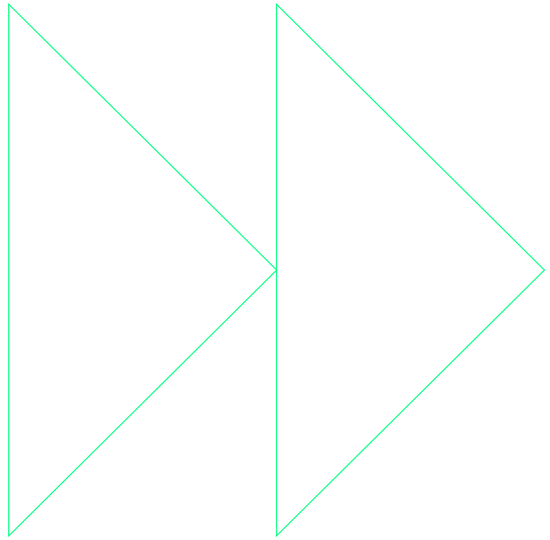
- The UK's telecoms market remains one of the largest in Europe. It is characterised by fierce competition and market consolidation, but also a large number of small and medium enterprises (SMEs);
- Almost every UK business is dependent on telecommunications to transact business, as well as every branch of local and central government including defence and national security;
- The economic impact of the telecoms sector in the UK is larger than in other OECD countries, having, e.g., a strong positive relationship between broadband investments, speed, and economic growth.

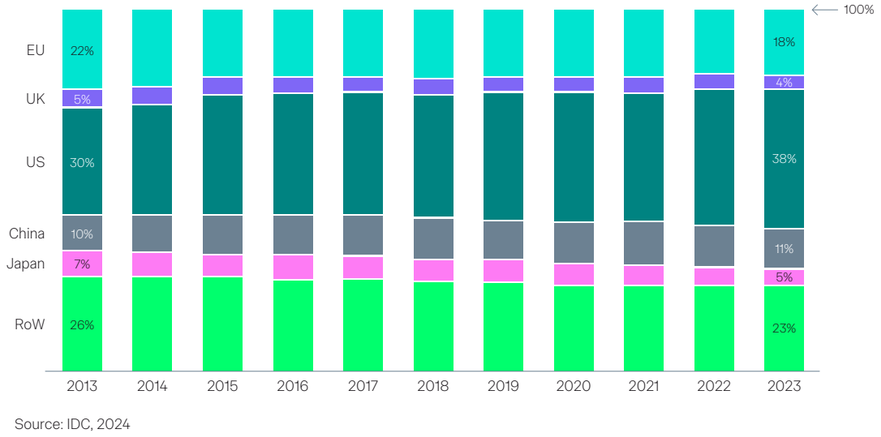
Telecoms accounted for 1.57% of total UK GVA in March 2023. Earlier DCMS estimates show that up until 2022, GVA in the telecommunications sector grew faster than GVA in the UK economy as a whole, increasing by 306% in real terms between 2010 and 2022 compared to 21.5% for the UK economy. The telecoms sector's GVA was 5.7% higher in real terms than in 2022. In comparison, GVA in the UK economy as a whole was 0.3% higher in 2023 than in 2022.[7]

We want to emphasise the role of telecoms as the most central enabler of a thriving digital economy in the UK. We need to view connectivity as the central element for future growth—irrespective of the technological choices behind it. Grasping the concept of connectivity as the source of value with systemic impact requires switching one's mindset from a vertical and traditional supply chain-focused perspective to a horizontal and cross-sectoral perspective. However, as structural and technological challenges persist in the sector, we must critically evaluate our capabilities in addressing:

- How can telecommunications providers reap the benefits of 5G-enabled disruptive business opportunities?
- How can they transform their business models to monetise these opportunities to realise revenue growth?
- How to navigate new disruptive technologies and changing industry dynamics and customer segments?

We have examined these opportunities and challenges in the telecoms sector, with recommendations for improving the competitiveness and productivity of the UK economy. Specifically, we have explored the role of new technologies, policies and regulations, and—importantly—new business models and how they feed into direct and indirect benefits for the UK economy.[8] A report by the former Italian Prime Minister, Mario Draghi, on European competitiveness argues that consolidation of the telecoms market should be increased in the EU to boost regional competitiveness in the global arena because European markets as a whole are fragmented.[9] According to the European Telecommunications Network Operators Association (ETNO), there were 45 large mobile operators in Europe, as opposed to eight in the US, four in Japan and three in South Korea in 2023. International standards play a key role in shaping the telecoms market globally and nationally in the UK.[10] Especially in relation to telecommunications technologies, equipment and infrastructure, a common set of requirements supports new firms in entering the market. Therefore, we consider consolidation to hamper innovation rather than boost the competitiveness and growth of the UK economy as a whole. As a single digital market, the UK is too small to afford this. Having more players involved in developing standards and standard essential patents helps prevent further market consolidation.





Source: IDC, 2024

Figure 1. Global market share of ICT sector at large by geographic area 2013-2023. Image: IDC, 2024

The use of these services grew tremendously during Covid-19 lockdowns, which contributed greatly to the GVA growth of the telecoms sector from 2019-2021. Today, 4G offers consumer data rates in megabytes per second, latency (time between transmission and reception) of (at best) tens of milliseconds, and device density for approximately 2,000 connected devices per square kilometre.

However, the unprecedented growth in connected device numbers and mobile data traffic has also shown the limitations of 4G in addressing this enormous data demand, resulting in the development of a fifth generation of mobile communication technologies—5G. Compared to today's 4G technology, initially designed for high-speed mobile broadband, 5G is a complete redesign of network architecture with novel capabilities, flexibility, and agility to support an array of future service opportunities not available in previous generations of network technologies. 5G has the potential to connect one million devices per square kilometre, which is 1,000 times more than present mobile connections and is 100 times faster than a typical home-based broadband connection.

The National Infrastructure Strategy, published in 2020, indicated that the UK government aims to enable a gigabit-capable connection to at least 85% of UK premises by 2025. Promoting gigabit-capable infrastructure is a priority for several countries in Europe. In Germany, for instance, the plan outlined in the "Gigabit Initiative for Germany" is promising a gigabit network to all citizens by 2025. On the other hand, France aimed to have connectivity at a minimum of 30 Mbps to all by the end of 2022. Sweden will have 98% of its citizens covered by a gigabit connection by 2025, with the rest covered by at least a 30 Mbps connection. The European Commission has the "Connectivity for a European Gigabit Society" vision to provide a gigabit connection to all the main socio-economic drivers (schools, universities, transport hubs, airports, digital-intensive businesses, etc.) by 2025, with all European households having access to at least a 100Mbps connection. The vision is to have full gigabit coverage in the EU by 2030. In the UK, currently, over 10 million homes (37%) have the capability to take advantage of gigabit-capable broadband; the coverage for superfast broadband (>30 Mbps) is at 96%. Mobile Internet is also a crucial part of the UK's connectivity infrastructure. 4G is currently the most widely available standard, with 91% of the UK covered by at least one operator. In 2017, the UK government launched the 5G Testbeds and Trials Programme to accelerate the adoption of 5G in the various sectors of the UK economy.[12] The 5G Programme findings published in 2021 estimated the programme's benefits to be £2.58 billion or £15 for every £1 invested. Currently, 5G is available in 385 UK cities and towns. The technology front of telecoms in the UK has been widely addressed in the 5G Supply Chain Diversification Strategy, as well as the Wireless Infrastructure Strategy.[13]

Section 2: UK performance and international comparison

International market trends

The development of ICT as the backbone of telecoms has especially impacted the methods of production and patterns of employment. In this section, we review the outlook of telecommunications based on the Standard Industrial Classifications 2007 (SIC) codes, aligned with Eurostat (J61), which includes wired, wireless, satellite and "other" telecommunications activities. We focus primarily on benchmarking the UK against the biggest economies in the EU and those that are technologically advanced in the field of telecommunications. In general, the adoption of 4G peaked in Europe in 2022. Despite increasing investments in 5G, 4G is still expected to remain the dominant technology until 2025, with approximately half of connections. Most of Europe has deployed commercial 5G services, and nearly two-thirds of telecoms operators in the region have launched 5G networks. Consumer 5G is growing steadily, with 5G adoption being led by Norway (16%), Switzerland (14%), Finland (13%), the UK (11%) and Germany (10%), while the overall European average is 6%. Even so, European countries are lagging behind global peers of South Korea, the US and Japan. It is anticipated that by 2025, the UK and Germany will have the highest 5G adoption rates in Europe, as illustrated in the GSM Association figure below.[14]

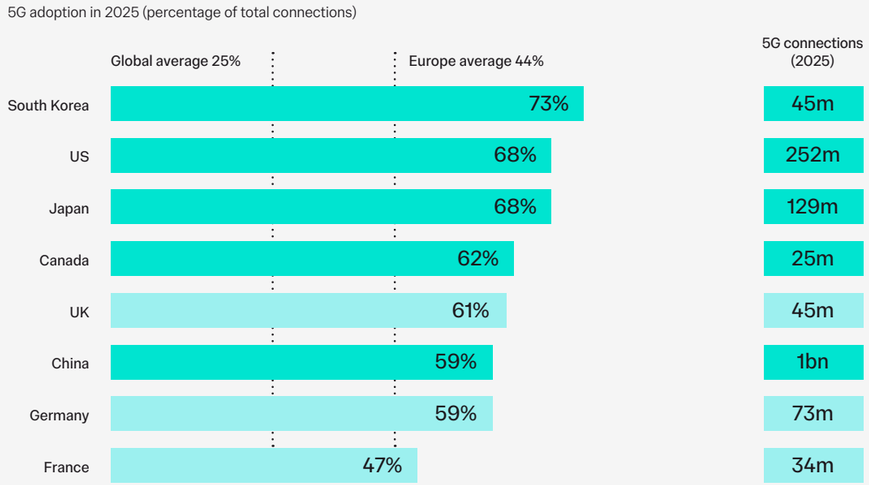
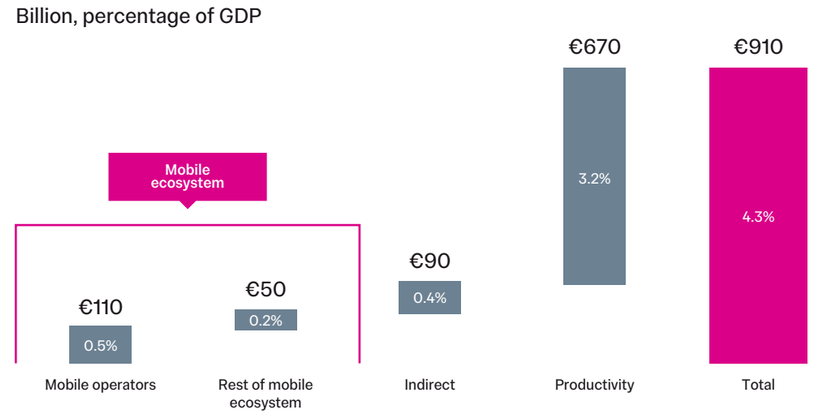


Figure 2. Global 5G adoption rates by 2025. Image: GSMA Intelligence 2022

According to the GSMA, mobile technologies and services generate 4.2% of Europe's GDP.[15] Mobile contributed €910 billion of economic value added, approximately £761 billion, across Europe in 2022. As Figure 2 below shows, the telecoms sector, wireless in particular, has a tremendous impact on economic productivity. This further emphasises the role of telecoms as a value enabler for various other sectors.



Note: Totals may not add up due to rounding
Source: GSMA Intelligence

Figure 3. Total economic contribution of mobile to European economic value added. Image: GSMA Intelligence 2023

Telecoms companies in Europe have invested greatly in the development of 5G. However, this also means that these companies have reached their highest investment intensity for many years, and the sector overall is considered a low-growth industry, especially in advanced economies. If we compare the GVA of different European countries, we can see that overall, none of them has experienced sharp economic growth. Although Covid-19 increased the need for telecoms services, the question of long-term profitability of the sector is a major concern. Despite telecoms being the central infrastructure in the modern economy, it has become increasingly difficult for telecoms operators to generate a return on investment. As countries are investing in 5G, national broadband and high-speed internet coverage, the sustainability of these investments is a concern, as there is an acute discrepancy between the returns on investment in European telecoms infrastructure and the returns on investment of the largest services that run over this infrastructure, i.e., the Over-The-Top (OTT) services provided by major US- or China-headquartered "superscaler" companies, such as Meta, Amazon, Netflix and Google (for further details, see e.g., Axon Partners Group report, May 2022). [16] Whilst telecoms operators have carried the investment burden these other foreign service providers have benefited the most. There are no major UK or European cloud providers and only a few major customer-facing content and applications providers.

In addition, the business models used by most European operators is to seek benefits from tying the provision of physical connectivity to the service layer. The physical layer mostly consists of network infrastructure such as towers and cables, whereas the service layer increasingly resides in software, as described in the previous chapter. Wireless telecommunications is the largest subsector, comprising approximately 60% of the sector. Therefore, we need to evaluate the industry dynamics in more detail to understand how the sector is performing and, most importantly, where new growth opportunities can be identified. The UK stands out, especially in investments of tangible goods in satellite communications, but Germany and France in wired telecommunications activities. As we point out in our study, satellite communications is an important domain, especially in ensuring strategic autonomy.

Proprietary lock-in is a cause of inefficiency in parts of the network. In radio access networks (RAN) from 2G to 4G, the interface between the radio and the baseband unit equipment is closed and vendor-specific, i.e., they

use propriety hardware and software. That is why Mobile Network Operators (MNOs) have tended to use a single vendor at a particular base station (or collection of base stations) for all elements of the RAN network, i.e., "end-to-end supply". Nokia, Ericsson, and (in some regions) Huawei have a combined global market share of over 80%.

The major challenges for the telecoms sector, as raised by the ETNO in 2022:[17]

- Low profitability increases the risk that the European communications industry outsources the skills required for new technology paradigms, which yields competence to non-European companies in, for example, China, India or the USA. The development of a more robust domestic position in the communications technology ecosystem has been a long-standing strategic challenge for Europe since the beginning of the 4G era, which is even more crucial for the UK now as a single market.

- Low valuation because of decreasing revenues in traditional communications services makes the sector more susceptible to aggressive mergers and acquisitions (M&A) and potential hostile approaches from non-European actors, some of which may have little interest in developing a digital advantage for Europe. Yielding control to outside entities could seriously damage the European aim of open strategic autonomy and dent any hope of a renaissance of innovation and investment in new digital communications technologies. This is highlighted even further due to OTTs reaping the benefits of content services despite being equally dependent on connectivity.

- In terms of governance and ownership models, ETNO has observed that in addition to the vertically integrated model, several markets are now proceeding to separate network assets, fixed or mobile. Especially in Europe, this is a way to create value in a low-growth sector. How structural separation is implemented is particularly delicate, as breaking up vertically integrated players might hamper resources and skills to pioneer technology, especially vis-à-vis global competitors. This last point relates especially to the 'platformisation' and cloudification of connectivity and communications. However, this last point is also the seed for new growth.

Although consumer services are still the most significant source of operator revenue, industry players have started acknowledging the need to explore growth opportunities beyond the consumer market. BT announced in 2022 that they are investing nearly £100 million in the development of B2B (business-to-business) and B2G (business-to-government) solutions that converge 5G with the Internet of Things (IoT), cloud and edge computing, and AI. Operators in other countries have published similar strategies and growth plans. Figure 6, adapted from Analysys Mason report, illustrates some applications where telecoms operators have identified and experimented with novel business opportunities and use cases. In the consumer sector, gaming and the metaverse are big domains where reliable and fast connectivity is needed. The gaming industry has relied on mobile and broadband connectivity for a long time, and operators have also started to consider the metaverse as a new domain for capitalising on the technical advantages of connectivity provisioning.[18] The Vodafone-Ericsson trial in 2022 was the first in the UK to experiment with virtual reality (VR) and network slicing.[19] Network slicing is one of the fundamental 5G technologies that allows the creation of separate, tailored network sectors that can be used for specific purposes. In the UK, one successful trial with slicing included the broadcasting of the coronation of King Charles III.

Sector	Applications	Operators (solution name)
Retail	Shopper behaviour, competitive intelligence, supply chain assurance and customer profiles	BT (BT Business), Orange (Flux Vision), Telia (Crowd Insights), Swisscom (Mobility Insights) and Telefónica (Telefónica Tech)
Government	Smart cities, traffic monitoring, digital behaviour, mobility and disease surveillance	BT (BT Business), Telenor (BDSG), Telia (Crowd Insights) and TIM (Cloud Hub)
Transport	Traffic analysis, environmental monitoring, emissions surveillance and population flows	Orange (Flux Vision), Telia (Crowd Insights), BT (BT Business) and Swisscom (Mobility Insights)
Manufacturing	Smart factories, automation, remote robotics, supply chain monitoring, environmental surveillance and health and safety	Telia (IoT Platform), A1 Telekom (A1 Digital), Elisa (IndustrIQ) and Deutsche Telekom (IoT Cloud)

Figure 4. Emerging sectors and applications for telecoms (Image: Analysys Mason, 2022)

Policymakers have a central role in enabling the exploration and realisation of these kinds of converged business opportunities so that a return on investment can be made, and broader economic and social goals can be achieved. As suggested in our recommendations, the UK can take advantage of convergence by building specific innovation programmes similar to the UK's Supply Chain Diversification Strategy and Wireless Infrastructure Strategy. On the technology front, the UK already has several strategies in place. For instance, SONIC Labs was launched in 2021 as a joint testing facility for Open RAN between Ofcom and the Digital Catapult, which the UK government partly funds. The UK government is also funding an initiative under the heading: "Future RAN: Diversifying the 5G supply chain" with a budget of approximately £33.5 million across 15 projects.[20] To support the 5G Supply Chain Diversification Strategy, the 30+ companies in this initiative include the operators BT, O2, and Vodafone; cloud providers Amazon Web Services (AWS) and Microsoft; technology providers Amdocs, Cisco, Intel, Thales, and Toshiba; O-RAN players Parallel Wireless and VIAVI; integrator Capgemini; as well as eight universities.

In comparison, similar funding in the EU seems limited, which means that industry-academia collaborations can foster innovation in the UK telecoms sector and play a central role in boosting competitiveness, as well as in relation to other advanced countries. Especially as the traditional RAN architecture creates vendor lock-ins and tight supply chains, Open RAN can be seen to increase competition and new entrants in the equipment and infrastructure side. In practice, the market dynamics of the telecoms industry enable relatively little choice for the supply of network equipment in the UK, and the market is dominated by two providers (Nokia and Ericsson). However, the introduction of Open RAN architecture, which is currently being developed and trialled as described above, could give MNOs more flexibility in choosing vendors as they deploy 5G and, subsequently, 6G networks. Enabling a better "mix-and-match" approach for building new 5G networks and services fosters business model innovation, as MNOs can use different vendors for discrete elements within the RAN network instead of using a single vendor for end-to-end supply. The disaggregation of software and hardware in RAN equipment could lead to more innovation, given that software development is generally less capital-intensive. The general characteristics of the telecommunications market are such that, if, for example, the benefits from innovations in the mobile RAN equipment market are significantly shared across vendors, then a larger number of potential innovators might discourage firms from investing in R&D. Therefore, R&D investment incentives may be stronger with some continued use of proprietary platforms or exclusive dealing in the mobile RAN market. Open RAN is considered an opportunity to kickstart a new round of innovation in the supply of mobile network equipment.

In 2024, the global telecommunications industry has seen several significant developments, especially the increasing interest in AI in customer care and data services, as well as the network-wide use of AI as a tool for the design, automation and optimisation of network infrastructure. AI is a key trend over the next five to ten years. The use of fast-moving AI technology is likely to become critical in keeping infrastructure and services competitive and secure. However, the lack of expertise in AI can risk market concentration, as operators may depend on vendors—including the "superscalers"—to provide AI services due to a lack of computational or financial resources, in-house skills and training. In order to reap the economic benefits that AI can bring to the telecommunications sector, more emphasis should be placed on educating a skilled workforce in advanced analytics and AI. Industry players need to invest in network automation, including the use of AI, machine learning (ML) and software skills. There are currently only a few telecoms vendors developing credible AI networking solutions and hardware platforms. Telecoms data can be difficult to access for new entrants, inhibiting the development of a diverse and competitive market for AI solutions in telecoms, as pointed out in the recent Telecoms Supply Chain Diversification Taskforce Report.[21] In our report, we emphasise the most prominent near-term growth opportunities in the telecommunications sector—5G. 5G standalone networks (5G SA), which refers to networks that use a 5G core network with no dependency on 4G infrastructure, with a promise of better reliability and coverage, have gained more attention during 2024. Furthermore, the recent geopolitical situation and the ability to secure the supply chain should particularly be considered.

Sectoral performance

Investment in telecoms have remained resilient during the COVID-19 pandemic and also post-pandemic period, increasing by 35.3% from 2019 till 2022. To compare, total business investment across the same years increased by only 7.5%, as revealed by Office for National Statistics (ONS) article on an alternative method for producing investment in infrastructure statistics. Although not official statistics aimed for policy or decision making, the ONS article provides good grounds on discussing the performance of the telecoms sector.

Breaking down the expanded estimates of digital infrastructure investment into its components reveals that most of the investment from 1997 to 2022 has been in telecoms equipment and software. For 23 out of the 26 years with available data, these assets have made up more than 60% of the total investment. Both telecoms equipment and software investments have generally increased over recent years, with software investment reaching its highest level in 2022, and telecoms investment peaking since 2002. Conversely, investment in hardware has been on a decline since the telecoms crash. In 2002, investments in software and hardware were nearly equal, at £1.4 billion and £1.3 billion, respectively.

However, over the next 20 years, software investment surged by 129.5%, while hardware investment dropped by 41.8%. This trend may reflect changes in the efficiency of different types of capital in maintaining communication systems. According to ONS, 69% percent of market sector investments in digital infrastructure in 2022 was for telecoms equipment and software, as illustrated in Figure 5 below.

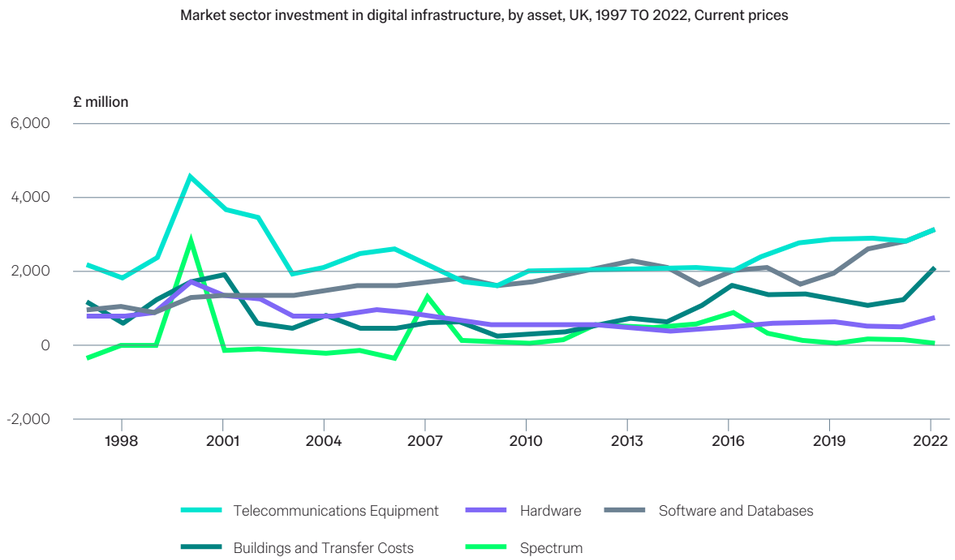
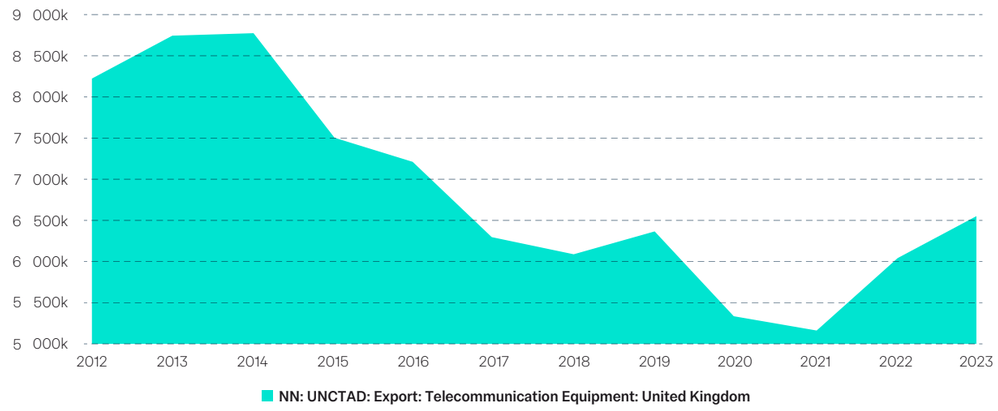


Figure 5. Market sector investment in digital infrastructure in the UK. (Image: Office for National Statistics)

The asset class for buildings and transfer costs, which includes structures like fibre optic cables and base stations, and buildings like data centres, saw the largest percentage increase in investment in 2022, at 77.7%. Investment in buildings reached £2.1 billion in 2022, the highest on record, slightly surpassing the £1.9 billion invested in 2001. Since 2015, annual investment in buildings and transfer costs has consistently exceeded £1 billion. Significant investments in radio spectra permits occurred in three periods: 2000 (£2.8 billion), 2007 (£1.3 billion), and 2012 to 2017 (£3.3 billion), aligning with major spectrum auctions for 3G, fixed and mobile services, and 4G.

When excluding spectrum, total investment in digital infrastructure assets shows year-on-year increases leading up to spectrum auctions, with positive growth rates in the years 1999-2000, 2004-2006, and 2010-2013. This pattern is expected as firms build the necessary infrastructure to utilise the spectrum acquired in auctions. Investments in 5G spectrum made in 2018 will be reflected in the data over the next 20 years.

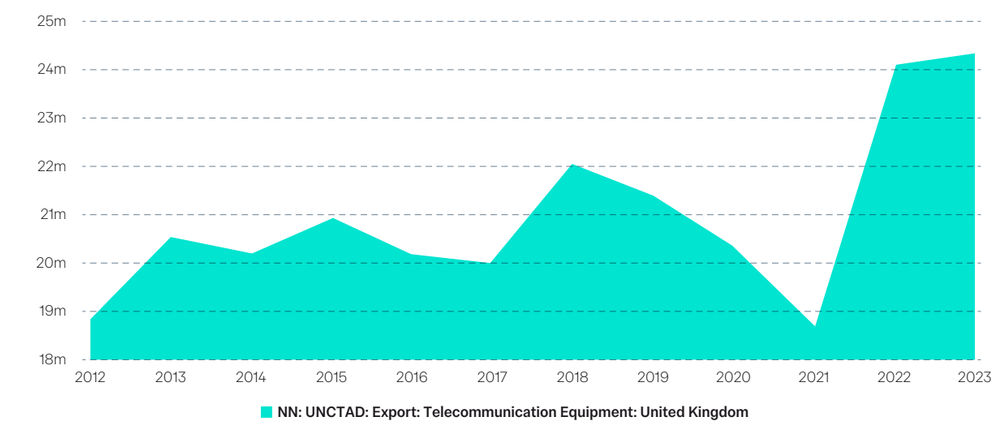
As seen in Figure 6, in the last two years, telecommunications equipment exports have increased since the original decline in 2014, which is a positive trend affected directly by the global rollout of 5G networks, which has driven demand for advanced equipment. As the UK is at the forefront of 5G technology, it has benefited from the increasing demand. Also, the UK government's large investments in telecommunications R&D have fostered innovation and improved the competitiveness of UK products.



Source: www.CEICDATA.COM | United Nations Conference on Trade and Development

Figure 5. UK telecommunication equipment exports from 2012 to 2023. (Image: UNCTAD 2024)

However, at the same time, telecommunications equipment imports have increased tremendously since 2021, which is also due to the increased domestic need for components. This need is driven by both the 5G rollout and the rise of remote work as well as the increased use of digital services boosting the demand for better telecommunications hardware, devices and consumer electronics.



Source: www.CEICDATA.COM | United Nations Conference on Trade and Development

Figure 6. UK telecommunications imports from 2012 to 2023. (Image: UNCTAD)

As emerging markets invest in technology adoption, infrastructure development, and expanding mobile penetration, UK companies may discover new market opportunities in (1) Africa, (2) Southeast Asia and (3) Latin America. These regions present the potential for telecommunications infrastructure, including Internet and mobile telecommunications. Additionally, the Gulf Region offers prospects with its focus on smart city projects and 5G deployment, while Eastern European countries seek to modernise their telecom networks. Naturally, the current geopolitical tensions must also be considered in this context.

The UK has also invested heavily in accelerating 6G research, with the launch of the National 6G Research Facility in July 2024 consistent with our recommendation in last year's report. 6G is expected to be commercially available within a decade, but what is important to note already at this phase is its central role in digital technology convergence. For economic, efficiency and resilience reasons, future connectivity is likely to be provided by a "network of networks" comprising fixed (fibre and Wi-Fi), mobile and satellite communications, offering ubiquitous connectivity. The integration of non-terrestrial networks (NTN) is likely to be a native feature of 6G. This trend could increase overall network resilience and increase the number of companies involved in enabling connectivity, with a direct impact on international trade as well. Strengthening international partnerships and promoting the UK as a hub for global telecommunications innovations can attract foreign investors looking to set up a strategic base in Europe, as envisioned in the UK's international technology strategy of 2023.[22]

Employment, labour and research and development (R&D)

Depending on sources, there are roughly 8000-8400 companies classified as telecoms companies in the UK. The market is highly consolidated, with a few major players: Vodafone, Virgin Media O2, EE and Three, known as MNOs, that participate in the context of mobile broadband but also a large number of SMEs in software and hardware development as well as services. BT, which also offers broadband services, is the biggest player in the sector. BT and Vodafone are the only telecoms companies headquartered in the UK. In the second quarter of 2024, there were approximately 1.64 million people employed in the overall ICT sector in the UK. The telecommunications sector accounts for a significant share of these figures, although there has been a slight decrease in employment between 2022 and 2023. During the 2023 calendar year, there were a total of approximately 183,000 filled jobs in the telecommunications sector, approximately 5,000 fewer than in 2022. This marks a decrease of 2.7% in employment in the telecommunications sector, in contrast to the slight growth observed in employment in the wider digital sector.

The vast majority of employers in the telecommunications sector are small businesses, employing fewer than five people. Around 650 companies employ between five and nine people, and 55 companies employ 250 or more. Between 2022 and 2023, employment in the 'Wired telecommunications activities' industry and the 'Satellite telecommunications activities' industry grew by 12.9% (approximately 5,600 filled jobs) and 2.1% (approximately 100 filled jobs), respectively. Employment in the largest subsector, the "Wireless telecommunications activities" area, constituted 52.8% of employment in the telecommunications sector in 2023.

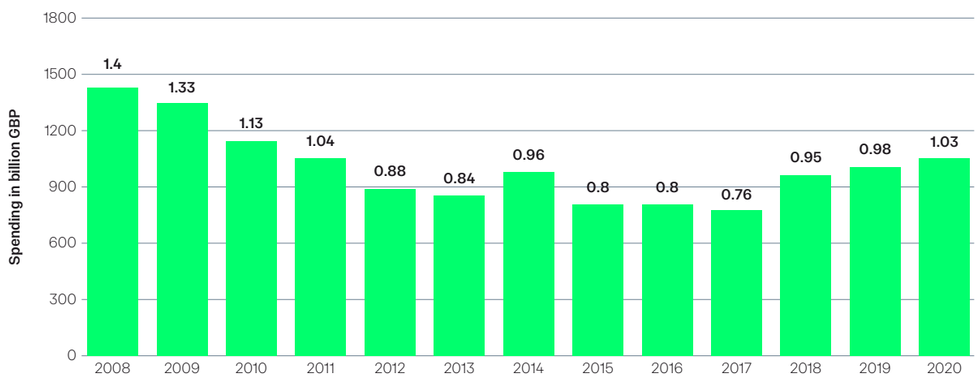


Figure 7. Telecoms R&D in the UK 2008-2020. Telecommunications industry in the UK - Statista[23]

Expenditure on R&D performed by UK businesses was £46.9 billion in 2021, an increase of £2.9 billion since 2020 and £5.9 billion since 2018. In 2021, telecoms R&D comprised 3.8% of total UK R&D spending. Businesses in the telecoms sector have reduced their spending on R&D over the past 12 years, falling from £1.4bn in 2008 to £1.03bn in 2020 (Figure 8). This trend started due to the global financial crisis, with the Covid-19 impact more recently. Despite 5G infrastructure, gigabit and satellite broadband development, there has been no remarkable growth in telecoms R&D in recent years. Approximately 10,000 jobs in the sector are directly involved in telecoms R&D, whereas the overall employment in R&D jobs in the UK is 280,000.

The roles and skills needed in the telecommunications sector relate to technical and business skills, as illustrated in Figure 10 below. Some specific roles central to the telecommunications sector are network engineers, who are responsible for designing, implementing, and maintaining network infrastructure, and security engineers, who ensure the security and integrity of networks. In addition, there is a great demand for telecommunications engineers who focus on installing, troubleshooting, and repairing systems. However, business development managers are equally needed to drive sales and business growth in telecommunications. As we highlight in this report, business models are essential for capturing emerging business opportunities, specifically relating to strategic management and innovation commercialisation.

Technical skills	**5G and Network Technologies** • Proficiency in 5G technology, including deployment and maintenance. • Knowledge of network protocols and infrastructure.
	Cloud Computing • Experience with cloud platforms such as AWS, Google Cloud, Microsoft Azure. • Skills in cloud architecture and cloud-based network solutions.
	Cybersecurity • Expertise in network security, including threat detection and mitigation. • Familiarity with cybersecurity standards and regulations.
	AI and machine learning • Ability to integrate AI and ML into network management and optimisation. • Experience with data analytics and predictive maintenance.
	IoT and edge computing • Understanding of IoT ecosystems and edge computing technologies. • Skills in deploying and managing IoT devices and networks.
Soft skills	**Problem-Solving and Troubleshooting** • Strong analytical and critical thinking abilities to diagnose and resolve network issues. • Ability to work under pressure and handle complex technical challenges.
	Communication and Teamwork • Excellent verbal and written communication skills to explain technical concepts clearly. • Ability to collaborate effectively with cross-functional teams.
	Project Management • Skills in managing large-scale network projects, including planning, execution and monitoring. • Familiarity with project management tools and methodologies.
	Adaptability and Flexibility • Ability to adapt to rapidly changing technologies and work environments. • Willingness to continuously learn and update skills.

Table I. Employee skills in the telecommunications sector

Jobs filled in the UK based on education levels are described in Figure 11 below.

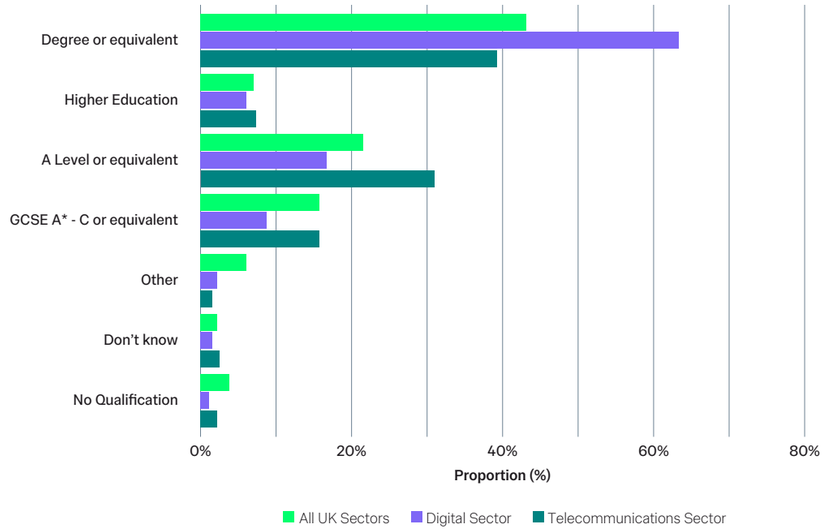


Figure 8: Proportion of background education in telecommunications and other employment (Image: DSIT economic estimates – Employment)

In 2023, the proportion of jobs held by women in the telecommunications sector was 28% (approximately 51,000 filled jobs) compared to 47.9% in the UK overall. This represents a decrease in the proportion of jobs held by women in the telecommunications sector from 2022, down from 32.6% in 2022 (approximately 61,000 filled jobs). Gender balance is something that educational campaigns and Women in Tech initiatives could help support.

Section 3: Opportunities and capabilities

Key drivers and challenges of transformation in the telecoms sector

A key question in the telecoms sector, driven by dynamic technological advances, is how to ensure future-proofed and targeted policies and regulations to suit such a rapidly changing environment. The key trends that drive transformation in the telecoms sector can be summarised as:

- Evolving customer demands in both the consumer sector and industry: e.g., seamless online experiences and rapidly increasing demand for mass-customised data and high-resolution content;
- The convergence of technologies, such as AI and ML, cloud computing, edge computing, open radio access networks (RAN) and IoT, together with platformisation due to (third party) data growth, analytics, and automation, contribute to the blurring of industry boundaries.

Evolving technology domain

One critical development affecting telecommunications is the increasing availability of satellite-based communication services supporting mission-critical infrastructure. The UK already has a fast-growing satellite communications industry, with services contributing £10.4 billion to the economy and creating more than 26,600 jobs. In the agreed Eutelsat and OneWeb merger in early 2023, the UK government retained a special share and exclusive rights in OneWeb for national security purposes. Other players include Inmarsat, Surrey Satellite Technology Limited and L3Harris Technologies. The satellite communications industry in the UK is experiencing significant growth and innovation, with a value of approximately £2.24 billion in 2023, with an estimated 14.2% compound annual growth rate (CAGR), with an expectation to reach £4.9 billion by 2029. The UK is also participating in the European Space Agency ARTES programme and committed to developing the industry to become a leading power in space with the National Space Strategy, published in 2023.[24] The industry is focusing on developing new satellite constellations, integrating 5G systems, creating space-based networks, and developing novel business models for global operations.

The UK satellite communications industry is poised for continued growth, driven by government support, technological advancements, and significant economic contributions. Some key areas here include satellite manufacturing, launch services, and low earth orbit (LEO) satellites. Satellite communications link the telecoms sector with the UK's space sector in broadcast, Internet, and communications services, which also strengthens the UK's position as a world leader in the satellite communications market. The UK could become a global leader in the telecoms R&D areas central to national and digital sovereignty due to its strategic autonomy, e.g., in the control of data, algorithms, standards, protocols, processes, and critical infrastructure. We recommend that the focus in telecoms shifts towards industrial and enterprise customers due to increasing demand for application-driven data services. The primary focus both in the current 4G and early deployments of 5G was on reducing capital expenditure, optimising network performance, and building new revenue streams through better customer experience. The more that 5G development advances, the more it draws commercial attention to value-adding services. Despite massive investment in the current 4G/5G networks, the MNO's capacity to differentiate (and thus capture value) has still been limited because users have seen differentiation more at the device and content level.

The ongoing convergence of mobile communication networks with the digital platforms of cloud service providers has triggered a need to consider how the telecoms sector should transform from vertical, hierarchical structures to horizontal platforms, as new sources of competitiveness and growth can be identified from the convergence of technologies. Digital platforms enable software developers to add value through applications and complementary assets to the ecosystem by attracting users and building network effects. In addition to conventional direct and indirect network effects, data network effects (DNEs) are becoming increasingly important. As currently conceptualised, DNEs are the combination of platform owners' ability to collect proprietary user data from their platforms and use these data to train ML models that they can use to improve their services. Perhaps more important will be DNEs in a broader sense, where parties other than the platform owners can create DNEs by accessing (and not necessarily collecting) data and use them to train ML models, not only to improve current services to current users but to invent new ones.

Access to data is going to be key, and we are seeing how some of this access is becoming increasingly open, with general-purpose datasets (as opposed to proprietary ones) also increasing in importance. 5G and 6G are expected to amplify these trends. In addition to AI, another example of technology convergence is the exploration of the Internet of Things (IoT) by telecoms companies, together referred to as AIoT by Frost & Sullivan.[25] Telecoms players can have a significant role in the deployment of enterprise AIoT solutions, especially due to the

increasing deployment of 5G networks, edge infrastructure capabilities, and location-based data. Given their network and connectivity capabilities and AI and services focus, telecoms service providers are in a unique position to commercialise and monetise opportunities based on other emerging technologies, especially in the industrial context. This, however, requires both collaboration and business model transformation. In addition to the dynamism in the business, technology, and regulatory contexts, sustainable development has become an important driver in the telecoms sector. It will directly affect the design of future 5G and 6G telecoms infrastructure and services reliant on mobile connectivity. Traditionally, sustainability in telecoms refers to energy-efficient networks. Although the telecoms industry has continuously attempted to develop and implement more energy-efficient technology solutions, end-user data demands and increased energy consumption have continued apace, developing into a serious concern with how overconsumption can hamper the benefits achievable from efficiency improvements. With growing concerns around “e-waste”, circularity has gained policymakers' attention in the telecoms industry. Europe is at the forefront of promoting sustainable 5G solutions, including green consumer options and enterprise use cases. For instance, telecoms network manufacturers Nokia and Ericsson have committed to reducing the environmental impact of their products, operations, manufacturing and supply chains.[10] The vendors are mainly concentrating on recovering assets, refurbishing and recycling outdated equipment within the country where it was initially deployed, or repurposing it for use in global markets.

Business model innovation, especially circular business models (CBMs), are seen as crucial for sustainable economic growth worldwide in various other industries. A key component of these CBMs is enabling technologies such as a fit-for-purpose and malleable telecommunications infrastructure that can facilitate two main technology pillars of circularity. First, digital instruments (such as digital twins, distributed ledgers, and digital wallets) are seen as being key to enabling widespread product tracking, tracing, and certification and in developing digital nudges to influence human behaviour. Second, telecommunications infrastructure is key to the realisation of business models that are based on the widespread servitisation, i.e. the combined selling of goods and services.

In the global context, the UN Sustainable Development Goals (SDGs) have already been adopted as guidelines for developing future 6G. Future 5G and 6G will therefore be directly influenced by the need to decrease emissions of greenhouse gases and the harmful environmental impact of materials used in the manufacturing of the necessary hardware. Hence, at a global level, sustainability goals extend beyond resource efficiency, covering zero emission aims and circularity. This is something the UK telecoms industry should pay close attention to.

Changing industry dynamics

The ongoing convergence of mobile communication networks with the digital platforms of various web-scale cloud service providers has triggered the need to consider the transformation of the sector from vertical and hierarchical structures to horizontal platforms. New roles in the future mobile communication business ecosystem include system integrators, neutral hosts, and brokers. The traditional role of MNOs is to provide wide-area communication services in public networks, whereas neutral host networks may be able to provide services for MNO customers in specialised settings, similar to what we have already seen in the industry in terms of mobile virtual network operators that lease spectrum from the main MNOs (Vodafone, Three, EE, and Virgin Media O2); but in neutral hosts, the end user is completely unaware whence the network comes. For instance, the role of BT as a traditional fixed-line telecoms service provider has extended to broadband and mobile, but also to subscription TV and IT services.

Therefore, whenever addressing 5G business models, other kinds of technology-enabled business models, cloud technologies, and web-service models should also be kept in mind. We highlight that the emerging concept of private mobile networks provides the most interesting context, especially in local areas, in driving 5G disruption. The key question is, who is going to drive this transformation? Mobile operators have tried to lead industry change before but have not been very successful. Cloud operators have had better success in implementing transformation because they seem more comfortable with an open-source approach (MNOs tend toward proprietary systems) and therefore participate in and drive ecosystem dynamics that ultimately precipitate the transformation. Consider how Google has been driving the AI/ML ecosystem and how it is now reaping benefits from the resulting momentum.

The market for telecoms services has seen huge advances in data speeds. Customers choose Over-The-Top (OTT) channels in today's digital age for a multitude of reasons, the most significant of which is the variety of viewing alternatives and costs available. Video, music, and other media content is delivered over the Internet through OTT solution providers. They are usually not restricted by price agreements and have a limited number of viewing options. Netflix, Amazon Video, Roku, Hotstar, HBO, and others are examples of OTT applications, along with messaging services such as WhatsApp. OTT applications and content are becoming increasingly familiar to both consumers and marketers.[27],[28] Furthermore, smartphone display and sound quality, open-source platforms, and super-fast Internet Protocol (IP) networks, among other innovative services, act as motivators to attract more consumers to OTT providers’ “freemium” (free basic services with paid-for premium add-ons) business models, resulting in an ever-increasing adoption rate and boosting market growth.

Regional mobile operators are maintaining 5G connectivity for consumers as a stable revenue source with a proven business model while they explore other growth opportunities (for example, bundling connectivity with value-added services and 5G enterprise solutions). It is the transformational power of 5G converging with cloud, edge computing, and AI that will enable the next generation of innovative digital services for enterprises. Frost & Sullivan noted that not all manufacturers will opt for 5G, and only a select few with bigger visions for their businesses will transform their operations with 5G.[19] As AI holds the potential to drive the most transformative change over the next decade, it is currently holding the spotlight as a technology innovator and automation enabler; network automation, in particular, is gaining traction as a must-do.

Challenges and opportunities for UK companies

5G will bring network and service capabilities that will ensure continuity, higher data rates, lower latency, massive simultaneous connections, and ubiquity of networks across the world, even in challenging situations for current 4G, such as high mobility (e.g., on trains) and in very densely (e.g., stadia, shopping malls) or sparsely populated areas. Radio access network (RAN) makes up the largest portion of 5G network infrastructure. There are many RANs but relatively few core networks. The move to 5G as stand-alone (SA) networks is happening more slowly than anticipated. 5G is presently being implemented in the UK in non-standalone mode, which means it still depends on the 4G LTE core network. Because setting up 5G base stations and networks is approximately seven times more expensive than acquiring more spectrum, investments require greater and more certain revenue projections.

The increased number and complexity of mobile connected devices, together with the fast-growing number of frequency bands and variety of spectrum access concepts, heavily influence competitiveness in the sector; for example, localised spectrum licensing will enable distinct network deployments and lower barriers to entry for a variety of new stakeholders. Ofcom regulates spectrum allocation and has limited the amount of spectrum to 37% per MNO. MNOs install and manage a portion of their radio access networks through network sharing agreements to cut costs and optimise network rollout, but also through mobile virtual network operator (MVNO) agreements. Access to the necessary spectrum can therefore be a challenge for new industry players. In the saturated consumer sector, the identification of use cases and business value between telecoms companies and OTTs is challenging. In the industrial (B2B) sector, the key use cases can be summarised in Figure 12 below. These can be mapped onto three broader capabilities:

- Massive machine-type communications for IoT and smart devices, sensors, utilities, manufacturing, and smart city services;
- Enhanced mobile broadband for entertainment, videos, video conferencing, “work and play”, smart appliances, devices and phones;
- Ultra-reliable and low latency communications for critical services; healthcare, security, and safety.

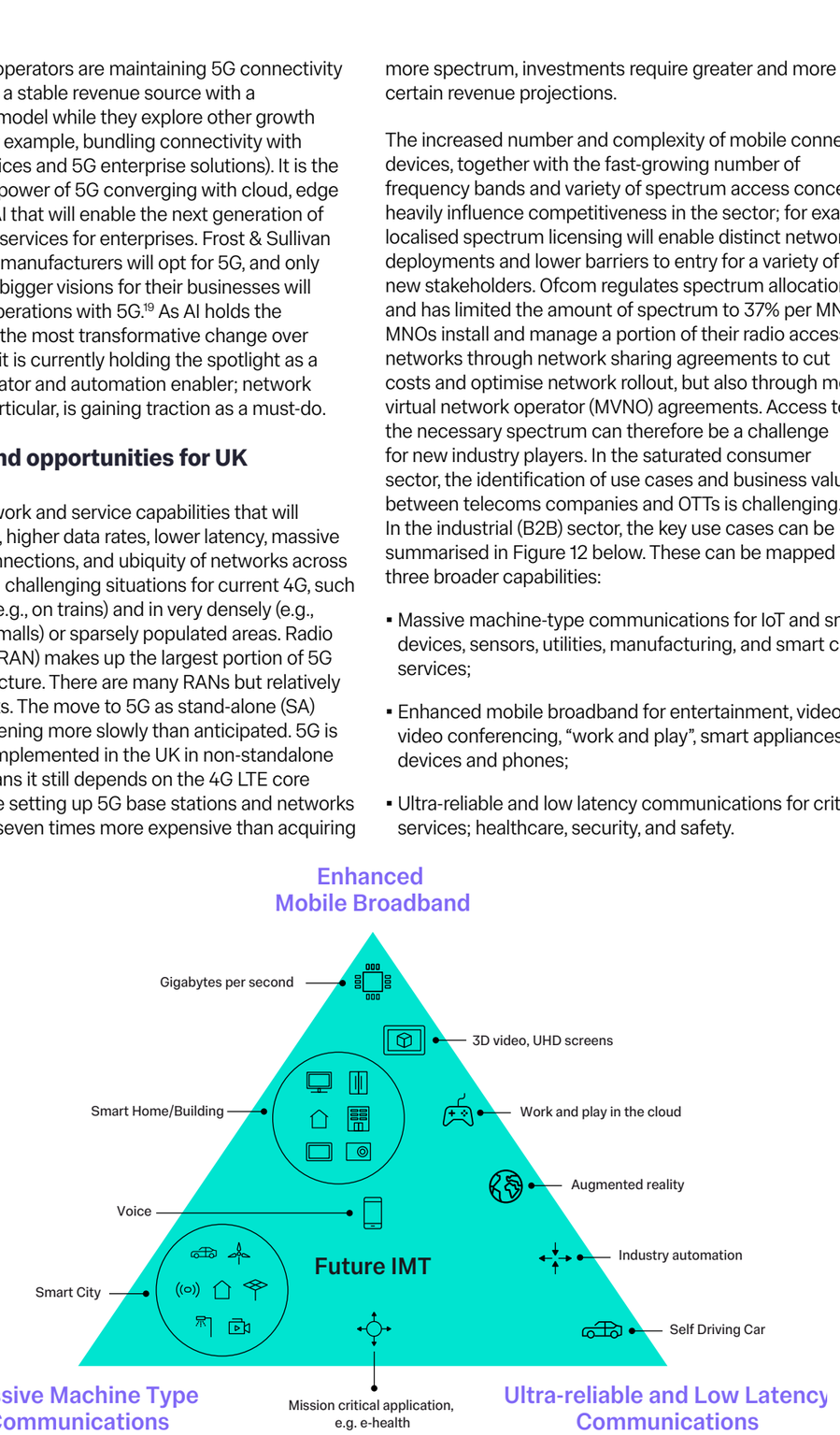


Figure 9. 5G use cases (Image: ITU-R)

Communal assets and public funding in telecoms have mainly been targeted at network infrastructure and radio spectrum. Telecoms network funding and support for deployment programs have conventionally been engaged with rural area coverage and other underserved areas, as set out in national strategies, including in the UK. Now they have been extended to public-private partnerships (PPPs) covering several segments of smart communities, such as logistics, transportation, health, public safety, and utilities. It is worth noting that sustainable development is becoming an increasingly important factor, especially in the case of PPP funding models. Together with the use of wireless telecoms infrastructure as a digital platform, these developments highlight the role of collaborative standards development, modularity, and the complementarity of technological solutions in future telecommunications toward 6G. Therefore, even though in our study we focus on the near future 5G transformation over an approximately ten-year timeframe, we also need to be aware of the potential scenarios relating to 6G beyond 2030. The EU funded Hexa-X-II project has presented general use cases for 6G, illustrated in Figure 16 below.[29] 6G use cases expand the more technology-driven 5G use cases into more impactful, value-driven business opportunities in all sectors of the economy, with a triple-bottom-line sustainability view at the core.

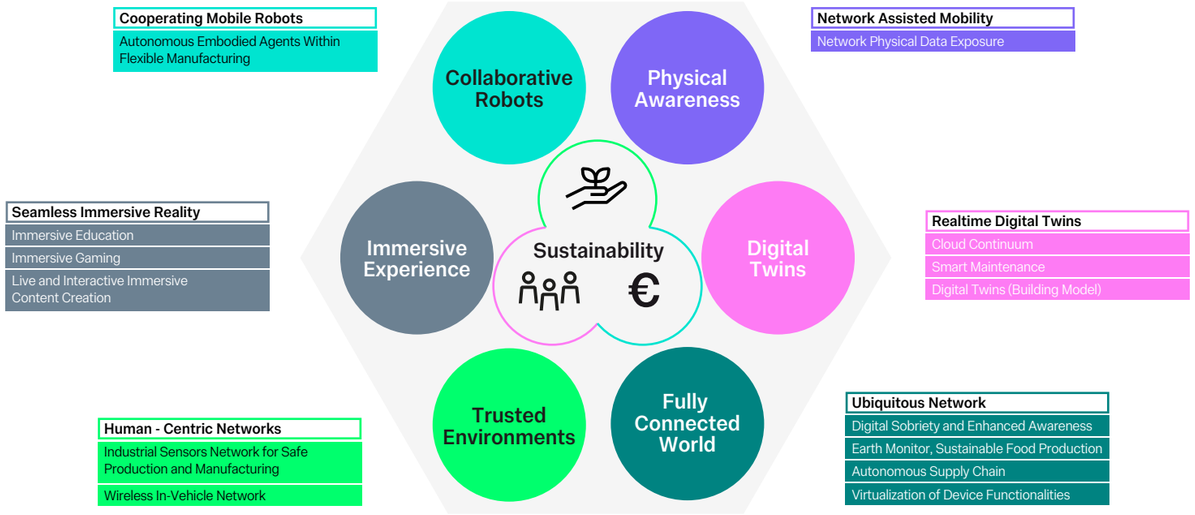


Figure 10. 6G use cases. Image: Hexa-X-II Deliverable D1.2 6G Use Cases and Requirements.

One key challenge relates to data privacy and security. 5G brings new technologies, often based on new complex software stacks, which may be more vulnerable to attacks, and it is increasingly critical to protect the telecoms infrastructure from malicious intrusions and disruptions. Besides the requirements to protect every data item on the entire network, customers are demanding anonymity and privacy, although younger generations have a greater willingness to share data, particularly if the sharing can lead to better service or discounts. Customers are increasingly distrusting global technology firms, which puts local telecoms operators in a good position to gain market share by positioning themselves as ethical users of consumer data and protectors of their privacy. Furthermore, the growing concern of energy usage from cloud-based computation and the associated data transfers can provide leverage for greener operators to gain market share.

Emerging operator concepts

One example of the current disruption that 5G is enabling in the telecoms sector is the emergence of the local (or micro) operator concept that complements traditional nationwide public MNO services through local and mainly private mobile communication networks for tailored use. 5G can provide local context-specific connectivity and content services for various end users, both humans and machines and highly localised and heterogeneous environments. Incumbents have already started to respond to this change by introducing commercial open radio access networks ("Open RAN"). Open RAN can be described as a disaggregation of the radio access network into parts that are interconnected by standards-based, interoperable, open interfaces and protocols for communicating over those interfaces. The four core principles of Open RAN are open disaggregation, standards-based compliance, demonstrated interoperability, and implementation neutrality. Open RAN has implications, especially for industry standards relevant to the buildout of 5G infrastructure and the enhanced security, resilience, innovation, and competition in the UK's critical national infrastructure and beyond.[30] Furthermore, Open RAN contributes to increased vendor diversity for telecommunications networks, considered central for the UK and other governments. Open RAN has globally attracted significant interest from operators as it defines standard interfaces between different elements of the network, enabling equipment, cloud infrastructure and software from multiple vendors to be combined in a standardised way. The ETNO report on the state of digital communications 2024 states that the drivers to support Open RAN include expansion of the RAN supply chain and innovation base; reduced risk of vendor lock-in; and a simplified route towards a virtualised RAN architecture. Open RAN has, therefore, a potentially large impact on the emergence of new specialised operator roles for the telecoms sector. In the European context, open RAN is poised to significantly influence the development of new specialised operator roles within the telecoms sector. In Europe, Vodafone leads with the highest number of Open RAN sites, aiming to replace 2500 UK sites with Open RAN between 2023 and 2026, and has begun deployments in Italy. Vodafone targets 30% of its European macro sites to support Open RAN by 2030, with ongoing trials in the Netherlands, Romania, and Spain. Deutsche Telekom is also making strides, planning over 3000 Open RAN-compatible antenna sites in Europe by the end of 2026. Orange has committed to ensuring all new procurements comply with Open RAN standards from 2025. Additionally, TIM and Telefónica have initiated their own Open RAN deployments. Analysys Mason forecast indicate that by 2028, about 52% of newly provisioned sites in Europe will support Open RAN interfaces, at least in the fronthaul, and of those, over 40% will be in multivendor networks, highlighting what technology convergence in the industry means in practice.

Consequently, we have identified one of the major novel sources of growth and competitiveness as being new location-specific operator concepts and private mobile communications networks. It is worth noting that hyper-scalers such as AWS and Microsoft; IT vendors such as Cisco and HPE/Aruba; and service providers such as NTT and Verizon also see potential in the private 5G network space and are offering private 5G managed services integrated with Wi-Fi. Their services leverage dashboards, workflows to automate configurations, and flexibility with core deployment (for example, the option of on-premises or cloud-based solutions). It is also worth noting that the term "mobile network operator" as a telecoms service provider is subject to specific regulatory rights and obligations in national legislation, which highlights the need to review the applicability of current regulations in the case of local and private mobile communication networks. The localisation trend in 5G services in connection with spectrum management and regulation leads to the identification of centralised, fragmented, and hybrid configurations of converged connectivity and data platforms in 5G.

As new forms of local operators are expected to emerge in the near future, it is imperative to map the factors that influence the economic viability of these specialised operators and their respective business models. First, in 5G, new operators can accumulate value on new kinds of platforms and ecosystems. Second, 5G should be therefore considered as a dynamic connectivity platform that is converging with various other digital platforms. This has the biggest impact on the traditionally MNO-dominated sector, as these new platforms form ecosystems of complementary business models that are not necessarily hierarchically controlled by any of the stakeholders of the emerging ecosystem, disrupting the traditional roles of the MNO-dominated telecoms sector, as in the small cell networks, any player can be a so-called micro-operator. The local micro-operator is basically an entity that combines connectivity with specific content services in spatially confined domains, being dependent on the availability of spectrum resources. The two most important drivers toward local and private networks in connection with 5G are operations in higher carrier frequencies and the virtualisation and componentisation of the network infrastructure. The development of 5G networks in technological terms, therefore, aims at meeting increasingly stringent requirements for higher capacity, higher data rates, lower latency, massive device density, and reduced capital and operational costs in these kinds of heterogeneous environments.

New business models in telecoms

The business model used by most operators globally revolves around seeking to benefit from tying the provision of physical connectivity to the service layer. The physical layer mostly consists of network infrastructure such as towers and cables, plus physically distributed active network assets, whereas the service layer increasingly resides in software. Markets appear to regard this vertically integrated approach as an inefficient means to maximise the value of the physical assets. The problem for this model is compounded in Europe because pro-competition regulation can have the effect of neutralising whatever advantage investment in those physical assets confers. As a consequence, markets tend to regard European telecoms operators as even more hobbled in their ability to monetise the investments they make, as addressed by ETNO.

Consequently, whether a local operator is a new market entrant or an existing MNO pursuing new opportunities, several tensions have emerged that challenge new market

development in the telecoms sector. Understanding and overcoming the following challenges are the keys for the successful development of dynamic capabilities in the sector:

- To what extent can existing industry structures remain responsive? For instance, the current dominant model of bundling services and price competition by MNOs, not only in the UK but in the industry in general, cannot adapt forever to meet the evolving needs and demands of customers. The existing business models realised in the consumer sector, i.e., providing telecoms services in public networks, cannot simply be replicated directly in specific industrial 5G or local service contexts, as they require the development and use of private network operator services, as illustrated in the previous chapter.

- New telecoms innovations are to be expected due to the development of wireless 5G and 6G telecommunications technologies and their convergence with other emerging technologies like AI, ML and IoT, but also with traditional broadband and satellite communications. This leads to the question, how fast can new innovations and solutions be commercialised, implemented, launched and adapted for the market? Agile development and continuous integration models in telecoms software may resolve some of these commercialisation challenges; however, the time-to-market for telecoms hardware, devices and equipment is much longer. The semiconductor industry has a central role in telecoms sector – also where UK companies could get a stronger position. Therefore, there is a need to align resource requirements and total cost of ownership approaches of traditional industry players towards new market development of digital-first services in telecoms transformation.

- From here, we naturally move to tensions in business model transformation and creation in order to build innovations that contribute to the productivity of the industry through commercial viability. The key question is how to monetise data-driven telecoms software and hardware solutions and consequently build and support economically sustainable value-adding services, which boost the dynamism of the market by enabling new innovative players to enter the telecoms sector. We highlight this kind of disruption of traditional vertical industry structures and business models to emerge through ecosystems and platform logic.

- When we are discussing the transformation and productivity of the telecoms sector as a whole, economic viability and sustainability concerns need to be coupled with societal and environmental needs. Not only are these driven by UN Sustainable Development Goals on topics such as ICT footprint and Green ICT or Circular Economy, but they can also function as a seed for building a competitive edge and new source of growth. Global OTTs that have greatly challenged the existing business models of telecoms operators are not able to fulfil all of the key requirements for national value-added telecoms services, e.g., sufficient capacity for peak periods, data protection, or disaster recovery and reliability. Therefore, to realise the benefits that new innovations, service concepts, and business models can bring to the UK economy, it is critical that policies and regulations be not only tailored but flexible enough to support an industry that is going through such rapid change both in terms of industry structures and technology development.[31],[32],[33]

Role of policies and regulations in driving productivity and growth

The growing importance of digital platforms for the delivery of communications services, and the emergence of new kinds of industry players, shake the structures of the traditional MNO-dominated industry, as we have described earlier. All major technology providers in telecoms have relied on licensing a value capture mechanism that relies on the European Telecommunications Standards Institute (ETSI). The collaborative standards development process has enabled massive downstream innovation and a mobile technology and application ecosystem.

The ongoing convergence of mobile communication networks with digital platforms and various web scale cloud service providers has triggered the need to consider what a future-proofed and targeted regulation of the telecoms sector can look like and what is required to promote innovation so that novel innovations in products, services and processes can be turned into sources of national growth and competitiveness. The multi-layered, dynamic, and co-operative (simultaneous co-operative and competitive) character of the telecoms business environment is only expected to increase with the transition from 5G to 6G.

Within the next ten years, the adoption of 5G technology will speed up, creating opportunities for policymakers to support and boost local business networks and ecosystems in new growth areas. Regulatory and policy bodies should consider how to support the business potential of these novel kinds of services and roles that 5G enables. Many of the emerging industry players in 5G have not been part of the traditional MNO-centric value chains of the telecoms sector. Therefore, 5G as a technology is also shaking up the operating context for business as firms increasingly cooperate vertically in open software architectures while simultaneously competing horizontally in sectors that are directly dependent on connectivity and communications. Therefore, the specifics of ongoing 5G development should also be considered as the basis for an effective 6G policy framework. 5G is not only an extension of the previous generations of mobile communications technologies; the enhanced mobile broadband, massive machine-to-machine type of communications, and local, ultra-reliable and low latency communications enable completely new types of vertical and horizontal innovation, as we highlighted in previous sections. They mean more data, more devices, and instant response for both private and public sector services using mobile connectivity in the future. Therefore, a smart combination of regulation, innovation policy, and industry policy is needed. This can promote regulatory innovation, such as anticipatory regulation or sandboxing and agile policymaking in the telecommunications and digital ecosystem.[34]

Challenges and opportunities in 5G and 6G policymaking in the UK

The services dependent upon telecommunications have fallen under the responsibility of a range of different UK government departments in the past. As briefly mentioned in Section 1: Sector Background, the Department for Science, Innovation and Technology (DSIT) was established in February 2023 in order to bring clarity to the policy front in regards to the digital and the telecoms sectors. DSIT brings together the relevant parts of the former Department for Business, Energy and Industrial Strategy as well as the former Department for Digital, Culture, Media and Sport (DCMS). DSIT focuses on positioning the UK in the forefront of global scientific and technological advancement. Their responsibilities include driving innovations “that change lives and sustain economic growth”, especially by delivering talent programmes, physical and digital infrastructure, and regulation to support the UK economy, security and public services, and they also provide funding for R&D. The existing 5G programmes, established prior to DSIT, supported by central and regional governments, test and explore the technical interoperability and integration of open networking solutions, vendors, and system integrators. For example, general opportunities in the telecoms sector within these programmes have been identified to include the development, trial, and use of new capabilities in core networks, as well as interactions involving a range of wireless networks (also potentially including a variety of traditional connectivity technologies in addition to future 5G radio networks, such as 2G, 3G, 4G, low power wide area networks, narrowband IoT, Wi-Fi and fixed wireless access networks).

However, not only are these measures largely MNO-centric, but they are also traditional telecoms value chain oriented. They do not directly contribute to the advancement of convergence of connectivity and services with other sectors. Nor do they address the emerging service concepts and roles at the ecosystem level. The Wireless Infrastructure Strategy, published by DSIT in April 2023, provides the most holistic and future-oriented perspective to the future of telecommunications, but as the name states, it also focuses on infrastructure. The UK still lacks bodies that would advance the value perspective of connectivity perspective, that would look beyond technical deployment options on how to ensure economic viability and feasibility. The dynamism of the industry makes this particularly challenging because connectivity is also a nationwide critical infrastructure, and not only consumer or enterprise market digital infrastructure. This means that as a critical infrastructure, telecoms has direct implications for ensuring national security, not just economic growth. This kind of support is urgently needed to advance the development of emerging private local networks in particular. In addition, the role of digital platforms and cloud technologies in the context of telecoms has not been widely discussed but rather in connection with their growth at the expense of the existing MNOs and current vertical structures of the industry.

The novel opportunities that 5G is bringing highlight the value of innovation collaboration. The three cross-sectoral domains of current 5G use cases, mentioned earlier in this report, show vast potential in business: (a) machine-to-machine type of communications in the context of industrial telecoms, the (artificial) IoT and connected vehicles; (b) enhanced mobile broadband in smart devices that connect users and services, especially in the consumer sector; and (c) ultra-reliable and low latency communications that are relevant for critical infrastructure such as smart cities, connected health, and the energy sector. Each of these technical 5G use cases enables different kinds of value configurations. In addressing how national policies can support the economic development and innovation collaboration in telecoms, we also need to be aware of the role of international regulations.

ITU-R and Ofcom

Since mobile communications is based on wireless connectivity, the radio spectrum is the fundamental resource needed. In the regulatory domain, the International Telecommunication Union Radiocommunications unit (ITU-R) plays a fundamental role in the global management of radio-frequency spectrum and satellite orbits. Collaboration is a key factor for the cross-sectoral platform opportunities, especially in human-computer level 6G value creation and capture, where European and international collaboration in technology standardisation and global regulation is crucial. As an active participant in ITU-R, the UK can collaborate closely on drafting the central activities and policies in 5G and 6G, such as how much the European 5G action plan is applicable to the UK in relation to the importance of removing spectrum-related bottlenecks; promoting early deployment and multi-stakeholder trials with 5G; facilitating venture funds; and joining leading actors in the industry to promote global standards. If the EU promotes market consolidation in the operator business, such networks will be central

for knowledge sharing.

According to DSIT, the widespread adoption of 5G can bring a cumulative productivity benefit of £159 billion by 2035, driving growth and inward investment, and improving lives for communities in every corner of the country. In addition to fixed and mobile communications, there is an increasing need for connectivity in a variety of other types of services such as broadcasting, amateur, space research, global positioning systems, emergency telecommunications, meteorology, environmental monitoring, and communication services orbits. Essentially ITU-R oversees the implementation of the Radio Regulations (RRs) and Regional Agreements as well as the timely and effective update of these instruments through the processes of the World and Regional Radiocommunication Conferences.

Ofcom represents the UK in several ITU activities, balancing the needs of various UK-based stakeholders and UK consumers, ensuring that regulations are practical, proportionate and serve the interests of UK citizens and consumers.[35] As the UK is now a single market, we need a deeper and more open collaboration with central and regional policymakers, Ofcom and industry players beyond MNOs. As Ofcom's role in 5G is "to work with the Government and industry to help the UK become a world leader in 5G," it will play a central role in the facilitation of the local private operator concept. Ofcom releases airwaves needed for 5G products to work, helps companies test 5G services, and helps get innovative new services off the ground. Ofcom also plays a role in helping smaller businesses and startups by giving them access to the airwaves they need to set up their own local 5G networks. These airwaves are licensed to mobile companies but are not always used by them. Therefore, we need a holistic and future-oriented policy that views novel business opportunities and innovations emerging from new value configurations, especially in the private 5G context, with an open and innovative approach. Ofcom's approach to the shared use of radio spectrum is more advanced than in the rest of Europe. It includes principles, such as "use it or lose it," which are uncommon in other European countries.

Section 4: Conclusions and recommendations

Recommendations for boosting productivity and dynamic capabilities in telecoms

We have explored the impacts and outlooks of key transformational powers telecoms industry transformation in the UK: (1) the impact of 5G and 6G at both the **business model** and technology levels; (2) through convergence in technology, data and platforms **beyond the vertical** telecoms sector; and (3) the regulatory context that **enables new entrants and industry dynamics to evolve**. We have also identified three key principles that should be relied on when developing the telecoms sector:

- Focus on the development of new telecommunications innovation ecosystems
- Embrace convergence of the digital domain
- Re-imagine the role of data, platforms, and analytics beyond the vertical telecoms sector

The overall perspective for developing policies and industry recommendations for boosting innovation and competitiveness in telecoms should have a holistic and future-oriented framework that addresses user-centric and sustainability-motivated approaches. Such a framework would consist of the following:

- A competitive innovation policy
- Anticipatory regulation
- Integrated triple bottom line of economic, social, and environmental sustainability
- Privacy, security, and safety of users

Next, we present our focus areas and detailed recommendations of action.

Competitive innovation policy

Recommendation 1: Increase investments in a national 6G programme in the UK to foster industry-academia collaboration, with a focus on co-designing cutting-edge technology and promoting business model innovation and experimentation.

6G is poised to leverage several complementary technologies, such as AI and ML , which are considered general-purpose technologies. This makes the development and standardisation of 6G a cross-industry effort, requiring collaboration between leading developers and users of 6G and those of adjacent technologies.

Strategic Importance:

1. **Global Leadership:** Establishing a national 6G programme will position the UK as a leader in the global race for 6G development, ensuring that it remains competitive with other advanced economies.

2. **Economic Growth:** By fostering innovation and collaboration, the programme can drive economic growth, create high-tech jobs, and attract investment.

3. **Technological Advancement:** Collaboration between industry and academia will accelerate technological advancements, leading to the development of cutting-edge 6G technologies and applications and smoother transition from 5G to 6G.

Actions

1. **Benchmark Against Global Initiatives:** The UK's innovation policies should be benchmarked against both European and global innovation policies in other advanced economies. For instance, the first national 6G flagship programme initiated in Finland in 2018 and extended to the European level with the Hexa-X-I and Hexa-X II programmes, which can serve as valuable references.
2. **Foster International Collaboration:** It is crucial to look beyond Europe and engage with global 6G initiatives. Countries such as China, the US, South Korea, and Japan have already launched significant 6G programmes. The UK needs to initiate relevant collaboration efforts and ensure sufficient funding for both national and international research collaborations.
3. **Create an Internal Market for Research and Innovation:** In Europe, the aim is to create an internal market for research, technology, and innovation in telecoms. The UK should adopt a similar approach, fostering a collaborative ecosystem that includes industry, academia, and government stakeholders. Leveraging data and analytics to gain insights into market trends, customer behaviour, and operational efficiency is central, since data-driven decision-making can enhance the effectiveness of new business models.
4. **Support Business Model Innovation:** Encourage the development of innovative business models that leverage 6G technologies. This includes providing grants and incentives for startups and established companies to experiment with new applications and services, e.g., using regulatory sandboxes where companies can experiment with new business models in a controlled environment. This allows for testing and iteration without the risk of regulatory penalties.
5. **Facilitate Knowledge Exchange:** Establish platforms for knowledge exchange between industry and academia. This can include joint research projects, conferences, and workshops focused on 6G technologies and their applications with an emphasis on customer centric design, business modelling and innovation commercialisation.
6. **Ensure Sufficient Funding:** Secure adequate funding for the national 6G programme through public and private investments. This will ensure that the UK can sustain long-term R&D efforts.

By taking these steps, the UK can establish a robust national 6G programme that fosters industry-academia collaboration, drives technological innovation, and supports the development of new business models.

This proactive approach will ensure that the UK remains at the forefront of global 6G development and commercialisation.

Anticipatory regulation

Recommendation 2: Foster new market growth with a dynamic regulatory framework in telecoms that encourages the emergence and expansion of local private mobile networks.

Anticipatory regulation refers to a proactive, iterative, and responsive approach to regulation. For markets undergoing rapid change, it emphasises flexibility, collaboration, and innovation in policymaking. The Digital Economy Act, which replaced the Electronic Communications Code in 2017, applies to infrastructure forming networks that support broadband, mobile internet, mobile telephony, cable television, and landlines in the UK. It is designed to facilitate the installation and maintenance of electronic communications networks and digital infrastructure. Over the next five years, the UK could boost new market development by implementing a flexible, adaptable regulatory framework that supports spectrum allocation, licensing, and infrastructure sharing. This collaborative approach, involving telecoms operators, local governments, and industry stakeholders, will foster the emergence and scalability of innovative local private mobile networks, driving innovation and competition in the telecoms sector. An anticipatory approach to regulation can help overcome the potential risks related to flexibility, such as supporting consistency of standardisation and regulatory compliance risks, supporting strong cybersecurity measures, more stable markets among small players and incumbents, stronger consumer protection, as well as the ethical concerns related to data privacy and the ethical use of AI.

Strategic Importance:

1. **Adaptability to Technological Advances:** As 5G and 6G technologies evolve, regulations must adapt to incorporate considerations for AI, cybersecurity, and other emerging technologies.
2. **National Security and Resilience:** Initiatives such as the UK Telecoms Lab, launched in Birmingham in October 2022, aim to identify national security risks and vulnerabilities in telecoms technology, particularly against cyberattacks.
3. **Economic Competitiveness:** A flexible regulatory landscape can foster market dynamism, encouraging the emergence of new service concepts such as local 5G operators, which can disrupt traditionally consolidated industry structures.

Actions

1. **Develop a Telecoms Innovation Strategy:** Create a comprehensive 'Telecoms Innovation Strategy' for the UK that aligns regulatory frameworks with economic incentives and policies supporting market dynamism. This strategy should address the evolving vertical-specific regulations and cross-sectoral horizontal needs of the market in connection with Recommendation 1.
2. **Encourage Collaboration and Innovation:** Foster collaboration between government, regulators, and industry to ensure that regulations are responsive to technological advancements. This includes regular consultations and workshops to gather input from all stakeholders.
3. **Incorporate AI and Cybersecurity Considerations:** Update regulations to explicitly address the integration of AI and cybersecurity measures in 5G and 6G networks. This can include guidelines for secure AI deployment and protocols for protecting against cyber threats.
4. **Support Local Private Mobile Networks:** Provide regulatory support for the development and scalability of local private mobile networks. This can involve simplifying licensing processes, offering financial incentives, and creating a supportive legal framework.
5. **Monitor and Evaluate Regulatory Impact:** Establish mechanisms to continuously monitor and evaluate the impact of regulatory changes on market development. This can help identify areas for improvement and ensure that regulations remain effective and relevant.
6. **Promote Sustainable Practices:** Ensure that regulatory frameworks consider wider economic, societal, and environmental issues (see below). This includes promoting sustainable practices in the deployment and operation of telecoms networks.
7. **Facilitate Infrastructure Roll-out:** Currently, roll-out of both fixed (fibre) and mobile (5G) services face regulatory and bureaucratic obstacles. Examples are:
   - Privacy and electronic communications regulations (PECR) impede sales of B2B products because every employee needs to explicitly consent
   - Roadwork permissions for laying fibre are street by street rather than by zones as the projects are done, creating a huge bureaucratic challenge and cost
   - Fibre installers don't have rights of access to multiple dwelling units (blocks of flats), unlike electricity and gas, making installations there difficult.

By implementing these steps, the UK can create a flexible and adaptable regulatory landscape that supports the emergence and scalability of local private mobile networks. This approach will enhance national competitiveness, foster innovation, and ensure the resilience and security of the telecommunications sector.

Recommendation 3: Strive to become a leading force in shaping and governing international telecommunications standards and regulations.

As the telecommunications landscape evolves, the UK must position itself as a leader in setting international standards and regulations. Reviewing the evolution of regulations in Europe—from open telecoms markets (version 1.0) to a combined perspective on innovation, investment, and regulation (version 2.0), the birth of the Electronic Communications Code (version 3.0), and regulation of all digital players through the Digital Economy Act (version 4.0)—UK organisations need to be well-prepared for the next phase of evolution based on platforms, AI, and 6G.

Strategic Importance:

1. **Global Influence:** By taking a leading role in international standards-setting bodies, the UK can influence the development of global telecommunications standards, ensuring they align with national interests and supporting the economic success of UK companies.

2. **Technological Leadership:** Active participation in the development of 6G standards will position the UK at the forefront of technological innovation, fostering a competitive edge in the global market.

3. **Regulatory Convergence:** As telecommunications technologies converge with other emerging and general-purpose technologies into platforms, the regulatory landscape will also be impacted. Anticipatory, collaborative approaches to regulation can support national productivity in innovation across both the private and public sectors.

Actions

1. **Engage with International Standards Bodies:** Increase participation in international standards bodies such as the International Telecommunication Union (ITU) and the European Telecommunications Standards Institute (ETSI). This includes contributing to the development of standards for International Mobile Telecommunications (IMT) for 2030 and beyond.

2. **Foster Open Dialogue:** Promote open dialogue among stakeholders in the digital sector, including industry, academia, and government. This can be achieved through regular fora, workshops, and collaborative initiatives to ensure that the global vision of technology trends and works can be realised in the UK.

3. **Develop a National Standards Strategy:** Create a comprehensive national strategy for standards development that aligns with the UK's economic and technological goals. This strategy should outline the UK's priorities in international standards-setting and provide a roadmap for achieving them.

4. **Support Innovation and Investment:** Encourage innovation and investment in emerging technologies by providing funding and incentives for R&D. This includes supporting initiatives that align with international standards and promoting the adoption of best practices.

5. **Enhance Regulatory Agility:** Develop agile regulatory frameworks that can quickly adapt to technological advancements and market changes. This includes adopting a proactive approach to regulation that anticipates future developments and addresses potential challenges.

6. **Leverage Strategic Alliances:** Build strategic alliances with key international partners to share knowledge, resources, and best practices. This can enhance the UK's capabilities and influence in the global telecommunications arena.

By implementing these steps, the UK can secure a leading role in international telecommunications standards and regulation setting. This proactive approach will ensure that the UK remains at the forefront of global telecommunications development, fostering innovation, economic growth, and technological leadership.

Integrated triple bottom line of sustainability

Recommendation 4: Integrate the triple bottom line of sustainability to position the telecoms sector as a catalyst for other digital sectors.

The triple bottom line perspective of sustainability integrates economic factors with social justice and environmental protection. This holistic approach sets new demands for telecoms industry players, especially as we transition to 6G. The combined environmental, societal, and economic perspectives of sustainability have become increasingly important in developing future technologies, aligning with the United Nations Sustainable Development Goals (UN SDGs). UN SDGs serve as a crucial framework for the development of future 6G technologies. **Economic sustainability** focuses on the opportunities, value creation potential, and advantages that technology can offer. This is achieved through the scalability, replicability, and sustainability of technological innovations, which collectively enhance economic resilience. **Societal sustainability** in the context of 6G ensures that individuals can engage and contribute to society in new, meaningful ways. This is contingent on the affordability of the technology and the freedom for users to opt-in or out as needed. For instance, affordable 6G connectivity can bridge the digital divide, enabling greater access to education and healthcare services. **Environmental sustainability** extends beyond mere resource efficiency to embrace circularity and zero-emission goals. This involves designing technologies that minimise waste and promote the reuse and recycling of materials. For example, implementing energy-efficient network infrastructure can significantly reduce the carbon footprint of telecommunications.

Strategic Importance:

1. **Economic Sustainability:** Ensuring profitability while considering the broader economic impacts of telecoms innovations.

2. **Societal Sustainability:** Promoting social justice and human-centric development in telecoms technologies.

3. **Environmental Sustainability:** Minimising the environmental footprint of telecoms networks, devices, and services.

Actions

1. **Integrate Energy Efficiency:** Continue the tradition of developing "green radios" by enhancing energy and spectrum efficiency in 5G and 6G networks. This includes optimising telecoms use case scenarios such as massive machine-to-machine communications through advanced frameworks based on ML and AI.

2. **Adopt a Balanced Approach:** Ensure that economic sustainability does not overshadow societal or environmental consequences. For instance, while profitability is crucial, it should not come at the expense of social equity or environmental health.

3. **Promote Human-Centric AI:** As 6G converges with AI, prioritise human-centric and ethical aspects of AI development. This means designing AI systems that enhance societal well-being without compromising environmental or economic sustainability.

4. **Support Cross-Sectoral Collaboration:** Foster collaboration between telecoms and other sectors to drive innovation that benefits the broader digital ecosystem. This can include joint initiatives with sectors like healthcare, education, and transportation to develop integrated solutions that address multiple sustainability goals.

5. **Implement Sustainable Practices:** Encourage telecoms companies to adopt sustainable practices across their operations. This includes reducing the carbon footprint of network infrastructure, promoting the use of renewable energy, and implementing circular economy principles in device manufacturing and disposal.

6. **Leverage Regulatory Frameworks:** Utilise regulatory frameworks to support sustainability goals. This can involve setting industry standards for energy efficiency, data privacy, and ethical AI, as well as providing incentives for companies that demonstrate leadership in sustainability.

7. **Monitor and Report Progress:** Establish mechanisms for monitoring and reporting progress on sustainability goals. This can include regular sustainability audits, transparent reporting practices, and the use of sustainability metrics to track performance.

By embracing the triple bottom line of sustainability, the telecoms sector can position itself as a catalyst for innovation across the digital space. This approach will ensure that technological advances contribute to economic growth, social equity, and environmental protection, ultimately supporting the sector's long-term success and resilience.

Privacy, security, and safety of users

Recommendation 5: Develop sectoral legislation to support legal clarity in the management and security of raw data, metadata, and access to information on end-user devices.

Cybersecurity considerations, as briefly discussed above in the context of anticipatory regulation, must comprehensively address all aspects of security in the digital domain. This includes the implementation of robust measures to protect and build resilience against cyber threats and ensure network integrity. Also central is the safeguarding of user data through stringent privacy protocols and data protection laws. The ethical and safe application of automation in network operations and applications needs to be considered as well, highlighting the need to view cybersecurity in all aspects of digital products, services and systems.

Strategic Importance:

1. **Innovation and Trust:** Clear and comprehensive legislation will foster innovation by providing a secure and trustworthy environment for businesses and consumers.
2. **Economic Growth:** By reducing barriers to innovation, the UK can stimulate economic growth and maintain its competitive edge in the global market.
3. **National Security:** Ensuring the security and privacy of telecommunications networks is crucial for national security and public safety.

Actions

1. **Develop Clear Legal Frameworks:** Establish detailed sectoral legislation that defines the management and security requirements for raw data, metadata, and access to information on end-user devices. This includes specifying the roles and responsibilities of different stakeholders.
2. **Promote Collaboration:** Foster deep interaction between academia, industry, and relevant authorities to ensure that legislation is informed by the latest technological advancements and practical insights. This can be achieved through regular consultations, joint research initiatives, and public-private partnerships.
3. **Balance Precautionary and Innovation Principles:** Strike a balance between the precautionary principle and the innovation principle to ensure that regulations protect users without stifling innovation. This involves creating flexible regulatory frameworks that can adapt to new developments.
4. **Implement Codes of Conduct and Regulatory Sandboxes:** Establish codes of conduct and regulatory sandboxes to provide safe environments for business and technological experimentation. These frameworks can help businesses assess new technologies and business models while ensuring compliance with security and privacy standards, as set out in Recommendation 1, step 4.
5. **Enhance Regulatory Oversight:** Strengthen regulatory oversight to ensure compliance with the new legislation. This includes regular audits, monitoring, and enforcement mechanisms to address non-compliance and emerging threats.
6. **Educate and Train Stakeholders:** Provide education and training programmes for businesses, regulators, and consumers to ensure they understand the new legal requirements and best practices for data management and security.

By implementing these steps, the UK can develop a robust legal framework that supports the secure and innovative use of telecommunications networks. This proactive approach will enhance data protection foster trust, drive economic growth and support innovation, while ensuring the resilience and security of the digital infrastructure.

Recommendation 6: Support the development of "prosumer" telecommunications networks and foster an environment that promotes an open and collaborative ecosystem.

In today's rapidly evolving technological landscape, the need to innovate at an accelerated pace is more critical than ever. The technology lifecycle is shorter, and mature, accessible, and affordable telecommunications infrastructure is essential for accelerated discovery and development. The telecoms sector faces significant challenges related to technical cybersecurity, reliability, privacy, safety, and security of users. **Prosumers**—users who not only consume telecoms services but also contribute to and enhance these services—can play a pivotal role in this ecosystem. By managing their own data and participating actively, prosumers can drive innovation and improve service quality.

Strategic Importance:

1. **Accelerated Innovation:** Embracing prosumer networks can drive faster innovation by leveraging the collective input and participation of users.
2. **Enhanced Competitiveness:** Creating an open collaborative ecosystem can enhance the competitiveness of the UK telecoms sector on a global scale.
3. **User Empowerment:** Prosumers, who actively participate in the telecoms ecosystem, can drive demand for more personalised and innovative services.

Actions

1. **Promote Open Technology Initiatives:** Encourage the development and adoption of open technology standards and open-source software. This can enhance interoperability and foster innovation across the telecoms sector. For example, supporting projects such as Open RAN (Radio Access Network) can help diversify the supply chain and reduce dependency on proprietary systems.
2. **Facilitate User Participation:** Create platforms and tools that enable users to actively participate in the telecoms ecosystem. This includes user-friendly interfaces for data management and opportunities for users to contribute to service development. For instance, community-driven networks where users can manage and optimise their own local networks.
3. **Support Regulatory Frameworks:** Develop regulatory frameworks that support prosumer networks and ensure compliance with privacy and security standards. This includes creating guidelines for data management and user participation, ensuring that users' rights are protected while fostering innovation.
4. **Encourage Industry Collaboration:** Foster collaboration among industry players, academia, and government to create a robust and open business ecosystem. This can include joint research initiatives, knowledge-sharing platforms, and public-private partnerships aimed at developing and scaling prosumer networks.
5. **Invest in Education and Training:** Provide education and training programs to equip users with the skills needed to participate in prosumer networks. This can include workshops, online courses, and community events focused on digital literacy and network management.
6. **Monitor and Evaluate Impact:** Establish mechanisms to continuously monitor and evaluate the impact of prosumer networks on the telecoms ecosystem. This includes tracking user engagement, innovation outcomes, and market dynamics to ensure that the ecosystem remains vibrant and competitive.

By embracing the development of prosumer telecommunications networks and creating an environment that enables an open collaborative ecosystem, the UK can build a competitive advantage in the global telecommunications market. This leadership will not only enhance technological capabilities but also empower consumers to become active participants in the digital economy. Additionally, it will attract global talent, stimulate job creation, and position the UK as a hub for cutting-edge technological development. Policymakers can encourage 'prosumerism' through technology by incentivising innovation by providing grants, tax incentives, and subsidies for startups and companies developing prosumer technologies. This can stimulate innovation and make it easier for new ideas to come to market. Developing and maintaining robust digital infrastructure, such as high-speed internet and smart grids, to support prosumer activities will also help in that regard, ensuring that consumers have the necessary tools to actively participate. The adoption of open standards and interoperability in technology can also be encouraged. This allows different systems and devices to work together seamlessly, fostering a collaborative environment.

General Recommendation: A National Strategy for the Telecommunications Sector.

Given the high planned investment, the importance of regulation, and the underpinning of other industries, the UK should formulate an industrial strategy for the telecommunications sector to mobilise industry, government, and other parties to collaboratively grow the sector's contribution to the UK economy. The recommendations above can form a framework for developing such a strategy.

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