



Department for
Science, Innovation
& Technology

UK WIRELESS INFRASTRUCTURE STRATEGY

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Department for Science, Innovation and Technology

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Foreword by the Secretary of State



Our Plan:

On 13 May 1897, the pioneer Guglielmo Marconi sent the first wireless communication across open sea, almost four miles across the Bristol Channel. His message: Are you ready?

We were. Looking back over a century later, wireless technology has transformed our world almost beyond recognition. Today, radio waves connect communities across the country not just with one another, but with the world thousands of miles beyond our shores, and the satellites hundreds of miles above our skies.

Connectivity has brought benefits for British households and British business, boosting growth, productivity, and opportunity for all. And change shows no sign of stopping. In fact, we find ourselves on the brink of a new revolution which promises to transform the world once more.

5G will be the cornerstone of our digital economy. With higher capacity and lower latency, standalone 5G will drive growth in the industries of today and tomorrow, including in emerging sectors like artificial intelligence where Britain leads the world. Just take smart ports, where 5G-enabled remote operation can help us to move containers more quickly, efficiently, and safely, boosting our international competitiveness. 5G can improve our public services, too, in everything from

education to social care. In transport, for example, we can use 5G to power forward progress in everything from real time travel information to augmented reality navigation and self-driving buses and taxis.

This is an incredible opportunity; widespread adoption of 5G could see £159bn in productivity benefits by 2035. And it is exactly the kind of opportunity which the Department for Science, Innovation and Technology was created to seize. It is my personal mission as the Department's first Secretary of State to put Britain right at the forefront of scientific and technological progress. By bringing together world-class research and a dynamic business ecosystem, we can harness enterprise and innovation to grow the economy, driving forward the delivery of one of the Prime Minister's five priorities.

To do all this, we need world-class digital infrastructure. Last year, we met our ambition to deliver a basic 5G signal for the majority of the population by 2027 - five years early. And we have redoubled our efforts to build gigabit broadband in remote regions like Cornwall or Cumbria, together with our work to extend 4G coverage across the country through the £1 billion Shared Rural Network.

Today, we are setting our sights even higher, with our ambition to deliver nationwide coverage of standalone 5G to all populated areas by 2030, ensuring that we can bring its full benefits to villages and rural communities well beyond cities and towns.

Government will lead by example, putting wireless connectivity right at the heart of new and existing infrastructure to ensure that we do build infrastructure fit for the digital age. 5G will improve the safety, punctuality, and connectivity of our trains. Today, we are announcing that our new hospitals will be 5G or equivalent wireless enabled, enabling us to take advantage of cutting-edge healthcare innovations.

By flying the flag for 5G, government will drive private investment. We are also working with local authorities and businesses to ensure that they are ready for 5G - investing £40m to create 5G Innovation Regions across the UK and building better markets by boosting competition and creating the conditions for informed consumer choice.

We will strengthen the infrastructure that underpins these markets, too, by managing Spectrum for the benefit of all, driving forward the rapid deployment of mobile networks, and ensuring that rigorous cyber-security requirements are respected.

But we are not just thinking about tomorrow; we are thinking about the day after, too. Our 6G strategy outlines how we will draw on our expertise and experience and provide an initial investment of up to £100m to pioneer future telecoms and 6G research and shape the global debate on the standards which underpin it, protecting our position in an increasingly competitive global economy, securing the UK's international competitiveness and ensuring that our wireless future works for British people and businesses in every corner of the country.

Because this must be a revolution that delivers.

126 years after Marconi kick-started the radio revolution, we find ourselves at the dawn of the next era of wireless connectivity. We can ask ourselves Marconi's question again: are we ready?

This strategy provides our answer: yes, we are.

**MICHELLE DONELAN, SECRETARY OF STATE FOR SCIENCE, INNOVATION
AND TECHNOLOGY**

Foreword by the Minister of State



The more our lives are conducted online, the more access to the internet becomes critical for social and economic opportunity.

This is why delivering world-class digital infrastructure to all Britons is a fundamental mission of this government - and our efforts to build it the modern equivalent in scale and ambition to the Victorians' construction of the railways. Our plan is for every corner of our country to get lightning fast connectivity, not only to give people real choices about where to live and work today but so they will not be left out of future technological revolutions because of poor infrastructure.

It is this sense of purpose that underpins Project Gigabit, our flagship £5 billion programme to reach hard-to-reach communities across the UK with gigabit-capable broadband. It is complemented by a staggering competition now underway between commercial suppliers to supply Britons with great connectivity.

Extraordinary progress is being made on coverage. When I began my role in September 2021, gigabit coverage was just over 50%. Now, it stands at almost 75%. With £1bn of Project Gigabit's funding now available to suppliers, our contracts are not just delivering better internet but skilled jobs everywhere from Blandford to Berwick. By the end of next year, we hope to have every part of our country under contract.

Which is why the time is right to turn our sights to mobile connectivity, where the same sense of mission is needed to deliver the kind of wireless infrastructure that will transform how we live our lives and run our economy. This is not simply a matter of improving download speeds as people browse the internet on their phones or dial into work calls. It is far more transformative than that.

The power of 5G and future telecoms advances will unlock new solutions in everything from industry to healthcare. Falling behind in coverage will mean falling behind in international competitiveness when it comes to the technologies of tomorrow, and failing to provide British people with innovative, life-enhancing services on secure, resilient networks.

The Wireless Infrastructure Strategy, developed through close engagement with industry and local bodies right across the country, sets out our plan for gripping this critical challenge and delivering our new ambition to provide nationwide coverage of standalone 5G to all populated areas by 2030.

We will invest £40m to drive adoption of 5G-enabled tech in local areas, transforming our public services and driving business productivity. We will improve coverage reporting, including on the rail network, and will continue our work with local areas to transform how the public sector uses wireless connectivity to deliver better public services. And, finally, with our 6G strategy, we will invest up to £100m in cutting-edge research and development to make sure we play an active role in shaping the standards and driving the adoption of future telecoms technologies.

Superb broadband and a vision to put the UK at the heart of the wireless revolution - it is this dual connectivity mission that must be fulfilled if we are to make good on the promise that technology holds to deliver more prosperity, opportunity and productivity to the people and businesses we serve.

JULIA LOPEZ, MINISTER OF STATE FOR DIGITAL INFRASTRUCTURE

Executive summary

The Prime Minister has set out his five priorities for this government - to build a better, more secure, more prosperous future for the UK, including growing the economy, and creating better-paid jobs and opportunity right across the country, which this strategy is focused on delivering.

We can only deliver on that priority with world-class digital infrastructure. Advanced wireless connectivity will be the foundation on which we build industries, jobs, skills and services for the future, and this strategy sets out our plan to harness its potential for our economy and our society.

The next decade will see seismic changes both in terms of what wireless connectivity can deliver and how we can use it. The economic and social benefits from these changes promise to be vast, from supercharging growth to accelerating our transition to net zero. But we can only realise these benefits with concerted action from government, industry, and others. This strategy sets out our plan to do just that.

Progress so far

In the last five years, UK government policies have driven impressive progress in the deployment of world class fixed and wireless networks across the whole of the UK, removing regulatory and practical barriers to deliver stronger growth, more jobs, and better public services in every corner of the country.

- through Project Gigabit, we are investing £5 billion in gigabit broadband networks, with an ambition to get gigabit broadband to at least 85% of premises by 2025 and over 99% by 2030
- through our £1bn deal with the mobile network operators, we are supporting rural communities by ensuring that 95% of the UK landmass have 4G coverage by 2025. This currently stands at 92%
- we have made substantial progress with 5G, too. Last year, we met our ambition for the majority of the population to have access to a 5G signal by 2027 five years early through the deployment of basic, non-standalone 5G using existing 4G networks to deliver increased network capacity
- we have also taken steps to strengthen the security of our networks and diversify supply chains through the [Telecommunications \(Security\) Act 2021](#) and the [5G Supply Chain Diversification Strategy](#)

This is already a high bar of digital connectivity, but we want to set it higher. The question is - why?

The potential of advanced wireless connectivity

To answer that question, we can look at how far we have come in the past decade. 2G and 3G mobile networks opened up a new realm of connectivity and mobile communication, but these legacy technologies are being phased out over the course of the next decade to free up spectrum for next generation networks and remove barriers to new companies entering the telecoms supply chain.

4G revolutionised the way people use their mobile phones, supporting access to bandwidth-hungry content on platforms like YouTube. Today, a 4G mobile phone can process data four times as fast as a 2G equivalent at the turn of the millennium.

By building world-class, secure digital infrastructure networks, we can realise the vision we set out in our [Digital Strategy](#) for a competitive and innovative digital economy, support our vision for new technologies like that set out in the [AI Regulation White Paper](#) and deliver on our commitment to grow the economy. This will play an important role in:

- **underpinning other new technologies** - the next decade will see the development and maturation of transformative technologies from AI and self-driving vehicles to digital twins, which will drive demand for advanced wireless connectivity. Our £200 million 5G Testbeds and Trials Programme invested in a wide range of projects from testing healthcare applications in Liverpool to delivering 5G music lessons between Bristol and London to help build the business case for investment in 5G applications. But this is only the beginning
- **transforming public services** - there are also significant benefits for improving our public services, supporting smart cities which are cleaner and less congested and delivering connectivity to our schools and hospitals that will provide better, more interactive lessons and personalised healthcare

By transforming our economy, widespread adoption of 5G can bring a cumulative productivity benefit of £159bn by 2035, driving growth and inward investment, and improving lives for communities in every corner of the country. By ensuring that everyone can access the technology they need, including through specific support for rural economies by enabling applications such as agritech, we can make it as easy to start and scale up a digital business in rural Yorkshire as it is in central London.

Challenges

However, there are challenges we need to address to ensure the UK can realise these benefits, as the economics of investing in wireless networks are changing:

- high costs of upgrading and maintaining networks are exacerbated by falling revenues and global inflation

- we still need to overcome uncertain demand for 5G-enabled services and continuing practical barriers to network deployment need to be overcome
- many of the economic benefits we have identified require significantly higher quality connectivity than is likely to be deployed in national public networks - for example, smart factories, where remote repairs and self-driving vehicles can significantly improve productivity, may require a dedicated private network
- 5G roll-out in the near term is likely to focus on urban areas, where the commercial returns are more certain
- research we commissioned shows significant variation in the quality of mobile coverage in different parts of the country over the next decade - economically important areas like Freeports and industrial parks could be underserved
- new and existing applications also require access to spectrum - but this is a finite and increasingly contested resource.

Market dynamics are also changing:

- **newly emerging operators** including private network, satellite and neutral host providers – have a key role to play in delivering advanced wireless connectivity
- **demand is uncertain** as connectivity moves beyond smartphones to enable an array of new, innovative use cases, businesses and the public sector will need to navigate an increasingly complex ecosystem to get the connectivity they require. As many businesses and local authorities do not yet clearly understand the benefits 5G offers or how they can effectively deploy 5G-enabled services to realise these benefits, there is no clear articulation of the demand for higher quality services. In turn, this makes it more challenging for providers to make the business case for investment
- **private networks are increasing in number**, powering innovative use cases in key sectors. To unlock the full benefits of digital connectivity, it will be essential to build, design and manage private telecoms networks securely. Our planned call for information on the security of private telecoms networks will help us to better understand how dependent critical sectors are on private telecoms networks and consider how the government can help ensure their secure development.

We are determined to address these challenges. Through this strategy, we set out a new policy framework with six key steps to do just that, and ensuring that the UK maximises the potential of advanced wireless networks over the next decade, securing our international competitiveness for the future and driving economic growth across the UK.

How we will do this

1. Ensuring good connectivity for all

As networks are upgraded with 5G technologies over the next decade, 4G will continue to play an important, albeit diminishing, role in providing mobile connectivity across the UK. Through our £1 billion Shared Rural Network programme we are moving further and faster to push 4G coverage to 95% of the UK's landmass.

Coverage reporting also needs to improve so that it more accurately reflects consumers' actual experience, equipping them with the information they need to choose the right contract. In turn, we expect this to drive further commercial investment to address previously unidentified gaps - ensuring that people and businesses get the connectivity they need, whether to start and grow a business or to have a remote healthcare appointment.

To continue to drive good connectivity for all, we are taking action on two key points:

a) Reporting:

- **we have asked Ofcom to continue to hold the mobile network operators (MNOs) to account through on-the-ground signal testing and to improve the accuracy of its coverage reporting through increased use of crowdsourced data**
- **we have also asked Ofcom to consider how it can improve the accuracy of reporting of network performance levels in rural areas and for indoor coverage, to help policy makers and industry understand where coverage improvements are needed**
- **to help commuters and other rail users, we will work with Ofcom to increase their reporting on coverage on the rail network, and to assess the cost and feasibility of reporting this data annually**
- **we have also emphasised to Ofcom the importance of it continuously reviewing how it defines and measures good coverage of 4G and 5G networks to ensure that this reflects new and increasing uses**

b) Affordability:

- **we will continue to work with the industry, Ofcom and other stakeholders to ensure that services are affordable, including for those who are struggling to pay**
- **we will also continue working with Ofcom to monitor general affordability in the market**

We want rural economies to benefit from the huge benefits connectivity offers. That is why we will be appointing a Rural Connectivity Champion to report to DSIT and Defra Secretaries of State to remove local barriers for deployment and promote digitally based innovation in rural areas.

2. Setting a bold 2030 ambition

Given the substantial potential that 5G offers for businesses and public service delivery, we are setting out a bold vision for the next generation of our national networks to galvanise investment across our economy. We want to move beyond the basic 5G that is being deployed now over 4G networks to build higher quality, standalone 5G networks that do not rely on older infrastructure. We also want to extend 5G coverage well beyond cities and towns to all populated areas of the UK, including rural villages and communities.

We are therefore setting a new headline ambition for the UK to have nationwide coverage of standalone 5G to all populated areas by 2030.

This ambition is rightly stretching and we will work with the industry to achieve it. This strategy sets out the policy framework we will implement to do that - removing barriers to investment and stimulating demand - recognising the need for ongoing dialogue with key stakeholders.

3. Strengthening the investment climate

While the government already has a range of policies in place to drive forward the deployment of digital infrastructure, our 2030 ambition requires significant commercial investment. We are therefore committed to creating an environment where commercial investment can thrive, increasing competition, driving down costs and improving demand for MNO services.

This includes:

- continuing to remove practical barriers to the deployment of 5G infrastructure
- confirming our openness to market consolidation, noting that merger decisions are taken on their merits by the Competition and Markets Authority
- continuing to work across government departments to ensure that new policies and regulation have a positive impact on investment in wireless networks wherever possible
- reducing regulatory barriers to investment and innovation by:
 - a. **Ensuring that net neutrality rules are fit for purpose and support operators' ability to innovate and invest in infrastructure - with due consideration for broader policy implications across the digital and media sectors**
 - b. **asking Ofcom to review and set out a clear evidenced-based and forward-looking rationale for its approach to setting spectrum fees by the end of 2023**
 - c. **working with Ofcom and industry to reform spectrum where it is not being used efficiently**
 - d. **ensuring spectrum governance arrangements are working as intended**

- e. **maximising the UK's influence at international spectrum negotiations, with alignment of international and domestic spectrum frameworks where possible**
- f. **ensuring eligible mobile network operators benefit from the relief available in Freeports, Investment Zones and other economic areas with similar regimes**

4. Realising the full benefits of 5G

We want people, business and public services across the UK to realise the full benefits of 5G and advanced wireless connectivity. However, without concerted action, this will be slow to materialise and limited to larger businesses, in fewer sectors, and in certain geographies.

Supporting places to attract investment: we set out how we will drive greater opportunities for industry and public service providers to be empowered customers for future connectivity solutions – supporting places to attract investment and encouraging adoption of 5G services.

We will do this by:

- **encouraging commercial investment in wireless connectivity by supporting local authorities to identify and aggregate industrial and public sector demand for advanced wireless connectivity and build a clear business case for investing in it**
- **supporting secure new entrant providers, and scaling up existing provision, such as through neutral host operators and private network providers**
- **driving local leadership and coordination, and encouraging local authorities across the UK to employ digital champions to provide strategic leadership for local authorities' own digital infrastructure strategies**
- **providing up to £40m for regions and local authorities across the UK to establish themselves as '5G Innovation Regions' to promote innovation and growth through investment in, and scaled adoption of, 5G and other advanced wireless technologies by business and public services**

5. Driving adoption

Without a clear direction, uptake of public services enabled by advanced wireless connectivity may remain slow. In this strategy, we set out a comprehensive suite of

policies to drive up the adoption of 5G and advanced wireless technologies by the public sector and connected places.

Leading by example: As a user of 5G, government must lead by example, maximising the potential of wireless technologies to enhance everything we do. We will work across Whitehall departments to drive innovation in public services through public sector adoption of 5G and other advanced wireless connectivity by:

- **building on the work by the [Government Office for Science](#) and working with key departments to understand how 5G and advanced wireless technologies can support delivery of key government's objectives and improve public services**
- **ensuring that digital connectivity requirements for future users of infrastructure are at the heart of major infrastructure projects**
- **bringing the full purchasing power of government to support public sector adoption, and working with the Crown Commercial Service to drive demand for 5G use cases**
- **today, we are announcing that our new hospitals will be 5G or equivalent wireless enabled - with this crucial step, we will be in the position to take advantage of cutting-edge healthcare innovations**
- **supporting smart places, by highlighting the benefits of 5G and promoting investment in 5G-enabled services by local and regional authorities**
- **establishing a Digital Infrastructure Advisory Group made up of a selection of regional digital leaders to advise the government on how places can act to promote investment in and adoption of digital connectivity**
- **supporting local authorities and regions across the UK with digital infrastructure and connectivity ambitions as part of any City Region and Local Growth Deal, Devolution Deal, Investment Zone, or Levelling Up funding activities**

We will work with the devolved administrations to realise our UK-wide ambitions, ensuring businesses are ready to take full advantage. We will galvanise the adoption of industrial 5G, driving productivity, growth and better paid jobs across the economy. Through this strategy, we will address barriers to the supply and adoption of private networks by:

- **undertaking a nationwide campaign to drive 5G adoption by business**
- **working with Ofcom to continue to improve access to spectrum, through measures including the automation of shared access spectrum licence applications by 2024, ensuring that this finite resource is an enabler rather than a barrier to innovation**

- **working with the telecoms industry and other sectors to assess the role 5G and advanced wireless connectivity can play in delivering net zero to the UK**

6. Shaping the development of 6G

And we are not just thinking about tomorrow. We are thinking about the day after, too, and drawing on our expertise and experience to shape the global debate on the vision and standards that will underpin 6G. The international race to develop 6G has already started, and we have a significant opportunity to shape this sixth generation of wireless connectivity to maximise its benefit to the UK's economy and society so that it supports the UK's international competitiveness in the decades ahead. Through our 6G Strategy we will harness and develop the UK's strengths in telecoms and ensure that the UK can influence and benefit from the development of 6G in a way that meets the future connectivity needs of people, businesses and public services.

We will do this by:

- **investing up to £100m in future telecoms research and development, including through the Engineering and Physical Sciences Research Council's (EPSRC) Future Telecoms Research Hubs, putting the UK at the forefront of the diverse 6G research agenda**
- **developing a UK 6G vision and advocating for it at international fora**
- **forging international alliances to conduct joint research and expand our influence**
- **working with relevant standards bodies to shape our 6G future with the UK's key interests in mind**
- **considering whether the spectrum management framework remains appropriate to support future networks - setting out a roadmap for the UK for 6G**

Implementation

As we implement this strategy, we will work closely with the devolved administrations, telecoms industry, public sector, academia, investors and other key stakeholders. We will closely monitor future developments too, including any need for further actions beyond those outlined.

As part of our work to set a clear vision for wireless infrastructure, we have published a statement on the government's spectrum priorities, which looks at spectrum for digital communications infrastructure as well as its broader uses.

Chapter 1 - Approach and scope

This strategy sets out a policy framework to help deliver the government's priority of growing the economy and to ensure the UK benefits from advances in wireless connectivity for the next decade. We have considered the major technological developments that we expect will occur, and the vast potential these offer for the UK economy and society. We have also considered the challenges and barriers to investment in - and adoption of - advanced wireless connectivity and the uses it enables.

To inform the development of this strategy, we have undertaken extensive evidence gathering. We have commissioned reports from Analysys Mason, Oxera and Cambridge Econometrics that assessed the level of market supply and provided us with an understanding of the economic benefits of 5G.

We also conducted a call for evidence in November 2021. This attracted over 75 responses from the telecoms industry, local and regional authorities, academia and business trade bodies. This evidence played a crucial role in building our understanding of future demand for, and supply of, wireless connectivity and where the government needs to act. We would like to thank all of those who responded.

We have worked closely with Ofcom as we have developed this strategy. Ofcom has recently published its [Mobile Market Review and Mobile Spectrum Demand Study](#), which sets out its future approach to mobile markets. The government's Statement of Strategic Priorities (SSP), laid before Parliament in 2019, set out the government's priorities for Ofcom in this parliament. We will continue to work with the regulator as we move to implement the various measures in this strategy, and the policies in this strategy will be important considerations as the government updates the SSP.

We recognise the critical role spectrum plays in delivering digital communications and in many other sectors, such as defence. Alongside this strategy, we have published a statement on the government's spectrum priorities and updated governance arrangements to ensure that spectrum plays a full role in support of the UK's aspirations as a science and technology superpower.

In terms of scope, we take into account the full range of wireless technologies for communications services. Given the continued importance of cellular mobile networks, we naturally have a significant focus on 4G and 5G but also recognise the role of other wireless technologies such as Wi-Fi, as well as the use of satellite communications services, private networks and low power wide area networks. This strategy recognises the significant and continuing evolution of wireless technologies and the telecoms market more broadly. The main emphasis of our policy making is in relation to cellular networks, but we recognise the continuing importance of

technologies such as Wi-Fi for indoor coverage and networks aimed primarily at IoT technologies. We provide more detail on the evolution of wireless networks in the [Annex](#).

The remaining chapters in this strategy are structured as follows:

- Chapter 2 - Ensuring good connectivity across rural and urban areas
- Chapter 3 - Our 2030 ambition
- Chapter 4 - Strengthening the investment environment
- Chapter 5 - Realising the full benefits of 5G and advanced wireless connectivity
- Chapter 6 - Driving adoption in key economic sectors
- Chapter 7 - Shaping the development of 6G
- Chapter 8 - Conclusion
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Chapter 2 – Ensuring good connectivity across rural and urban areas

The government's priority to build a better, more secure, more prosperous future for the UK includes a clear commitment to grow the economy, and create better-paid jobs and opportunity right across the country. To do this, it is vital that people who live and work in all parts of the UK, including in rural areas, have access to good quality mobile and broadband coverage.

Project Gigabit

We have set an ambition to deliver gigabit broadband to at least 85% of premises by 2025 and to reach at least 99% by 2030 and to support rural communities by ensuring that 95% of the UK landmass has 4G coverage by 2025. We have in train policies to transform the UK's telecoms infrastructure through the deployment of secure and resilient fixed and wireless networks.

Our £5 billion Project Gigabit programme is being delivered by Building Digital UK (BDUK). Progress to date means that Project Gigabit has now made over £1 billion of public money available to extend gigabit-capable broadband to some of the hardest to reach parts of the country, and BDUK continues to award a steady stream of multi-million pound Project Gigabit contracts to broadband suppliers. In January, the government announced £36 million of public funds to help deliver to just over 19,000 premises in [parts of Cornwall](#). This commitment builds on £129 million [announced last year](#), connecting hundreds of thousands of people in Dorset, Teesdale, Northumberland and Cumbria. The government has also made a commitment that every school across the country will be able to access high speed internet by 2025, ensuring pupils can link up with others anywhere in the world to learn from one another and access an ever-growing library of online tools designed to make lessons more fun and engaging.

These policies are working: 74% of UK premises now have access to gigabit broadband, up from 6% in 2019.

Our Gigabit Broadband Voucher Scheme provides a subsidy to help people in hard-to-reach communities upgrade their broadband connections. The scheme provides more immediate help with the costs of installing broadband to rural communities and businesses, which it would be otherwise uncommercial for operators to connect.

Shared Rural Network

According to Ofcom's [Connected Nations annual report 2022](#), 92% of the UK landmass is covered by a good 4G signal from at least one MNO, while 70% of the

country is covered by all four operators. Ofcom also reports that the UK has 99% 4G indoor premises coverage from at least one MNO, and 84% from all four operators.

4G geographic mobile coverage will extend to 95% of the UK's landmass through the Shared Rural Network programme, the £1 billion deal with the MNOs announced in March 2020. The programme is on target to deliver by the end of 2025, and further improvements in the more hard-to-reach areas will continue until the start of 2027. Ensuring good mobile connectivity will support the delivery of the Emergency Services Network that will replace the current Airwave service used by the emergency services in Great Britain and transform the way they operate.

Whilst much of this strategy is focused on achieving the shift from basic 5G to higher quality, standalone 5G (see chapter 5), we also recognise that 4G will continue to have an important role to play in delivering mobile connectivity to people and businesses across the country. **We restate here our commitment to ensuring good quality mobile coverage where we live, work and travel across the UK and improving the quality of mobile coverage reporting data. We also want rural economies to benefit from the huge benefits connectivity offers. Our 10 point plan for rural connectivity sets out how we will achieve this, including that we will be appointing a Rural Connectivity Champion to report to DSIT and Defra Secretaries of State to remove local barriers for deployment and promote digitally based innovation in rural areas.**

The government's ambition for the majority of the population to have 5G by 2027 was met five years early and 5G coverage is now available from at least one operator to at least 77% of premises.¹ Even as 5G is more widely deployed, 4G will continue to have an important role to play and is expected to co-exist, albeit to a diminishing extent, as networks are upgraded to 5G.

Our 10 point plan for rural connectivity

- 1. The £5bn Project Gigabit will deliver future proof broadband to rural areas, with £1bn already made available.**
- 2. In very hard to reach areas, where it will be uneconomic to deliver gigabit broadband, the Government will work with industry to ensure that these premises get improved broadband, where required.** This year we will:
 1. launch an £8m fund to provide capital grants to further promote new satellite connectivity to the most remote 35,000 premises.

¹ Ofcom reports on the availability of 5G across a range of thresholds based on signal strength. A high degree of confidence is where a signal strength of -110 dBm or better is predicted with at least an 80% probability of coverage being present in the predicted location.

2. set out plans to encourage the provision of fixed wireless access to other hard to reach areas
3. **We are already investing £1bn in the Shared Rural Network to deliver 4G coverage to 95% of the UK landmass, with the biggest coverage improvements in rural parts of Scotland, Northern Ireland and Wales**
 - this will also deliver 4G coverage on a further 16,000 km of roads, with further indirect improvements over time, including a boost to 'in-car' coverage on around 45,000 km of roads.
 - and we improve geographic coverage to 79% of Areas of Natural Beauty, benefitting millions of visitors every year
4. **We have asked Ofcom to improve mobile coverage reporting, including** in rural areas
5. We are establishing a **new headline nationwide ambition for 5G** in all populated areas by 2030, and this will include connectivity in areas classified as rural - backed by measures that help improve economics of rural rollout
6. We are establishing a new **£40m 5G Innovation Fund** to establish 5G Innovation Regions. Driving innovation through adoption of advanced wireless technologies across rural industries will be a key focus of 5G Innovation Regions - supporting *5G-enabled innovation everywhere*.
7. We are funding a new **5G adoption campaign** that will help support adoption and investment in key sectors, including agri-tech
8. **We are working with Ofcom to improve access to spectrum for rural network providers**, making it easier for networks to be deployed and for innovative use cases to be realised
9. We will be appointing a **Rural Connectivity Champion** to report to DSIT and Defra Secretaries of State to remove local barriers for deployment and promote digitally based innovation in rural areas
10. **We are continuing to remove barriers to deployment in rural areas**, including changing planning regulations, making it quicker and easier to roll out digital infrastructure

Improving measurement and reporting of mobile coverage

We recognise how frustrating it is when a user's experience does not match up to expectations and the reported coverage, and want to see the accuracy of coverage reporting substantially improved.

An accurate picture of mobile coverage is becoming increasingly important as more and more critical services in sectors rely on coverage to function. Consumers should be able to make an informed choice of service provider, policy makers need accurate information on which to base their decisions, and network operators need accurate information on which to base their investment plans. Inadequate reporting of coverage is one of the barriers to improving connectivity in rural areas - improving coverage reporting highlights gaps in coverage and where networks need to be improved in all areas of the country.

Ofcom's Connected Nations report provides data on the availability of mobile coverage outside of premises to a granularity level of 100m x 100m map grid cells. This measurement is based primarily on predictive radio planning models submitted by the MNOs, which have been updated to model 5G deployments. Ofcom regularly carries out [drive testing](#) of mobile signal strength to assess whether these predictions are accurate across different regions and terrains. Modelled predictions can only provide a probabilistic view of coverage, leading to frustrations for consumers and challenges for businesses who do not get the coverage that they are expecting.

Factors that can impact the accuracy of the computer-modelled data include network capacity, handset capabilities, signal interference and local geographical factors, such as the presence of hills and buildings. The impact of local factors is a particular issue for reporting indoor coverage, for which Ofcom applies an average building entry loss factor to all buildings, which does not reflect differences in building materials which affect signal penetration.

Ofcom currently measures 5G availability based on the minimum signal strength required for devices to establish a reliable 5G connection and uses this to report on 5G availability with a 'high' or 'very high' degree of confidence. Predicted levels of 5G coverage can differ substantially between the 'high' and 'very high' confidence levels.

A number of respondents to our Call for Evidence called for coverage data to more accurately reflect real-world consumer experiences. Both mobile network operators and public sector organisations suggested that appropriately gathered crowd-sourced data² should play a greater role in the provision of coverage data.

The National Infrastructure Commission's report on [infrastructure, towns and regeneration](#) found that Ofcom's current reporting on 4G coverage did not correspond

² Crowdsourcing is an approach that gathers network performance measurements from the user experience perspective, over many different devices, to build up a view of the network quality in an area.

with users' experience of 4G coverage in towns. The study found that persistent connectivity problems are relatively rare with only 5% of 4G mobile users not able to successfully connect to a 4G network more than 20% of the time.

We have therefore asked Ofcom to continue to hold the MNOs to account through on-the-ground signal testing³ and to improve the accuracy of its coverage reporting through increased use of crowd-sourced data.

Furthermore, we have asked Ofcom to report on the extent of standalone 5G coverage as it starts to be deployed. This will help us track progress towards our 2030 ambition for standalone coverage in all populated areas (see Chapter 3).

Better information on network quality

Beyond coverage, Ofcom has committed to reporting on a broader set of performance indicators that determine people's quality of experience, and how information on performance can be used to support customer choice, promote investment in networks and improve quality. Ofcom has introduced new key performance indicators for 4G and 5G network performance. These indicators combine a number of technical thresholds to give an overview of performance as set out in the following table from Ofcom's Connected Nations 2022 report.

Table 1: Ofcom performance key performance indicator technical thresholds

	Download speed	Upload speed	Latency	Jitter	Packet loss	Time to first byte
Good	2Mbps	0.5Mbps	100ms	20ms	4%	1.2s
High	5Mbps	1Mbps	50ms	15ms	2%	0.8s
Very high	10Mbps	2Mbps	30ms	10ms	1%	0.5s

Ofcom has used these new metrics to provide an overview of network quality at the postcode district level. This data was provided using crowdsourced data provided by Opensignal. We welcome this work by Ofcom and their commitment to continue to refine their approach to providing network performance data.

Postcode districts in rural areas are larger than urban areas and the number of devices in rural areas providing the crowdsourced data is likely to be lower than in urban areas. This means that it is challenging on this basis to achieve the same accuracy at the same level of granularity in rural areas. **We have therefore asked**

³ Crowdsourcing gathers network performance measurements from user devices without needing user initiation

Ofcom to consider how it can improve the accuracy of reporting of network performance levels in rural areas.

It is important that the key performance indicators continue to reflect emerging use cases and applications and changing consumer expectations. **As such, it would be helpful for Ofcom to keep under review the key performance indicators as reported in Connected Nations to ensure that they are appropriate for future use cases and applications as well as the deployment of standalone 5G.**

We welcome Ofcom's plans to make available further information on quality of performance through its coverage checker tool - particularly if this is supported by a clear description of what the different performance levels would enable consumers to do through mobile networks.

Satellites, drones and fixed wireless access technology for rural coverage

Developments in both low earth orbit and geostationary orbit satellite technology mean that satellite technology is likely to play an increasingly important role in delivering broadband and mobile connectivity to remote areas, providing backhaul for cellular networks and establishing reliable narrowband links to IoT devices. The latest 5G standards begin to integrate commercial satellite and terrestrial mobile networks, providing technical specifications for direct-to-device 5G over satellite. We are starting to see commercial partnerships between satellite operators and mobile operators. It is now foreseeable that the integration of terrestrial and non-terrestrial networks will eventually lead to ubiquitous network coverage.

In recent years the satellite industry has seen significant reductions in production costs, and improvements in reliability and efficiency and, although we expect this to continue to improve, it should be noted that the business models for these connectivity solutions have not yet been proven.

DSIT is continuing to work closely with Ofcom to ensure that the UK's regulatory environment supports the deployment of satellite connectivity as the market matures. Satellite is also an important element of our rural connectivity policy ambitions. High altitude platforms and drones could also potentially play a role in improving coverage. For example, Virgin Media O2 has trialled the use of 5G drones to help emergency services patrol national parks.

Wireless connectivity can play a crucial role in delivering fixed broadband to the hardest to reach areas of the country. Fixed Wireless Access (FWA) employs 4G and 5G technology to bring enhanced broadband connectivity to homes and offices and is often used as an alternative to the last-mile of fixed connectivity where deploying fibre infrastructure affordably is challenging. Similarly, satellite can offer connectivity in areas where both fixed and mobile networks are not available due to cost barriers

particularly in rural or remote areas. In December 2022, we launched our first “Alpha Trials” to test new, low-latency low earth orbit (LEO) satellite connectivity. This technology, which has not yet been tested at scale in very hard to reach areas, could be one of the potential solutions to improving digital connectivity in these areas, complementing more readily upgradeable terrestrial wireless solutions.

The Alpha Trials will enable the government to test the capability of, and the response to, this new evolving technology. In addition, we will be able to better understand whether LEO satellites can offer a viable solution for those premises beyond the reach of gigabit-capable broadband, or other publicly funded schemes.

As well as testing the technical capabilities of the technology, the trials will assess what benefits faster connectivity will bring to these remote premises. Recent tests have shown that in many locations LEO satellites can deliver speeds of up to 200 megabits per second - well above the speeds capable of being delivered via copper fixed line connections commonly used in these communities today.

Satellites have already shown that they can quickly deliver to areas where other technologies are unable to - for example in Ukraine where Starlink has delivered capacity to enable internet access for both military and civilian use - and these trials will help us to seek to understand how this could help our own delivery.

The government has now announced sites in a wide range of locations across the UK, including in small island locations in England and Scotland. We remain in discussions with, with further trial sites in order to ensure a variety of areas are represented. .

The Alpha Trials will help us to better understand the full capabilities of low earth orbit satellite broadband as we move forward with our programme to connect the small number of very hard to reach homes and businesses across the UK that may be too difficult or expensive to connect via physical cables or terrestrial wireless solutions.

Upgrading the analogue Public Switched Telecoms Network

Ensuring good mobile connectivity will be increasingly important as the telecoms sector upgrades the analogue Public Switched Telecoms Network (PSTN) to digital voice services (VoIP) by 2025, due to the reliance of VoIP services on battery power in the event of an electricity network failure. Where indoor mobile coverage is poor or unreliable, there are a number of broadband-based solutions to make calls on services such as WhatsApp and Wi-Fi calling, alongside use of femtocells. However, while all MNOs offer Wi-Fi calling to their customers, not all mobile phones are configured to support this feature. The changing nature of the UK’s telecoms infrastructure and the move to digital means it is essential that we ensure that disruption is minimised and customers are protected, particularly those that are more vulnerable.

Mobile network resilience

The power resilience of mobile networks is becoming increasingly important for keeping people connected in the event of a power outage. In recognition of this, the Secretary of State has asked Ofcom to review how all communications providers are meeting the needs of their customers. The government continues to work closely with Ofcom to understand what may be considered appropriate and proportionate, while also working in partnership with the energy sector and its regulator - Ofgem - to better understand the co-dependencies and improve our joint approach to building resilience for the future.

Connectivity on transport networks - roads

There are currently good levels of 4G availability on the UK's roads network. In-car 4G coverage on motorways and A roads ranges from 83% to 88% across the MNOs, and 73% to 79% for B roads ([Ofcom Connected Nations 2022](#)). Outside vehicles, 4G coverage ranges from 94% to 98% across MNOs for motorways and A roads. The Shared Rural Network programme will deliver 4G coverage on a further 16,000 km of roads, with further indirect improvements over time, including a boost to 'in-car' coverage on around 45,000 km of roads.

To support the government's ambition to decarbonise road transport, the Office for Zero Emission Vehicles published the [UK Electric Vehicle Infrastructure Strategy](#) in March 2022 to accelerate the rollout of electric vehicle charging infrastructure in homes, on streets, at venues and on main roads. Public charging points will require the facility to pay for charging, and this in turn will require reliable coverage from all four national mobile networks at charge point locations. See Chapter 6 for more on emerging demand for connectivity from road users

Connectivity on transport networks - rail

Coverage on the rail network remains patchy. Responses from the rail industry, mobile operators and network vendors to our Call for Evidence were clear that connectivity for passengers on the railways is unsatisfactory, with passengers often struggling to connect to a network or carry out activities such as working online, accessing the internet or making a call. Not only is this frustrating for consumers but it acts as a barrier to growth and productivity.

There are a number of challenges that, over time, have contributed to the difficulties of improving connectivity along rail routes. Railway lines often run through cuttings and pass through tunnels so that signals from masts placed outside of the rail corridor cannot reach the trains. Trains may also run through rural areas with limited mobile coverage. Trackside infrastructure is necessary to provide a consistent signal, but this is more costly and complicated to deploy, as operators can only deploy infrastructure

when the railway line is not in use. Furthermore, the process to access trackside infrastructure is complex and resource intensive.

The National Infrastructure Commission's publication [Connected Future: Getting back on track](#) suggested that the government needs to address several areas to improve rail connectivity, including addressing the cost and complexity of deploying infrastructure alongside railway lines. The review recommended that the processes for accessing trackside infrastructure should be clarified and that DfT should facilitate access. To address commercial barriers, the review recommended that the government set out plans for the running of competitive processes to improve connectivity on specific rail routes.

DfT is taking a number of steps to continue to improve the passenger experience of digital connectivity on rail routes. Past initiatives include free on-train Wi-Fi on the majority of trains, coupled with selective improvements in addressing rail 'not-spots'. Recent initiatives include MerseyRail's dedicated infrastructure solution and Network Rail's procurement of a neutral host solution on the Brighton Mainline. The Brighton Mainline neutral host provider, Cellnex, recently signed an agreement with Three UK to host its voice and mobile data equipment on Cellnex's infrastructure. This will provide enhanced connectivity along the Brighton Mainlines for Three UK customers.

In 2021, Network Rail announced that it was seeking private sector investment for a 30-year concession called 'Project Reach', which will deliver new high fibre count cables and neutral host infrastructure on key railway routes. Project Reach's aims are twofold: the first to deliver a nationwide backbone of high-count fibre substantially upgrading Network Rail's current infrastructure, and the second to improve mobile connectivity in select stations and mainline routes.

In addition to Project Reach, the government welcomes the work of Evo-rail, a telecoms company part of FirstGroup, that has developed 'rail-5G' as the first multi-gigabit internet solution built for the railways. Rail-5G can dramatically improve connectivity on trains, with the technology enabling the delivery of superfast continuous internet, at 50 times the current average speeds.

In December 2019, Ofcom published mobile coverage measurement data for all four national MNOs gathered along the rail network in England, Scotland and Wales. This data was collected using antennas mounted on the outside of four of Network Rail's yellow engineering trains and published in its raw form. DfT is exploring the possibility of repeating this exercise.

The National Infrastructure Commission recommended that Ofcom should report at least every two years on the extent and quality of mobile coverage on the railways. This would ensure that progress to improve rail connectivity is accurately tracked.

In order to obtain an accurate picture of connectivity for on-train passengers, the signal would need to be tested from within the train, rather than outside of the train.

The complexity of obtaining this data is compounded by the fact that the consumer experience will be different on different kinds of rolling stock and that a busy in-carriage environment is not suitable for the technical ways of measuring coverage outside of carriages.

To help drive growth and productivity across the UK, government is asking Ofcom to report annually in their Connected Nations report on the availability of mobile coverage from each MNO on UK mainline rail routes and to present this data in a way that provides meaningful information to consumers. We have therefore asked Ofcom to advise the government on the cost and feasibility of obtaining this data annually.

Supporting and empowering consumers

For the full economic and social benefits of wireless connectivity to be delivered, consumers need to take up and fully exploit the innovative services made possible by the new networks. They need to understand the benefits of new networks, and have trust in providers and the new technologies they enable. The government and Ofcom have therefore implemented a range of measures to protect and support consumers.

In 2019, the government's Statement of Strategic Priorities set out key objectives for Ofcom: (i) to support consumer access information and data necessary to make informed decisions relating to their telecoms service, and (ii) for the removal of barriers preventing consumers switching services. In response to these objectives, Ofcom and the government have brought forward policies to empower consumers in the market, including end-of-contract notifications. Since February 2020, Ofcom have required communications providers (phone, broadband and pay-TV) to issue customers, nearing the end of their contract, information alerting them to the imminent end of their contract, details of any price increase which may take place following its expiry as well as new deals and offers available to them.

We also recognise that a key barrier preventing adoption of new wireless networks by consumers and business is the cost of services. While it is reasonable to assume that costs will fall as new wireless technologies become increasingly ubiquitous and 5G becomes the *de facto* standard, we consider it essential that as many people as possible should be able to benefit from the new services offered by these new networks.

To support affordability and internet access, we have worked with providers to enhance the number and promotion of [affordable tariffs](#) that are specifically designed to support low income families – this includes tariffs for mobile phone services. More is needed to ensure those who are entitled to social tariffs are aware of the help available. In November 2022, the government - as part of the national Help for Households campaign - launched a national social tariff awareness campaign and we continue to work closely with industry, charities and consumer groups to spread the

message. The government is also ensuring the sign-up process is as seamless as possible. In August 2022, the DWP released a new, digital tool for providers to check eligibility at the point of sale. The new tool allows people to sign up faster, but has also given a number of operators confidence to bring forward new or improved social tariffs into the market. We will continue to work with Ofcom to monitor the general affordability in the market and the take-up of social tariffs.

Chapter 3: Our 2030 ambition

World-class digital infrastructure underpins the digital economy – it was worth [£143 billion](#) in 2021, accounting for [5%](#) of the national workforce. This infrastructure provides the backbone of the UK economy and society with ever more jobs, public services and societal interactions built upon its foundations. As growth in the digital sector is nearly [six times faster](#) than across the economy as a whole, its importance will only continue to increase as we deliver the Prime Minister’s priority of growing the economy. We want to unlock opportunities for growth and prosperity across the UK - from fintech and E-Commerce, to entertainment services, connected transport and smart communities.

4G technology revolutionised the way people use their mobile phones. What today is considered normal, a decade ago was ground-breaking. We have seen the growth of streaming services, like Netflix and Spotify, and gained constant access to high-quality, user-produced content for free on platforms like YouTube, transformed the way we shop online, travel around cities through access to apps like Uber and Bolt and use public services, such as booking NHS appointments through apps. According to Ofcom’s [Communications Market Report](#), there are already close to 100 million mobile subscriptions in the UK, and a significant and growing number of machine-to-machine subscriptions.

The evolution of 5G

While 4G will continue to play an important role in providing widespread geographic connectivity to consumers through public cellular networks across the UK’s landmass, 5G can offer significantly better performance and support a far greater range of use cases. 5G enables data transfer speeds of more than 10 times faster than 4G, has the potential to offer lower latency and greater reliability and the ability to connect more devices. The implications of these improvements reach far beyond the potential to develop the capabilities of smartphones, enabling an array of innovative use cases and providing for transformative economic, and social benefits that were perhaps unimaginable a decade ago.

The government’s ambition for the majority of the population to have access to a 5G signal by 2027 has been met early through the deployment of basic, or non-standalone, 5G which is built on a 4G core network. While this has helped MNOs increase the capacity of their networks in more densely populated areas, it does not reflect the full functionality 5G can deliver.

The government has helped make the business case for 5G through the 5G Testbeds and Trials programme, investing £200 million in projects across the UK to deploy and

test 5G technology. We set out what this programme has achieved and how we are building on it in chapter 5.

For businesses, and particularly industry 4.0, where businesses are integrating new technologies including AI and machine learning into their operations, 5G can be a critical enabling technology. It can help increase productivity and efficiency by driving autonomous machines, enabling asset tracking and predictive maintenance and increasing the lifespan of machinery. In the public sector, 5G can support remote healthcare monitoring and smart city applications.

5G comes in different forms, with different features and functionalities which enable different applications. It is also being deployed in stages, which will be rolled out over the course of the decade.

Non-standalone 5G

In the UK, as in other countries, operators have begun rolling out 5G by deploying 'non-standalone' 5G ('5G NSA') which enables the 5G Radio Access Network (RAN) to connect to the 4G Core. This has allowed for 5G to be rolled out at pace and without the cost of building a new end to end 5G network from scratch. Most of the 5G infrastructure currently deployed in the UK is 5G NSA. 5G NSA offers consumers increased speeds and bandwidth to improve experiences such as streaming and video calls but cannot support the full range of capabilities that 5G ultimately will enable. It instead is providing enhanced mobile broadband (eMBB) in the form of important capacity upgrades in population centres via higher data rates and access to additional spectrum bands.

Standalone 5G

Standalone 5G ('5G SA'), which utilises a 5G network core, is required as the first step towards full 5G functionality in mobile networks. 5G SA will enable ultra-reliable, low latency communications, large numbers of Internet of Things (IoT) connections in discrete small areas, such as high-tech factories, (massive IoT), network orchestration (modifying network capacity in response to demand) and network slicing. This will enable applications such as self-driving vehicles or remote healthcare. As 5G NSA infrastructure is upgraded to 5G SA, starting in 2023, more 5G use cases will be developed and become available for consumers and enterprise customers.

Advanced 5G

5G standards are continually evolving. The first 5G standards release focused on the provision of enhanced mobile broadband, and the technology which enables ultra-reliable low latency communications and massive IoT is only now coming to market. 5G Advanced is expected to become available in 2024 and, building on 5G SA, will likely include use of artificial intelligence and machine learning techniques to further

optimise network performance and support for extended reality applications. Further functionality improvements of 5G will enable the most advanced 5G use cases to support transformation of public services and innovation in key business sectors such as advanced manufacturing and transport and logistics.

Each 5G deployment stage will introduce new features and functionalities and enable different applications:

Table 2: New features and functionalities of 5G deployment stages

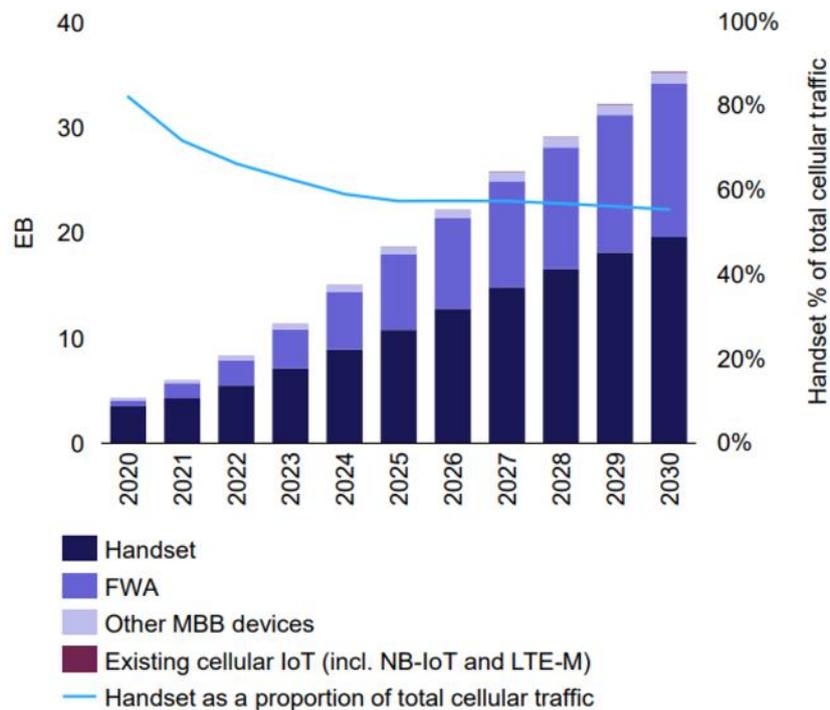
5G Non-Standalone	5G Evolution Standalone	5G Advanced
Enhanced Mobile Broadband (eMBB) Internet of Things (IoT)	Ultra-reliable Low Latency Communications (UR- LLC) Massive IoT Edge computing Network Orchestration Network Slicing Non-terrestrial Networks Enhanced Location Positioning	Artificial Intelligence (AI)/ Machine Learning (ML) Extended Reality (XR) High-Precision Position & Timing

Demand for 5G and advanced wireless connectivity

Although it is impossible accurately to predict when large scale demand for 5G and other forms of advanced wireless connectivity will emerge and how widespread that will be, mobile data provided over public mobile networks has grown 40% per year on average over the last decade⁴ and we expect to see continued growth in data traffic over the next decade. [Ofcom’s Mobile Market Review](#) suggests data growth could range from a 25% increase per year to 2030 to 55% increase per year to 2030. Research we commissioned shows that there will be an increase in demand for wireless data but notes that this would be less steep if a greater share of this traffic is carried over fixed networks.

⁴ Total data uploaded and downloaded over UK mobile networks, Ofcom’s Connected Nations Reports

Chart 1: Forecasted growth in data traffic, in exabytes, over public cellular networks over the coming decade



New applications will continue to emerge, contributing to the increase in demand for data over wireless networks. For example, virtual reality applications, such as the so-called “metaverse”, will largely use Wi-Fi in the short term, but they may increasingly use the public mobile networks as they gain in popularity and the capability of wireless networks improves. Alongside this, we also expect latent demand for existing services to emerge.

The Government Office for Science has published a [report](#) examining public service demand for wireless connectivity in 2030. The report sets out a number of scenarios that can be used by DSIT and other departments to help identify levers that balance supply and demand, and puts forward key findings and recommendations, which include:

- policymakers should consider measures to stimulate demand for connectivity in the public sector in addition to encouraging the market for infrastructure supply
- some public use cases would be held back more by a lower wireless infrastructure ambition than others
- the importance of digital service resilience
- public support and service provider engagement are just as vital to shaping future demand as providing infrastructure

Our work to realise the full benefits of, and support places to attract investment in, 5G and other advanced wireless connectivity, outlined at chapter 5 and 6, reflects key elements of these findings.

Analysis that we commissioned from Analysys Mason and Cambridge Econometrics estimates that, if adopted at scale, 5G could enable productivity gains that add £159 billion in cumulative GVA between now and 2035, reflecting a potential annual GVA increase of £37 billion by 2035. 5G can transform our public services and grow the economy, making our factories and workplaces more productive and creating better paid jobs, delivering on this Government's key priorities. 5G is also a foundational technology for other technologies, including augmented and virtual reality (which, according to [PwC](#), could increase UK GDP by £62.5 billion by 2030), AI and machine learning, and will be key to helping sectors across the economy maintain their international competitiveness.

Realising these benefits relies on the UK's wireless network providers investing in high-quality public 5G networks and private networks utilising 5G and other advanced wireless technologies such as Wi-Fi 6 and 7, as well as businesses, the public sector and consumers adopting these new technologies at scale.

5G has significant potential and, as 5G availability improves, this will support innovation and the emerging of new use cases. However, wireless operators are facing a challenging investment environment – delivering high-quality 5G is costly and potential additional revenues are uncertain at this stage. These factors are currently exacerbated by the global macro-economic pressures with rising inflation and energy prices. We want to work with the industry to ensure that we can exploit the potential that 5G and other advanced wireless connectivity has to offer. Adoption of 5G-enabled services is gathering pace.

However, without clear action, the market for advanced 5G services will remain nascent as many business and public services do not yet fully understand the benefits or how to navigate the supplier ecosystem for 5G enabled digital products, applications and services. The lack of clarity on demand for 5G services makes it harder for operators to make a clear business case for ongoing significant investment in 5G networks, and we want to help solve this 'chicken and egg' problem.

Underpinning all of these advancements is the need to ensure that our digital infrastructure is secure and resilient. As outlined above, the Telecommunications (Security) Act 2021 allowed necessary steps to be taken by the government to remove high risk vendors from the UK's wireless infrastructure and highlighted our dependence on a small number of suppliers. Our 5G Supply Chain Diversification Strategy, backed by £250 million research and development funding, aims to increase the number of vendors in our UK critical national infrastructure, ensuring it is resilient to future trends and threats. We outline below steps we are taking to consider the security of private networks and drive secure investment in connected places, and we will continue to put security and resilience at the heart of our policies.

We are also mindful of the need to ensure that wider infrastructure is in place to support 5G deployment. Data centres in particular play a critical role in the operation

of telecoms networks. Recognising this, the government is developing a stronger risk management framework to address the risks to UK data storage and processing infrastructure (including data centres), as publicly committed in the [National Data Strategy](#) and [National Cyber Strategy](#).

Ambition

In 2017, we set an ambition for the majority of the UK population to have access to a 5G signal by 2027. As we note above, Ofcom reports that (basic, non-standalone) 5G is now available with high confidence from at least one operator outside approximately 77%⁵ of UK premises. Coverage from all four operators is much lower at approximately 20%.

Similarly to how 4G networks were rolled out, the deployment of non-standalone 5G has initially been concentrated in densely populated areas where there is the need for additional network capacity to meet demand. However, this is beginning to shift, and Ofcom now [reports](#) that it is increasingly available beyond city centres in smaller towns and along busy transport routes.

However, this is only the start. The deployment of non-standalone 5G in public cellular networks alone, although a crucial step in increasing network capacity, will not be enough to unlock the full economic and social benefits that high quality 5G promises. Standalone 5G will be needed to support use cases which require increased upload capability (sending large files or videos), lower latency (fast response times necessary for gaming or other real-time applications) and greater reliability (required for any mission-critical or business-critical application).

Realising these benefits relies on the UK's wireless network providers investing in high-quality public and private 5G networks. We recognise that the macro economic environment which is impacting access to capital on a global scale, as well as a number of UK-specific issues, mean some operators are facing challenges making returns for their shareholders. This will impact their decisions on 5G investment across the UK; as with fixed broadband, there is a stronger commercial case for investment in areas with greater population density.

The decision to remove Huawei from our 5G networks was necessary to ensure the security and resilience of the UK's networks and the protection of consumers, but we recognise that this has affected the timetable for the UK's standalone 5G rollout.

The full benefits of 5G can only be realised if high quality 5G is widely available, and this requires commercial investment. Standalone 5G will provide the foundations for

⁵Ofcom reports on 5G availability across a confidence range covering High Confidence and Very High Confidence. These confidence levels reflect the likelihood of on the ground coverage for consumers in a particular location. A High Confidence range is associated with a signal strength (-110 dBm), to equate to at least an 80% confidence level, and a Very High Confidence range is associated with a higher signal strength (-100 dBm) - to equate to a circa 95% confidence level.

advanced 5G, which will enable the provision of new wide area, business-critical services in sectors such as transport and healthcare and services connecting businesses with operations in different parts of the country.⁶ Whilst these new service offerings are largely nascent, we want to ensure that people and businesses across the UK have the opportunity to benefit from them as soon as possible, that operators have the confidence to invest in advanced wireless networks and that no part of the country is left behind - this will be vital to securing the UK's competitiveness.

We want high quality coverage to extend well beyond cities and larger towns to all populated areas of the UK, including villages and rural communities. **We are therefore setting a stretching new ambition of nationwide coverage of standalone 5G to all populated areas of the UK by 2030.**

This ambition will help drive investment in high quality, standalone 5G across the UK, including in more rural populations. However, as discussed in chapter 2, 4G coverage will still have an important role to play in providing geographic (landmass) coverage beyond the 5G footprint, and will continue to co-exist with 5G over the course of the decade. In chapter 5 we set out how businesses, including those in more rural areas, can also benefit from advanced 5G.

It is too early in the development lifecycle of 5G to set specific quality targets or performance metrics such as speed and latency. However, a necessary prerequisite for offering services which rely on the full functionality of 5G is the installation of a 5G network core which supports standalone 5G. We welcome the fact that some MNOs have signalled they will launch standalone 5G this year as this will provide the foundation for the provision of advanced 5G services. Continued investment in 5G across the UK will enable the market to demonstrate the wider social value of more widespread and higher quality coverage - and allow new, innovative uses to develop. We expect standalone 5G rollout to follow a similar pattern to 5G NSA, starting with more densely populated areas. However, absent a new policy framework, it is unclear at this stage how far coverage will extend outside of those areas.

Through Project Gigabit and the Shared Rural Network, the government is investing substantially in areas where commercial deployment in digital infrastructure is not viable. This funding provides connectivity where the market fails to take into account the full economic and societal benefit of improved connectivity, or does not have enough information to forecast demand.

We recognise that this new coverage ambition is stretching but we will work with industry to achieve it. Our aim, through the measures set out in this strategy, is to work closely with the telecoms industry to strengthen the investment environment,

⁶ Ofcom notes in their paper on their future approach to mobile markets and spectrum that 'Wider rollout of higher quality connectivity may also support a wider range of social and business activities in lower demand areas, bringing them closer to those in higher demand areas, which should contribute to communities in those lower demand areas being more sustainable.'

continue to remove barriers to deployment, ensure regulation is not a barrier to innovation and boost demand for wireless services. This will support commercial investment across all populated areas of the UK by 2030.

Chapter 4: Strengthening the investment environment

Our 2030 ambition requires commercial investment, and this chapter focuses on creating the environment to support it.

The UK has a robust, dynamic mobile industry that has delivered widespread 4G mobile coverage and good early progress on 5G rollout, with UK consumers enjoying some of the lowest prices in Europe. However, deploying national 5G mobile networks requires significant capital investment and additional operating costs.⁷ The deployment of standalone 5G and ultimately advanced will require operators to deploy additional infrastructure, including:

- 5G core networks in addition to the 5G equipment in the radio access network
- upgrades to the existing grid of approximately 18,000 macro cell sites per MNO
- additional cell sites to provide 'infill' to cover gaps in coverage
- compute and storage infrastructure at the network edge for mobile edge compute (MEC) which will allow massive data processing closer to the user with much less delay

The market for the provision of digital infrastructure and services continues to evolve and the UK is likely to be part of these global trends. The government is supportive of a dynamic marketplace that promotes competition and drives innovation, efficiency and value for users. This aligns with government policies such as the [Integrated Review](#), [Innovation Strategy](#), the [Digital Strategy](#) and growth plans.

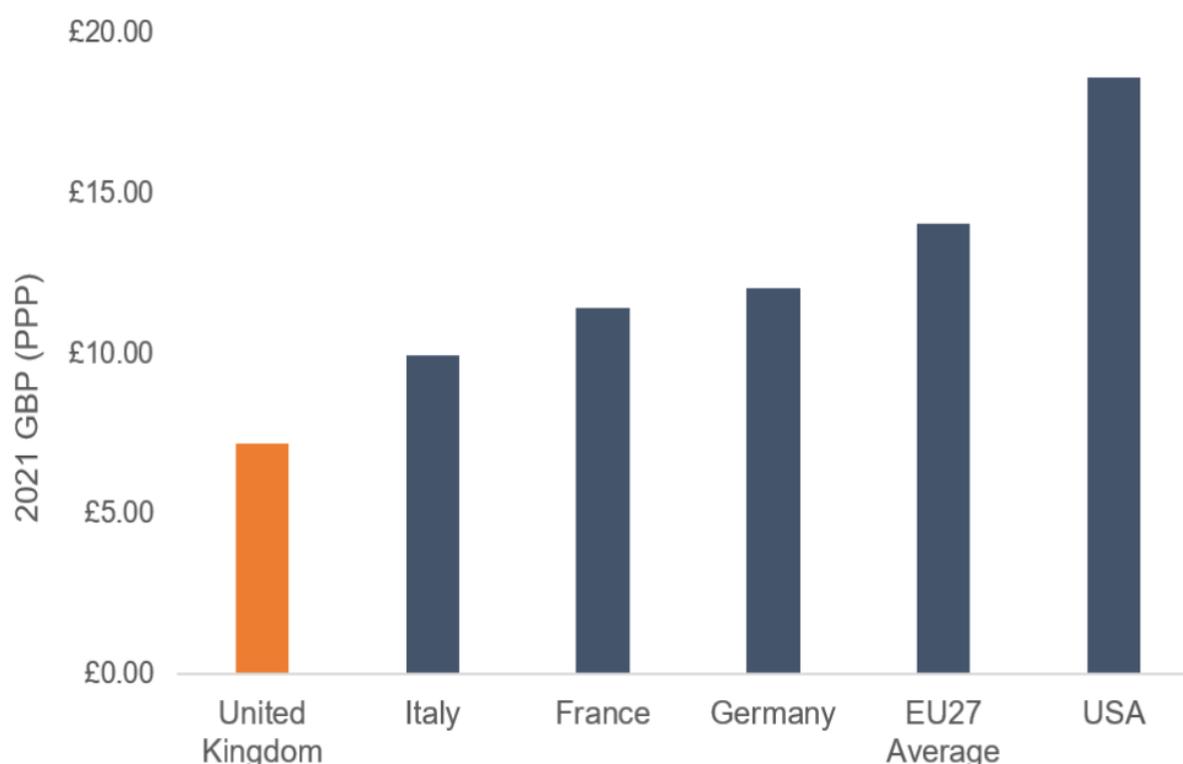
The costs of deploying infrastructure and operating networks have been exacerbated by global pressures. Mobile operators are large consumers of energy and are facing higher energy, material and labour costs. Mobile operators also face cumulative costs due to necessary consumer and data protection regulations, as well as the essential steps we have taken to place legal controls on the use of Huawei goods and services, as set out in the [government's response](#) to our 2022 consultation on proposals to issue a designation notice and designated vendor direction for Huawei. We have also put in place a new telecoms security regulatory [framework](#). These steps are required to ensure the security and resilience of the UK's networks and the protection of consumers; however, as a whole, we recognise that they represent a significant cost.

According to [Deloitte](#), since 2010, mobile operators have experienced flat mobile revenues, and declining revenues since 2018. This is largely driven by falling average

⁷ The estimated additional cost per operator to deliver 5G to meet forecast growth in mobile traffic is forecast to be around £2.8bn between 2022 and 2030. This will deliver 5G coverage to 99% of the population. See *Ensuring future wireless connectivity needs are met*, Analysys Mason, April 2022.

monthly revenue per user (ARPU) which Omdia World Cellular Information Services data reports declined from £13.80 in 2018 to £11.80 in 2021. Meanwhile, [Ofcom reports](#) mobile traffic has grown by 369% over the period. Even for upgraded services such as 5G, average prices have fallen in the last five years up to 2022⁸ and overall UK prices for mobile services are some of the lowest in Europe. Chart 2 below shows that the UK provides the cheapest monthly offer for a mobile package including 5GB data and 300 minutes, compared to the USA and EU countries.

Chart 2: Cheapest monthly offer, 5GB mobile data and 300 minutes, 2021 GBP (PPP⁹)



At present, there is limited evidence that consumers or businesses are willing to pay increased prices for new services. UK5G’s 2022 [survey](#) showed that 45% of surveyed businesses are planning to make investments in 5G by 2023, but there is little evidence to date on how much enterprises are willing to pay. This is likely to be due, at least in part, to the fact that demand is only just beginning to emerge and there is limited understanding among consumers and enterprises of the benefits 5G services can provide.

Consumers also face price rises due to inflationary pressures. Last year, the telecoms industry [signed up](#) to a range of commitments to help their customers through the rises in the cost of living, following significant engagement with the

⁸ Ofcom’s 2022 [Pricing Trends Report](#) shows that average mobile prices continue to fall in real terms up to 2022 and the price premium for 5G, relative to 4G has almost disappeared.

⁹ Purchasing power parity. Data drawn from [European Commission report](#) on Mobile and Fixed Broadband Prices in Europe in 2021

government. DSIT's recent [participation survey](#) found that 30% of consumers were not currently willing to pay extra for 5G.

Competition in the mobile market is also changing. The competitive relationships between market players are evolving and new relationships are being formed as the market becomes less vertically integrated with new players entering the market at different levels of the supply chain.

Infrastructure level

At the infrastructure level, operators have regularly engaged in site sharing arrangements to help reduce high fixed costs.¹⁰ However, these arrangements are evolving as operators sell their assets to independent providers to fund investment. As a result, independent tower companies have gained a more prominent role in the mobile value chain.¹¹ In addition, seeing opportunities for growth, several large international investment funds have identified telecoms infrastructure as a long term investment option, and backed players such as Cellnex, BAI Communications and Dense Air to enter the UK market.

Retail level

At the retail level, analysis by [Omdia](#) shows that the mobile virtual network operator (MVNO) market remains strong, representing 27% of mobile subscribers in the market. Ofcom [analysis](#) indicates that MVNOs offered the lowest average consumer prices for SIM-only mobile services for all but three months between December 2016 and March 2021. The affordability of MVNO services and the range of tailored products MVNOs offer has helped support competition in the market. The market also creates important revenue streams for MNOs through leasing network services to MVNOs.

Newer entrants

Encouraged by the 5G Testbeds and Trials Programme and enabled by new spectrum bands made available by Ofcom, companies such as AQL and Telet have also emerged to offer bespoke, relatively small-scale connectivity for enterprise and communities. Telet was a member of the consortium providing a private, high

¹⁰ The four national MNOs are engaged in two site sharing arrangements: Mobile Broadband Network Limited (MBNL) is a joint venture between EE and Three, and Cornerstone Telecommunications Infrastructure Limited is a joint venture between Virgin Media O2 and Vodafone. MNOs also deploy and manage infrastructure outside of these arrangements.

¹¹ Three sold approx. 6,000 towers to Cellnex of which 1100 were sold to the Wireless Infrastructure Group as ordered by the CMA as a key remedy of the deal. See Cellnex/CK Hutchison final report CMA. Vodafone transferred its stake in CTIL to its subsidiary Vantage Towers in which Vodafone retained an 81% stake. Vodafone admitted Vantage Towers to the Frankfurt Stock exchange in an IPO in March 2021 which raised EUR 2.3billion. Vodafone has recently sold part of its stake in Vantage Towers to Global Infrastructure Partners and KKR.

bandwidth 5G SA network supporting innovative applications in selected areas of Liverpool City, which supported remote health and social care and education delivery. Companies like these will play an important role in the provision of high quality, localised 5G connectivity, and we are interested in how these services will develop alongside MNO delivery of national 5G coverage.

Big Tech

Competition from Big Tech companies delivering 5G connectivity, like Amazon Web Services and Cisco, is nascent but they have potential to play a role in the provision of mobile connectivity, particularly in private networks.¹² Big Tech companies are already key to the value chain as suppliers of devices and operating systems but could potentially also become MVNOs by entering into agreements with MNOs or buying an existing MVNO¹³ meaning competition for subscribers would increase.

Big Tech can also offer new ways for devices to connect to networks such as through e-SIMs, which are embedded in devices and allow users to subscribe simultaneously to several data plans. The overall effect on consumers and the market is unclear, although there is potential for significant impact due to Big Tech's market power in other sections of the value chain.

Supporting investment in wireless networks

Our aim is to ensure that all consumers and enterprises have access to affordable and reliable wireless connectivity. This means maintaining a balance between incentives to invest in high quality infrastructure and services, and the availability of competitive and affordable services. Ofcom's recent [paper](#) on its future approach to mobile markets and spectrum has shown that, to date, competition in the market has delivered some of the lowest prices for consumers in Europe, and has maintained average annual investment of around £2.7 billion.

As competition evolves, new players will enter the market which, combined with ongoing fixed costs and the substantial further investment required to invest in 5G, is leading to increased pressure on MNOs. As discussed above, the MNOs tend to be focused on the high population density areas where returns on investment are more certain. Our public policy objectives for digital connectivity are focused on how we minimise the risk of a digital divide. Inherently, this means connectivity is likely to be needed in areas where the MNOs are not naturally commercially incentivised to go.¹⁴

¹² In the US, companies including Amazon Web Services and Cisco have launched Private 5G services, enabled by easy access to spectrum in the CBRS (Citizens Broadband Radio Service) Band

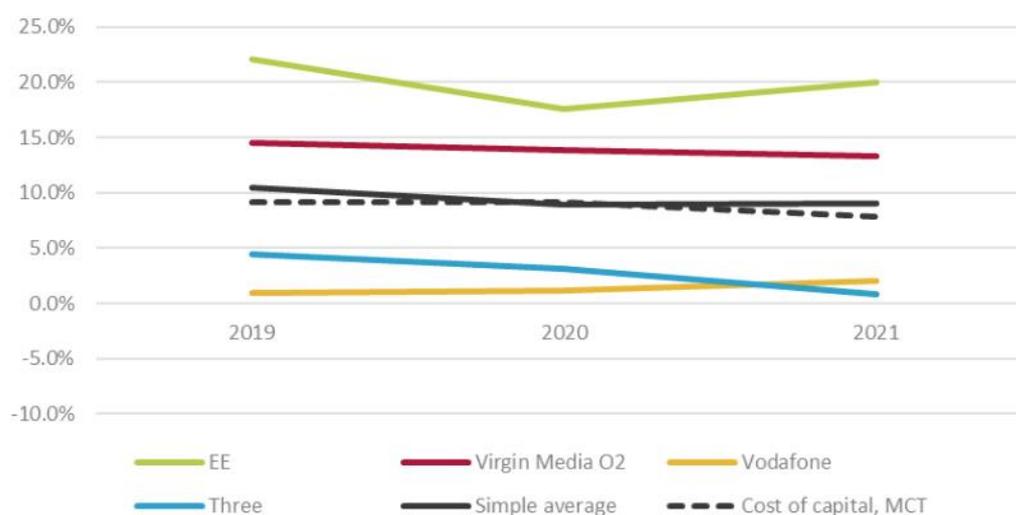
¹³ In the US, Google launched Google Fi, an MVNO service linked with several operators that automatically switches between different networks.

¹⁴ In 2022 the Digital Connectivity Forum and Frontier Economics published a report into the costs of rolling out 5G across the UK. It reported that the industry cost of delivering 5G to meet mobile traffic demand and extend 5G coverage to the existing mobile network footprint would be in the region of £12-14Bn.

Analysis from Ofcom shows that, although on average MNOs are meeting the cost of capital employed, the two smallest mobile operators, Three and Vodafone, have been struggling to achieve adequate return on capital employed (ROCE) and have been operating below Ofcom's estimated cost of capital since 2018 (see chart 3 below).

Chart 3: Economic return on capital employed by MNOs

(Source: Ofcom's future approach to mobile markets and spectrum, [conclusions paper](#))



In response to our Call for Evidence, mobile operators argued that the current four-player market structure means that investment in 5G is spread too thinly between operators. In order to achieve the necessary scale and drive up their returns on investment, operators have suggested that market consolidation (specifically, a reduction in the number of national MNOs from four to three) would allow them to raise funds for investment in 5G. Mobile operators add that increased investment will have a positive impact on the quality of connectivity available to consumers and enterprises. However, we note that strong competition from four mobile operators can also drive investment and that some - though not all - studies of mergers in other countries show a reduction in the number of mobile operators leading to increased consumer prices.¹⁵

¹⁵ There are several studies that look at the effects of consolidation in mobile markets and conclude that post-merger prices increased. For example Genakos et al.'s 2018 study analysed data from 33 European countries and concluded that more concentrated markets lead to higher end user prices and higher investment per mobile operator, though the impact on total investment is not conclusive.

Government does not have a role in any merger decision on competition grounds. It is the statutory responsibility of the Competition and Markets Authority (CMA) as the independent competition regulator to review mergers, with input from the relevant sector regulators – in this case, Ofcom. In any review, the CMA would consider to what extent the merger could cause a substantial lessening of competition in the market, and whether it is likely that this would lead to price increases or other negative outcomes for consumers and businesses. Alongside this, the CMA would consider whether the merger creates benefits to the relevant customers such as lower prices, higher quality, greater choice and greater innovation of goods and services, and would analyse both together to consider the merger’s overall impact on consumers and the market. If it is considered likely that the merger would reduce competition in the market, the CMA can also suggest remedies are implemented to alleviate the competition concerns whilst attempting to retain the potential benefits.¹⁶

In our 2018 [Future Telecoms Infrastructure Review](#), we stated that there is no ‘magic number’ of mobile network operators in the market. We continue to hold this view and confirm our openness to market consolidation, noting that merger decisions are taken on their merits by the CMA. Ofcom stated in its [future approach to mobile markets and spectrum paper](#) that its position on any future merger would be informed by its ‘view on the effectiveness of competition that can be expected after the merger, rather than just the number of competitors’. We agree that the impact of consolidation on the market will be highly contextual and specific and must be assessed on a case-by-case basis.

Addressing barriers to deployment

Since the publication of the Future Telecoms Infrastructure Review, we have taken significant strides to make it quicker and easier for operators to roll out new digital infrastructure including [making reforms to the planning system](#) to support the deployment of 5G and extend mobile coverage in England, and legislating to reform the Electronic Communications Code through the [Product Security and Telecommunications Infrastructure Act 2022](#).

Planning reforms

In the Future Telecoms Infrastructure Review, we committed to working with the industry to understand how new technology is best supported by the planning regime, and establish whether further reforms to the planning system were warranted to support network deployment. Following two public consultations, in April 2022 the government made amendments to permitted development rights in England to support the deployment of 5G and extend mobile coverage. These changes to the planning

¹⁶ At Phase 1 of the review, if the CMA decides there is a realistic prospect that the merger will lead to an SLC, the CMA can accept undertakings in lieu (UIL) from the merging parties. At Phase 2, if the CMA concludes the merger will or has already resulted in an SLC it will decide whether action should be taken to remedy the effects of the merger. See [CMA Merger remedies guidance](#) 2018 for more information on this process.

system will reduce the time, cost and uncertainty involved in upgrading mobile network infrastructure. The government is committed to ensuring that the planning system continues to support the deployment of wireless networks.

To that end, the Department for Levelling Up, Housing and Communities (DLUHC), will shortly make clarificatory amendments to Part 16 of the Town and Country Planning (General Permitted Development) (England) Order 2015 in relation to the definition of small cell systems and the application of constraints on the alteration or replacement of a mast. The current provisions in legislation that require operators to minimise the impact of any development on the surrounding local area as much as possible, particularly in more sensitive locations, will still apply in these cases. Through our [Barrier Busting Task Force](#), we will continue to undertake targeted engagement and barrier busting activities with local authorities where planning issues continue to act as a barrier to network deployment.

Access to public sector assets and land

Through the [Product Security and Telecommunications Infrastructure Act 2022](#), we have recently updated the Electronic Communications Code ('the Code'), which regulates agreements between landowners and telecoms operators regarding the installation of telecoms apparatus on private and public land. Once in force, the reforms to the Code will enable and encourage the efficient and cost-effective installation, maintenance and ongoing use of robust digital communications networks and, we believe, strike the right balance between the rights of landowners and the need to support the delivery of the government's digital connectivity ambitions.

The updates to the Code deal with issues relating to requests for new agreements and dispute resolution, expand operators' rights to upgrade and share apparatus, and clarify the process and framework for the renewal of expired agreements.

The Act received Royal Assent on 6 December 2022, but has not yet taken full effect. This is because further work is necessary to ensure the provisions in the Act work to facilitate rollout as intended. Different measures in the Act require different types of preparatory work. For example, some will require consultation, some will require changes to court rules and procedures, and others require implementing regulations to be prepared. This means that different measures will take effect at different times.

To further support the changes to the Code, telecoms industry stakeholders, including operators, infrastructure providers, site providers, landowners, trade associations, and relevant professional bodies, have come together to form the [National Connectivity Alliance](#). The Alliance will bring these stakeholders together to discuss issues of mutual interest, to improve collaboration and understanding, and to share best practice. The Alliance will report to DSIT as one industry voice in relation to access to land and build consensus on issues affecting the sector.

Operators' inability to secure suitable sites for electronic communications equipment is one of the biggest barriers to network deployment. Local authorities can facilitate network deployment by making their assets and land available to network providers. In recognition of the increasing industry demand for the use of local authority assets to deploy future wireless networks, and the overlap between advanced digital and transport connectivity, DSIT and the Department for Transport established the [Digital Connectivity Infrastructure Accelerator programme](#) (DCIA), supported by HM Treasury through the Shared Outcomes Fund.

Supported by £4 million of funding, the DCIA programme was set up to help places and the telecoms industry resolve a number of practical issues such as:

- digitalisation and streamlining of interactions involved in the site acquisition process - through piloting digital asset management platforms
- promotion of standard agreements for the rollout of small cells
- removal of constraints caused by legacy Private Financial Initiative (PFI) contracts for operation and maintenance of street lighting columns
- the creation of standards for multi-purpose use of street lighting and CCTV columns for smart infrastructure¹⁷

A collection of materials, including an asset data integration toolkit and a publicly available specification for smart infrastructure, will be published to help places across the UK engage and strategically collaborate with mobile network operators and other wireless telecoms infrastructure providers. Going forward, we want to work with the DCIA pilot regions, and all the local authorities involved in the Early Adoption Group, to ensure that best practice and the lessons learned from this programme are shared as widely as possible.

We are committed to continuing to address practical barriers to deployment through the Barrier Busting Task Force and to working with the industry on these. Further detail, including how we will work with local areas to galvanise roll out, is at chapter 5.

Weighing the impact of policy and regulations on investment

Policy making requires carefully weighing the impacts of our decisions across different issues. This can sometimes require difficult decisions and trade-offs to be made but we recognise that there is a substantial and increasing dependence on the MNOs for the delivery of wider government objectives and we will be mindful that any additional demands on the industry are necessary and proportionate.

We recognise the critical role the government plays in ensuring that our policies and regulations do not unduly hinder investment in networks. Supporting the market to invest at the scale required to deliver the government's new ambition will be a key

¹⁷ The programme comprises four workstreams: Digital asset management; PFI contracts; Standard contracts; and, Standards for smart infrastructure. Further information on the workstreams can be found at [UK5G](#).

consideration when considering the introduction and implementation of new policies and regulations.

DSIT will continue to work across departments to ensure that new policies and regulations take full account of the impact on investment in wireless connectivity, and that any potential negative impacts are mitigated as far as is practicable.

Ofcom plays a critical role in enabling investment and we therefore welcome its [recent statement](#) that it plans to set out more explicitly how it has considered investment when making future policy decisions. The government will continue to work with Ofcom to support investment in 5G and other advanced wireless connectivity.

Ensuring net neutrality rules support innovation and investment

The Open Internet Access Regulations, commonly referred to as the net neutrality regulations, were designed to encourage an 'open internet' where users, and not internet service providers (ISPs), control what they see and do online.¹⁸ The rules require ISPs to treat all internet traffic on their networks equally (whether in terms of quality or speed) and not to favour certain services or providers.¹⁹ As a government, we are committed to upholding the principle of the open internet and recognise that, to date, the regulations have provided positive outcomes for competition and consumer choice.

The internet ecosystem and how we consume content has changed significantly since the rules were introduced in the UK in 2016. New technologies have brought exciting new opportunities for consumers and businesses. The arrival of 5G means operators have the ability to deliver a wider range of services than was possible with 4G. For example, 5G allows operators to deliver multiple isolated network 'slices' over the public network whereby each slice is self-contained and tuned to meet the specific requirements of the end service or user. Operators and infrastructure providers have been trialling the technology in order to refine its delivery. For example, [Ericsson and Vodafone](#) announced the successful completion of a network slicing trial using 5G standalone infrastructure in March 2022 and, in August 2022, [Nokia and Google](#) trialled a slicing solution connecting a single smartphone to multiple network slices simultaneously.

However, there is some uncertainty as to whether these services would be permitted under the existing net neutrality framework, and operators point to this as a reason for not pursuing innovations in this space. Providing this type of connectivity will likely be

¹⁸ Net Neutrality in the UK is governed by the Open Internet Access (Amendment etc.) (EU Exit) Regulations 2018 which came into force on 31 January 2020. From 2016 to 2020, net neutrality in the UK was governed by the EU's Open Internet Access Regulation.

¹⁹ There are some exceptions, such as when employing general traffic management protocols, security measures (e.g. anti-virus/spam filtering) or complying with court orders.

important for providing services which require high quality, secure and reliable 5G connections such as remote healthcare and services based on self-driving vehicles or advanced manufacturing technologies.

In addition, the evolution of mobile technologies and the deployment of new services and products over mobile networks has generated increasing amounts of data. Ofcom [data](#) shows that mobile data traffic increased at an average of 40% year on year between 2017 and 2021.²⁰ According to data from [Three UK](#), traffic generated at peak times has continued to increase and, during 2022, peak data traffic records were broken, driven by consumers streaming live sports events and on demand content. Operators have said that, to ensure services remain reliable during peak times, investment in network capacity is required to keep pace with increases in data consumption.

Given these changes, our aim is to ensure that rules around network management remain fit for purpose and continue to support operators' ability to provide innovative forms of connectivity and invest in infrastructure for the benefit of consumers and businesses - with due consideration for broader policy considerations.

In October 2022, Ofcom published updates to their net neutrality guidelines and launched a [consultation](#) on the proposed changes. The updated guidelines would allow ISPs to:

- put in place increased traffic management controls during times of congestion
- develop specialised services over the public internet to support content or applications that require distinct optimisation such as self-driving cars, virtual reality or drones
- offer premium quality retail products as long as the terms on what consumers can expect are transparent and understandable
- offer 'zero rated' services in an increasing number of circumstances – which means a user's data allowance would not be used up accessing the service, for example, certain apps provided by the NHS

We welcome insight through Ofcom's consultation on how it will make sure their guidance supports access to the open internet and robust, efficient and innovative networks. Furthermore, we consider it important that Ofcom ensures that their guidance is clear and proportionate for industry. We will continue to engage with Ofcom as they progress this area of work.

We also recognise that there is a wider debate taking place internationally about who should pay for network investments.²¹ Some operators argue that content

²⁰ Whilst traffic growth is expected to continue, recent Ofcom analysis suggests growth in 2022 fell below 40%, but state it is too early to assess whether we are entering a period of sustained lower traffic growth, see [Ofcom's future approach to mobile markets and spectrum](#), Ofcom, 2022.

²¹ This argument is related to net neutrality because the current rules state that ISPs are not permitted to manage their traffic commercially.

providers or those whose services demand high levels of data usage, benefit disproportionately from operators' investments as operators direct their investment to meeting capacity demands driven by increasing data consumption. On the other hand, content providers argue that they already contribute to network costs and traffic management efficiencies and therefore should not have to contribute further towards network investment. **We recognise that this is a complex issue and one that affects industries across the value chain, from operators to content providers, and ultimately the consumers and businesses who use these services. We will continue to monitor these developments.**

Ensuring Annual Licence Fees promote the efficient use of spectrum

Annual Licence Fees (ALFs) for mobile spectrum are set by Ofcom. The baseline is for spectrum fees to be set to reflect the cost of administering the relevant licences. Where there is expected to be excess demand from existing and/or feasible alternative uses, Ofcom sets fees to reflect the market value of the spectrum based on its opportunity cost, that is, the highest value of alternative use of the spectrum that has been foregone due to the current use. This approach is known as administered incentive pricing (AIP). Opportunity cost-based pricing exists to provide users with a long-term indication of the value of spectrum, which will ensure its optimal use. This is intended to ensure that spectrum is used in a way that maximises benefits to society. More detail on Ofcom's approach to spectrum pricing can be found in its 2010 [Revised Framework for Spectrum Pricing](#).

While AIP principles are applied to licence fees in a few other sectors, such as in certain fixed links bands, the fees applied to mobile licences are by far the most significant. The costs to all four MNOs of ALFs between 2022 and 2030 is projected to be around £3 billion. MNOs have argued that these fees hinder investment and do not create additional incentives to use spectrum efficiently above and beyond the ability to trade spectrum. We note this view but also recognise that investment decisions are likely to be driven mainly by competition and expectations about future investment returns rather than current profitability.

However, given the significant costs ALFs present to industry, the evolving market conditions and the importance of spectrum to the deployment of mobile networks, it is important to keep the approach to fees under review. We want to ensure that the approach to spectrum fees continues to be fit for purpose in promoting the efficient use of spectrum. We also want to ensure that Ofcom has the tools it needs to adopt innovative spectrum management techniques, where appropriate.

We have therefore asked Ofcom to review and set out for ministers a clear and forward-looking rationale for its approach to setting mobile spectrum fees before the end of 2023. This should include an assessment of the current tools used to deliver the benefits of a market-based approach to spectrum management,

considering how well these mechanisms have delivered their stated objectives to date and the extent to which they may need to evolve to adapt to changing market conditions and support a strong investment environment. It would also be helpful to understand whether there are useful lessons from approaches taken in other countries.

Spectrum as an enabler of innovation

As the demand for wireless technology grows and changes, so too does the demand for spectrum. Refarming spectrum away from older technologies so that it can be put to use enabling more modern and efficient technologies is an important process that must be carefully managed.

Freeing up this finite resource for new and future use cases facilitates new entrants to the market and ensures that spectrum is an enabler rather than a barrier to innovation. This is an important step in removing barriers to the roll out of next generation technologies.

Globally, spectrum is being refarmed away from 2G and 3G as demand for these legacy technologies declines, they reach the end of their natural lifespan, and cost of maintaining these networks increases. Operators in the UK have been refarming spectrum away from 2G and 3G for some time.²² In December 2021, DSIT published a [Joint Statement](#) with the mobile network operators, setting out that all UK operators do not intend to offer 2G and 3G mobile networks past 2033 at the latest.

This industry-led switch-off will free up spectrum for 5G and beyond. The switch-off is also a key step in wider [government measures](#) to introduce new vendors to the UK mobile networks, contributing to nationwide security and resilience.

We welcome the work towards the planned sunset of 2G and 3G networks, and will continue to work with network operators and government users of 2G and 3G to ensure a smooth transition away from these technologies and towards alternatives, ensuring the needs of business users and consumers, including vulnerable groups, continue to be met.

Recycling legacy networks can also play a role in tackling the sector's carbon emissions and helping us to achieve our [net zero](#) ambitions. This is because maintaining older services becomes increasingly inefficient due to decreasing use. Moreover, new technologies and equipment require less energy and more efficient use of [spectrum](#).

It is important that spectrum use is regularly assessed to ensure that it is allocated appropriately and is an enabler of investment and innovation. **We will continue to work with Ofcom and industry to identify opportunities to refarm spectrum**

²² [The Potential Impact of Switching Off 2G in the UK, Real Wireless](#), 2019

where it is no longer being used efficiently and support a modern profile of spectrum use reflective of in-demand technologies and networks.

In our [Spectrum Statement](#), we have set out the broader steps we are taking to ensure that the management of spectrum in the UK is aligned with our ambitions and aims for the future of wireless technology. We are also working closely with Ofcom to improve access to shared spectrum bands. This is outlined in further detail in chapter 6.

We are taking steps to ensure that the UK’s spectrum governance arrangements are working as intended, delivering the best outcomes for people and business. DSIT has an overarching responsibility for spectrum across government. Effective cross-government coordination is critical to ensure spectrum management is aligned with our broader strategic priorities. To support this, we are reviewing existing governance structures and updating the Memorandum of Understanding (MoU) in place between government and Ofcom. It is of critical importance that the UK has a spectrum governance structure that is reflective of our strategic goals and ambitions.

International engagement and alignment is also essential to deliver access to future technologies and ensure that the UK’s interests are reflected in global standards and decisions. Ofcom represents the UK in international fora under ministerial direction. As set out in the Spectrum Statement and 6G chapter of this strategy, **we will continue to work closely with industry to understand its priorities internationally, we will actively support Ofcom in their role representing the UK, and we will utilise our influence on the global stage to push for UK priorities in international fora.**

The UK will be proactive in its involvement in the upcoming International Telecommunications Union (ITU) meetings, including World Radiocommunication Conference (WRC) 2023 and WRC 2027. These meetings will help deliver international harmonisation of spectrum bands, which will be vital to ensuring a developed ecosystem for UK sectors and other users of this technology. Though the UK has ultimate authority over the allocation of domestic spectrum, we recognise the benefits of internationally harmonised bands in terms of economies of scale and interoperability.

Business rates on mobile masts in freeport areas

At the Budget on 3 March 2021, the government committed to creating eight new [Freeports](#) in England, where businesses would benefit from more generous tax reliefs, including business rates relief. The government remains committed to establishing Freeports in [Scotland](#), Wales and Northern Ireland. Freeports will create hotbeds of innovation by focusing private and public sector investment in research and development, creating new markets for UK products and services and drive

productivity improvements, bringing highly skilled jobs and investment to Freeport regions and delivering the government's priorities of growing the economy and creating better paid jobs.

Full business rates relief will be available to eligible businesses in the Freeport tax sites in England. Relief will be available to all new businesses, and certain existing businesses where they expand, until 30 September 2026. **DSIT will work with DLUHC and devolved administrations to ensure that, where eligible, MNOs installing mobile cell sites within Freeports will benefit from any business rates reliefs that are attached to the Freeport and other economic areas with similar regimes.**

Chapter 5 – Realising the full benefits of 5G and advanced wireless connectivity

5G and other forms of advanced wireless connectivity pave the way for new services and applications that can have a transformative effect on our public services, businesses and our local economies, delivering this government's priority of growing the economy and creating better paid jobs. Wireless connectivity can support mobile healthcare workers and connected vehicles, improve traffic flow through our cities and enable our factories to be more productive, supporting the fourth industrial revolution. Our evidence is clear that the most significant economic benefits from 5G will come from widespread adoption of advanced 5G by industrial sectors, including manufacturing and logistics, and by public services.

The government is determined that the UK should take full advantage of these opportunities but this will only be possible if places across the country can attract commercial investment in 5G and other forms of advanced wireless connectivity and for that to be adopted at scale by businesses and public services.

In many cases, industrial applications will require more advanced 5G than the public standalone 5G networks will initially provide. Although the government's new national coverage ambition is for all populated areas to have standalone 5G, investment in advanced 5G, which will offer more reliable, lower latency communications necessary for the most advanced industrial applications, may be slow to materialise without government action to drive both demand and investment.

We are therefore providing the framework to ensure that people, businesses and public services across the UK are able realise the full benefits of 5G and advanced wireless connectivity as soon as possible.

We set out how we will achieve this in this chapter. This work builds on the success of our £200 million 5G Testbeds and Trials (5GTT) programme, which began in 2017 and fostered the development in the UK of the 5G ecosystem, building the business case for investment to support 5G use cases. The programme helped to establish the UK's leadership and supported industry, academic institutions and local authorities to realise the benefits that 5G can bring.

The 5GTT programme has co-invested in a wide range of projects, exploring areas as diverse as reducing loneliness among elderly and vulnerable people to precision automotive manufacturing. The projects helped develop 5G technology uses crucial to delivering connectivity solutions of the future. Many have continued to operate after our funding period, demonstrating the sustainability of benefits that 5G connected technology enables.

The programme has shown how and where the government could stimulate commercial investment to drive deployment and accelerate 5G adoption, especially in key sectors including agriculture, manufacturing, transport and logistics.

The West Midlands 5G trial programme enabled organisations to harness the power of a 5G private network to create cutting-edge smart city solutions, such as traffic management through sensors collecting images and sent to a real-time traffic management centre. Other projects included the [5G Festival](#), which demonstrated its first trial with a seamless live performance to an audience with musicians based in multiple locations; multiple projects have tested the impact of 5G on manufacturing, using 5G to enable factories to connect their machines and equipment.

Examples of how the 5GTT programme has shown how government could drive deployment and accelerate 5G adoption in key sectors

5G Trials

Transport

The 5GTT funded [Smart Junctions 5G](#) project used artificial intelligence to improve traffic signal control efficiency by reducing waiting times at signals, which in turn reduces journey times and cuts pollution.²³

Health and social care

The [Liverpool 5G Health and Social Care Testbed](#) demonstrated the technology's potential to provide solutions for health and social care services that can reduce the cost of those services and create extra capacity. 5G enabled interventions included creating applications that reduce loneliness for service users, remotely monitoring medication administration, and using sensors and assistive technologies to monitor patients.

Automotive

The [Connected Automotive Logistics project](#) (5G CAL) project demonstrated how 5G networks can drive operational efficiencies and improve productivity for automated logistics. The 5G CAL pilot demonstrated that a self-driving truck can distribute parts and assemblies across the Nissan plant in Sunderland. The vehicle's teleoperations system used next generation technology connected to a private 5G network to facilitate remote teleoperations.

The government will build on 5GTT to drive innovative applications powered by 5G and other advanced wireless connectivity from proof of concept to widespread adoption.

We will be providing up to £40m for regions and local authorities across the UK to establish themselves as '5G Innovation Regions' to promote innovation through investment in, and scaled adoption of, 5G and other advanced wireless technologies by businesses and public services. Our place-based approach will help empower regions to unlock opportunities using advanced wireless connectivity, tailored to their specific needs and strengths, generating value

²³ The West Midlands [5G Enabled Traffic Monitoring Sensors](#) project validated the application and use of 5G-enabled smart sensors to accurately identify and classify road usage in real-time.

and growth at the local level. Further details of the programme are provided in the Connection Places section below.

By empowering and enabling connected places, we will support regional and local authorities to identify and break down barriers to deployment at a local level, and bring together stakeholders across the public sector to build strong relationships with industry. In doing so, we will build on the work by the [Government Office for Science](#) and work with key departments to understand how 5G and advanced wireless technologies can support delivery of the government's broader strategic objectives and public service delivery (see also chapter 6).

Connected places

Improving digital connectivity is one of the government's Levelling Up Missions. We want places and communities across the UK to share in the benefits of good connectivity, enriching lives and driving local growth.

Wireless connectivity already forms part of many essential services within the public sector; for example, enabling people to book medical appointments remotely and order prescriptions through the NHS app. Standalone 5G could unlock new applications and enhance existing services, enabling new digital ecosystems that create wider benefits across the public sector. 5G can help create connected places, whether through enabling so many more connected devices and services to work reliably and securely, or providing efficiency and productivity benefits across key services for citizens and communities.²⁴

[Connected places](#), or 'smart cities and communities', utilise advanced technology to deliver services within the built environment, by collecting and analysing data from networks, sensors and 'internet of things' connected devices. These technologies can provide a range of tangible benefits to society, from more efficient management of traffic which reduces pollution, to providing public services more efficiently and enhancing the quality of living for citizens. 5G will enhance the delivery of secure, adaptive, immersive services and experiences, such as Augmented Reality navigation apps or retail shopping experiences.

We want to support connected places with their digital connectivity ambitions. **We will do this by helping regions and local authorities to build the case for adopting new technology, attracting investment and removing practical barriers to the deployment of advanced wireless networks.** Local and regional authorities play a pivotal role in facilitating the rollout of wireless connectivity and their role will become more critical than ever as investment in 5G continues, due to its technological complexity and the vast number of new applications and services it can support.

²⁴ For example see WPI Economics report for Vodafone UK, [Levelling Up: How 5G can boost productivity across the UK](#), and the O2 report, [The value of 5G for cities and communities](#).

Private organisations, governments and infrastructure partners all need to work together to enable places to leverage existing public infrastructure, alleviate budget constraints, deliver widespread connectivity and enable high-quality services.

5G innovation regions

We will be providing up to £40m for regions and local authorities across the UK to establish themselves as '**5G Innovation Regions**' through our **5G Adoption Programme**. 5G Innovation Regions will promote the development and scaled adoption of 5G - and other advanced wireless technologies - in businesses and in the delivery of public services.

Local authorities and regions will be able to apply for funding in Spring 2023, with a view to notifying successful applicants by Autumn 2023. Funding will be available up until the end of the current Spending Review period, supporting activities that break down barriers at a local level and create the right conditions to accelerate the adoption of 5G in key local sectors and attract investment in advanced wireless infrastructure.

The primary objectives of 5G Innovation Regions will be to:

- drive productivity and economic growth in places across the UK through supporting the development and scaled adoption of 5G by businesses and public services
- accelerate commercial investment in 5G and other advanced wireless technologies by aggregating and demonstrating demand
- foster the 5G ecosystem by enabling activities that will bridge the gap between trials and adoption

5G Innovation Regions will encompass a large area or region (at least combined authority area in size or multiple local authorities working together), though this will be flexible based on local circumstances and opportunities. Further information on how to apply to be a 5G Innovation Region will be provided in due course. Our place-based approach will help the UK to realise the benefits of advanced wireless connectivity sooner by focusing on local needs and sectors.

Attracting investment in advanced wireless infrastructure

Local leadership and coordination

Local leadership can help to identify and break down barriers to deployment at a local level by bringing together stakeholders across the public sector and building strong relationships with industry. The installation of telecoms infrastructure involves a number of different local government departments (such as planning, estates, highways) and their activities can be siloed and uncoordinated.

It is essential that, at a leadership level, local and regional authorities recognise the importance of wireless connectivity and identify decision-makers within the organisation who are empowered to facilitate private sector investment. By articulating the benefits of wireless infrastructure and connectivity and linking these to digital inclusion (and, in turn, tying these into local authorities' wider regeneration and growth or 'place' strategies) it can be viewed as an inward investment opportunity for places across the UK.

Establishing local digital infrastructure strategies

At the local level, a focused strategy for encouraging and facilitating the deployment of digital networks can help to boost economic growth, digital inclusion and deliver a range of societal benefits, including the more effective provision of local public services. This could be as a part of a broader digital strategy or growth strategy, or a standalone strategy in its own right.

Local digital infrastructure strategies should:

- set out how the local authority will facilitate the rollout of digital infrastructure, including actions to increase cooperation with infrastructure providers and network operators
- promote long-term investment by highlighting the significance of digital connectivity to the area and the social and economic benefits it will deliver
- identify and aggregate public sector and local industry demand for connectivity services to make the case for investment in digital networks and services
- provide the contact information for key local authority departments

Further guidance is available on the [Digital Connectivity Portal](#) on how local authorities can demonstrate leadership and create a strategy to encourage investment in digital infrastructure.

Strategic coordination case study: Greater Manchester Combined Authority

Through working collaboratively with telecoms partners, its local authorities and significant property owners, the Greater Manchester Combined Authority (GMCA) has set a goal to deliver ubiquitous high speed digital connectivity over full fibre and 4G and 5G mobile across the whole city region by 2025. Extending world-class digital infrastructure across the city-region is a key priority of the [Greater Manchester Digital Blueprint](#) – removing connectivity as a barrier to the region’s social, economic and public sector reform objectives.

The GMCA, which includes Transport for Greater Manchester, the Fire Authority and Police services, worked with the ten local authorities in the region to understand more fully the benefits that 5G can bring to public services. With the local authorities, GMCA has been looking to accelerate market investment by minimising the rollout costs for operators, and making public sector buildings and other assets available for infrastructure to support 5G rollout. Salford’s MediaCityUK was the UK’s first area to receive commercial 5G coverage, with the area deemed a perfect ‘living lab’ for 5G research and innovation by Vodafone who have invested in a 5G Innovation Lab at The Landing.

Digital champions and coordinators

Local authorities can appoint digital champions and digital coordinators to provide strategic leadership on the local authority’s digital infrastructure strategy. This can have a hugely positive impact on the deployment of digital infrastructure and help build more effective relationships both within councils and with telecoms providers. Research from [Mobile UK](#) suggests that local authorities which have prioritised digital connectivity and appointed digital champions have had significant success in speeding up rollout and improving relationships with telecoms companies. The same research notes that planning approval rates tend to be higher where councils have put in place digital champions or schemes to promote wireless connectivity. Planning approval rates for wireless network infrastructure can vary widely by local authority, ranging from 100% in some areas to below 20% in others, based on industry data from October 2022.

A Digital Champion could be a senior council cabinet member, councillor or senior local authority official, with the capacity to engage with stakeholders and leaders across multiple council departments. Digital champions should lead the development and implementation of the Digital Infrastructure Strategy and act as the ‘voice’ of the local authority, working with industry to promote the social and economic benefits of improved connectivity to residents and business in the local area/region. This role

should come with the resources and skills to deliver a comprehensive programme of change that accelerates the rollout of digital infrastructure. Through our Barrier Busting Taskforce we will continue to promote the benefits of digital champions and encourage local authorities to appoint one where possible, and with DLUHC we will work to support local authorities and regions with digital infrastructure and connectivity ambitions.

A local authority may also consider appointing a Digital Infrastructure Coordinator who can support the digital champion and act as the main point of contact or 'account manager' for industry on issues related to digital infrastructure. They would also work closely with local authority teams involved in the deployment process and help promote and coordinate the use of public sector assets for hosting digital infrastructure.

Further guidance is available on the [Digital Connectivity Portal](#) on how digital champions and coordinators can help facilitate the smooth rollout of digital infrastructure and encourage investment in networks.

Digital champion case study: Glasgow City Council

Glasgow City Council (GCC) has placed digital infrastructure at the forefront of its Digital Strategy (2018). GCC is aiming to reap the inclusive economic benefits of connectivity by facilitating investment in digital infrastructure, including 5G.

To do so, GCC appointed a dedicated Telecoms Unit in 2020, to work with industry to facilitate digital infrastructure investment and deployment in the area. The Unit has implemented standard processes and documentation and made public assets available on an online catalogue. It also acts as a single interface between the Council and the digital infrastructure industry, allowing simplified management and coordination. By simplifying the process required for connectivity deployment, the Council has improved internal efficiency and reduced time to market for MNOs and other infrastructure providers.

More broadly, the Unit has supported GCC to establish strategic relationships with a range of connectivity providers and encouraged investment in its infrastructure.

Glasgow is one of the first UK cities to have signed agreements for small cells to be deployed, which will improve capacity of 4G and 5G networks across the city.

Supporting network densification through neutral host providers

5G brings with it the need to deploy higher bandwidth services using higher frequency spectrum. This means that mobile base stations will have to be placed closer

together, also known as network densification. Neutral host models of deployment (where a third-party deploys network infrastructure and provides access or capacity to multiple providers) will likely have an important role to play in this, particularly where the economics of deployment are challenging, as the use of shared infrastructure reduces the duplication of capital investment, bringing down the cost of deployment for individual providers. They also help minimise street 'clutter'. Neutral hosts lend themselves in particular to delivering smart city infrastructure, as a connectivity layer which can be shared by a multitude of services and applications.

The use of public sector assets and land is likely to become increasingly important for the rollout of advanced wireless networks, including neutral host networks, particularly where extra capacity is required for services in high demand areas. Local authorities can help facilitate network deployment by making their assets and land available to network providers for the deployment of infrastructure. Our [DCIA programme](#) aims to make the transactions between public sector asset owners and telecoms companies as frictionless as possible, lowering costs of site acquisition and accelerating the rollout of digital connectivity across participating regions.

Digital Infrastructure Advisory Group

We are establishing a Digital Infrastructure Advisory Group to bring together regional digital infrastructure leads from across the UK. The group will be the forum by which regions can provide recommendations to government on how we can support their digital connectivity ambitions (with a focus on advanced wireless), share real-time learnings, and generate ideas about how together we can relay information about the benefits that advanced digital connectivity can provide – encouraging investment and supporting adoption at a local level.

The Digital Infrastructure Advisory Group will look to identify challenges and barriers to adoption and work with the government to formulate solutions. These will support the objectives of this strategy and the implementation of our adoption ambitions, including creating a feedback process with the industry through an appropriate representative body. We aim for the first outputs of the group to be generated by summer 2023.

Addressing barriers to deployment

Through our Barrier Busting Task Force, we will continue to support local authorities to address specific areas which can lead to friction and delays in deployment of networks, including by highlighting the benefits of 5G and communicating the opportunities that it and the new technologies it will support will offer places across the UK.

Access to public sector assets

Local authorities can facilitate network deployment by making their assets and land available to network providers. Both local authorities and network providers can benefit from the use of local authority assets in this way. Local authorities should identify suitable assets and infrastructure that they own that could be made available to support the installation of gigabit and wireless networks.

Further guidance is available on the government's [Digital Connectivity Portal](#) on how local authorities can:

- take proactive action to [map land, buildings and other assets](#) that are potentially suitable for digital deployment
- [engage with industry](#) when rights to access or use public sector assets is requested by network providers
- [progress agreements for the use of public sector assets](#) quickly, efficiently and in line with the legislative framework and public policy

Planning

Local planning authorities have a crucial role in the deployment of wireless infrastructure at the local level. They should make decisions on planning applications (including prior approvals) for electronic communications development in a timely manner and respond positively to requests for engagement.²⁵

The government has set clear policies to support the deployment of wireless connectivity and recently implemented reforms to the planning system to support 5G and extend mobile coverage. Section 10 of the National Planning Policy Framework (NPPF) sets out the planning policies for communications development in England, and states that advanced, high quality and reliable communications infrastructure is essential for the country's economic growth and social well-being. The NPPF also sets out that planning policies and decisions should support the expansion of electronic communications networks, including next generation mobile technologies (such as 5G).²⁶

Local Plans can help accelerate local growth and support jobs by setting out local planning policies that support the deployment of future wireless networks and create incentives for future investment in their area. This could include policies that will support the rollout of base stations and small cells for 5G and other advanced wireless networks, by facilitating sites and making public sector assets and land available. This is important as all formal planning applications will be assessed against the Local Plan.

Meaningful pre-application consultation and engagement between local planning authorities and operators is highly valuable. It should be seen as a two-way

²⁵ Planning is a devolved matter. Legislation, policy and best practice guidance varies in each nation.

²⁶ Applies to England only.

partnership and, if conducted in this way, it can lead to a more efficient process and better outcomes for all involved. Effective consultation and engagement also enables local planning authorities to give feedback on the planned installation of wireless infrastructure in a timely manner and provides transparency for the public.²⁷ Where multiple installations are planned over an area, it is useful for the operator and the local planning authority to discuss the rollout plan in advance – local planning authorities should be open to having this engagement. Strategic-level engagement can build understanding of the proposals, set out expectations and establish ways of working.

Local planning authorities may charge fees for pre-application services. If any pre-application consultation fees or charges are imposed then these should be based on a cost recovery basis only. Local Authorities should provide meaningful, site-specific feedback on proposals during pre-application consultations.

Further guidance is available on the [Digital Connectivity Portal](#) on how local planning authorities can support the rollout of wireless networks.

²⁷ The mobile network operators and wireless infrastructure providers have agreed to follow the consultation and engagement principles set out on the [Code of Practice for Wireless Network Development in England](#) for proposals in England. See also the [Code of Best Practice on Mobile Phone Network Development for Wales](#) for proposals in Wales.

Northern Ireland Mobile Action Plan

In 2020 the Minister for the Economy instigated the establishment of a cross sectoral working group to develop a [Mobile Action Plan for Northern Ireland \(MAP NI\)](#).

The objective set for the cross-sector MAP Working Group was to produce a Mobile Action Plan for Northern Ireland (NI), which identified the main issues that impact the roll-out of mobile technologies and explored options to remove these barriers. Through consultation with stakeholders, the working group identified several issues which inhibit the roll out of mobile networks and recommended solutions to enable better, faster, and more consistent mobile coverage throughout NI.

MAP NI was published in June 2022. The eight actions/ recommendations identified within it will now be delivered by the relevant NICS Departments and organisations.

One key recommendation within MAP NI was to establish a mobile technology Barrier Busting Taskforce for Northern Ireland (NIBBT). The taskforce will comprise of NICS Departments, Councils, Industry representatives, Ofcom and DSIT.

In terms of delivery, the Taskforce will establish working groups, populated with stakeholders (government and industry), who will deep dive into specific issues, with a view to identifying solutions and/ recommendations that will accelerate the roll out of mobile technologies.

Encouraging adoption of wireless technology in public services

Wireless technology can be used to improve the quality and efficiency of transport networks and health and social care services. Standalone 5G and more advanced forms of 5G connectivity, and the technology and data it supports, can transform services to address supply and demand issues, reduce inefficiencies, increase productivity, and help stimulate innovation and growth at a local level. Analysis commissioned by DSIT suggests that significant economic and societal benefits can potentially accrue from the digitalisation of public services, better use of data and the use of advanced wireless technology. With high levels of adoption, 5G applications within smart cities and public services could account for £100 billion in additional GVA between now and 2035.

Not only can the adoption of wireless technology improve public services, but it can also provide an important base layer of demand ('anchor tenancy') to support the business case for investment. We therefore want to support local and regional authorities to make the case for investment in wireless network services. The responsibility for delivering public services is in many cases devolved, and DSIT will

work with the devolved administrations and Territorial Offices on realising our UK-wide ambitions.

Identifying and aggregating demand – use case ‘stacking’

Places should identify, plan, and articulate their needs for digital connectivity and services. This can be done through their local development plans and economic and industrial growth strategies; as described above, a specific digital infrastructure strategy can provide a coherent and clear picture of a region’s demand for services and infrastructure, which can help make the case for investment.

To realise the full benefits that 5G has to offer, it is important for places to identify and aggregate all the activities and services that could potentially be supported by the same network infrastructure, and calculate the potential cumulative return on investment. Regional authorities should strive for a coordinated approach to procuring network services across their teams. By exploring how services can share a platform and how these will be scaled, authorities will be able to demonstrate how the overall benefits from adopting technologies like 5G will outweigh the costs.

Aggregating demand, or ‘use case stacking’, can help to attract investment by forming a more consolidated picture of demand for network and service providers, and can reduce the pressure on an individual use case to justify the cost of the network or service. It maximises the value that can be gained from a single deployment. It is therefore important to identify use cases from both the public sector and industry sectors in the local economy.

The government has established the UK Telecoms Innovation Network (UKTIN) to support the navigation of the telecoms ecosystem. UKTIN’s website has extensive guidance and information on how 5G can help transform services in various [sectors](#), and how local authorities can identify demand and combine 5G use cases to deliver benefits beyond just providing better wireless connectivity and use 5G as an enabler for unlocking and utilising new capabilities and technologies. We also continue to update [GOV.UK](#) to set out the findings and benefits of the 5GTT projects and the use cases developed through the programme.

UK5G’s [Digital Connectivity for Places Series](#) includes real world examples of local authorities that have gone through this process, and guidance on how to build a business case for digital connectivity.

While providing the basis for encouraging inward investment, business plans for digital connectivity and services should also articulate how places will:

- develop a sustainable digital ecosystem – including building relationships with relevant stakeholders across public authorities and industry
- improve digital inclusion and accessibility through better connectivity and services

- develop digital skills and capability in the public sector
- build in principles of [Secure Connected Places](#)
- embed the principles of openness and interoperability across wireless infrastructure to support a diverse and resilient supply chain (such as in [Open RAN](#))

Supporting local authorities to invest in digital connectivity

Creating a value chain around advanced wireless services can help boost investment and drive growth at a local level. Local and regional authorities can create a sustainable business model that allows for this value to be reinvested in public services for the benefit of local communities. Any public investment in advanced wireless services could be based around existing budgets or from wider local growth and levelling up funding opportunities. This could include additional local government funding opportunities such as the [Levelling Up Fund](#), [Town Deals](#) or City Region and Growth Deals where funding has already been allocated for digital connectivity activities. The [UK Shared Prosperity Fund](#) can be used to support relevant digital interventions, at the discretion of the local authority.

For example, the UK government has invested £790 million in the four City and Growth deals in Wales - with each region identifying and supporting projects including those aimed at improving digital connectivity and infrastructure. In Northern Ireland, as part of the [Belfast Region City Deal's Digital Programme](#) £40 million will be invested in enabling infrastructure to stimulate the conditions for innovation and business growth by targeting investment in digital connectivity (including advanced wireless), data infrastructure and other enabling infrastructure to support the Belfast Smart District and wider regional innovation. The Levelling Up Fund (Round 1) awarded £6 million to 'Margate Digital,' to provide new education facilities for the East Kent College Group, specialising in industry-related digital technology and the creative arts.

At Spring Budget 2023 the Government announced the creation of 12 Investment Zones which will leverage the success of industry and research to support growth across the whole country. The Investment Zones programme has developed a flexible menu of potential interventions, including funding for digital infrastructure, designed to complement existing Government support and programmes, and grow local innovation and private sector investment.

DSIT will work with DLUHC and the Territorial Offices to support local authorities and regions with digital infrastructure and connectivity ambitions as part of any City Region and Local Growth Deal, Levelling Up or Investment Zone funding activities. Additionally, DLUHC will support DSIT to facilitate data sharing on projects that have referenced Project Gigabit and 5G.

Alongside this continues a programme of devolution in England where local areas are being given more flexibility to deliver their local priorities whilst supporting national

objectives. The [Levelling Up White Paper](#) sets out the government's mission that, by 2030, every part of England that wants one will have a devolution deal with powers at or approaching the highest level of devolution and a simplified, long-term funding settlement. We have already made progress towards this by announcing a new Mayoral Combined Authority deal for York and North Yorkshire, the first ever Mayoral Combined County Authority deal in the East Midlands, the first ever unitary authority deal to establish a mayor in Cornwall and deals to establish directly elected leaders in Norfolk and Suffolk.

As part of the [North East Devolution Deal](#), the North East Mayoral Combined Authority will establish a Digital Connectivity Fund which will support the smart adoption and scale-up of advanced digital service and technologies within its industries and public services, building on the North of Tyne digital investment of £25 million, and major 5G investments. The aim is to establish the North East as a 'digital adoption accelerator' - a national centre of excellence for 5G use-case development and adoption – accelerating the economic, social and wellbeing impact of enhanced digital connectivity through focusing on rapid adoption and scale-up across their key sectors.

In the Levelling Up White Paper, the government committed to negotiate trailblazer deeper devolution deals with the Greater Manchester and West Midlands Combined Authorities to set the blueprint for deeper devolution across the rest of England. These deals have now been agreed, subject to ratification, and will equip these authorities with deeper and additional policy levers to deliver on their priorities.

We have already committed to provide support to level up regions by improving digital connectivity – for example, the West Midlands benefited from the WM5G Testbed programme and enjoys high levels of 5G connectivity across the city region; and the York and North Yorkshire, Suffolk, Norfolk and North East deals set out a commitment to engage with local leaders on regional delivery plans for Project Gigabit. DSIT will continue to engage with places to explore how English devolution could support their digital connectivity aspirations.

Alongside and in support of these funding opportunities, our 5G Adoption Programme will support places further by funding regions and local authorities with digital connectivity ambitions to establish themselves as 5G Innovation Regions, and drive local growth and productivity through the adoption of advanced wireless connectivity for local businesses and public services.

Public sector procurement

In their responses to our Call for Evidence, industry stakeholders called on the government to show leadership through its own procurement of digital services, to create the demand required to encourage investment, including by digitalising its own processes and services. TechUK has also [called on the government](#) to demonstrate

the value of 5G for the public sector by establishing itself as an anchor tenant for 5G infrastructure and services.

The Cabinet Office has introduced [legislation](#) that will substantially reform the UK's procurement legislation, allowing public bodies to take a more flexible and innovative approach to the way they procure technology solutions. This will help drive innovation and provide market opportunities by breaking down barriers for small businesses in bidding for public contracts.

The [Digital, Data and Technology Playbook](#) sets out plans to help enable innovative approaches to public service procurement, to improve efficiency in our commercial processes around digital, data and technology.

The Crown Commercial Service recently published a new [procurement framework](#) for Mobile Voice and Data Services and the latest version of the Network Services Framework, which includes provision for IoT and Smart Cities is due to be released in April 2023.

We recognise that the government has an important role to play as an early adopter of 5G and other advanced wireless technologies and we believe that the government can show leadership through its own procurement of digital connectivity services, to create the demand required to accelerate investment. **DSIT is working with the Crown Commercial Service to convene the largest public sector customers of wireless connectivity services and encourage them to identify their future connectivity needs, with a view to being able to articulate and aggregate demand for 5G and other advanced wireless connectivity from the public sector to the industry. Establishing a clearer picture of the emerging demand will enable departments and the Cabinet Office to develop a strategy for public procurement of advanced wireless technology by Autumn 2023, with a view to issuing a Procurement Policy Note.**

Major infrastructure projects

The government is committed to ensuring we maximise the opportunities major infrastructure projects offer to extend connectivity across the UK. The [Transforming Infrastructure Performance](#) (TIP) programme, led by the Infrastructure Projects Authority (IPA), aims to drive system change in the built environment and a step change in infrastructure performance – in both economic infrastructure, such as transport and energy networks, and social infrastructure, such as schools and hospitals. The TIP Roadmap to 2030 provides a vision of government and industry together prioritising societal outcomes and using innovative digital solutions to achieve them.

DSIT and the IPA are collaborating through the TIP roadmap to ensure fixed and wireless digital connectivity requirements for future users of infrastructure are

embedded from the early planning stages – improving performance during construction and the functionality of UK infrastructure, while encouraging investment in and adoption of advanced connectivity.

Ensuring security and resilience in connected places

Secure and resilient networks are of paramount importance. The economic benefits of digital connectivity can only be maximised if we have confidence in the underpinning networks and technology. We have outlined elsewhere the actions the government has taken to put in place a new telecoms security framework and manage the presence of high risk vendors in public telecoms networks. We are also clear that, as connectivity becomes increasingly important, the importance of resilient networks correspondingly increases.

We recognise that, for communities to capitalise on the benefits of advanced wireless technologies, particularly where they become increasingly integrated into existing local and national digital networks and infrastructure, efforts will need to be made to ensure that security is protected.

In 2021, the National Cyber Security Centre (NCSC) published the [Connected Places Cyber Security Principles](#). These principles support those designing, building, and managing connected places to ensure the security of their underlying infrastructure, so that they are both more resilient to cyber-attacks and are managed more effectively. As outlined further below, the call for information on the security of private networks will help us to understand the dependency of smart cities on private telecoms infrastructure and how the government can further support the secure development of these networks. Furthermore, the [National Cyber Strategy 2022](#) set out the government's aim to 'build on the NCSC's security principles for connected places to reduce the risks posed to businesses, infrastructure, the public sector and citizens' and 'to strengthen the capability of local authorities ... to buy and use connected places technology securely'.

This year, DSIT will publish an alpha version of its Secure Connected Places Playbook. It will contain a set of resources to support UK local authorities to apply the NCSC Principles. This playbook was developed by working with six UK local authorities to identify their challenges in securing their connected places, and collectively develop, test and iterate guidance to support the implementation of the Principles.

Chapter 6: Driving adoption in key economic sectors

Adoption of 5G-enabled use cases in sectors such as healthcare, transport & logistics, manufacturing and agriculture will drive economic growth and productivity across the UK, delivering our priority of economic growth.

There are a variety of wireless technologies available to businesses including Wi-Fi, 4G and 5G, satellite and LoRaWAN, each with different benefits and features. Each business or sector will have its own unique requirements but there will be many use cases for which 5G has an advantage, particularly where businesses require security, reliability, low latency, large amounts of bandwidth and local data processing. Industries like construction and manufacturing will particularly benefit from remote monitoring and operation of equipment and new training opportunities offered by AR/VR technology.

Key features of 5G for industry

Dedicated 5G networks can enable:

- data analytics: Utilising operational and environmental sensor data to make real time decisions about equipment and operational performance
- video surveillance and geolocation: Providing the location of workers and assets for security and safety purposes
- tracking moving assets: Working with self-driving vehicle technology and software guidance systems to provide situational awareness of mobile assets
- automation: Enabling independently operating robots to perform operational tasks

Adoption of 5G and other advanced wireless technologies will be key in unlocking additional GDP growth and productivity gains across key sectors of the economy. [Analysis](#) by PwC suggests that smart utilities and manufacturing are expected to add £9.4 billion and £6.1 billion respectively to UK GDP by 2030. Analysys Mason and Cambridge Econometrics estimate that high levels of 5G adoption in the manufacturing and logistics sectors could add £15 billion in additional GVA between now and 2035. 5G is a key enabler of innovative technologies like AR/VR and AI,²⁸

²⁸ AR/VR is expected to boost UK GDP by £62.5 billion by 2030, and enhance 400,000 jobs.

and can help unlock economic opportunities,²⁹ ensure the UK remains internationally competitive and bolster the UK's productivity.

5G can enable businesses to thrive, bringing productivity gains to the whole of the UK, driving the digital economy and helping businesses modernise and grow. Increased adoption can also help drive investment in 5G, helping operators make the business case for the deployment of the high quality 5G required to power industrial use cases.

Productivity benefits for industry

Stimulating and supporting increased adoption of 5G and advanced wireless connectivity is expected to increase productivity to firms:

- evidence from the 5G Testbeds and Trials Programme (5GTT) found that [5G enabled more machine automation](#). This led to a 25% saving on labour costs per part
- asset tracking can reduce loading time and wrongly transported goods - WM5G found search time for parts reduced from 25 minutes to 3 minutes, worth £40,000 in labour time saved over a 12 month period
- predictive maintenance can increase the lifespan of machinery and improve operational efficiency, raising task productivity (15-38%)³⁰
- 5G enabled AR/VR for maintenance in a logistics company resulting in an increase in repair rate of 30% and a reduction in maintenance costs of 20%³¹
- case studies³² show self-driving vehicles can reduce labour costs within logistics firms by 90%

These applications require enterprise-grade 5G, with high throughput, high reliability, low latency and potentially edge computing. Once standalone 5G is deployed in the public networks, such high-spec services could potentially be offered over the public networks, for example, through a network 'slice'.

However, in many cases connectivity for enterprises can also be delivered via dedicated private networks, which can offer the high-quality, secure networks businesses need for applications such as robotics, goods tracking and self-driving

²⁹ In terms of GVA, from Cambridge Econometrics (2021) [5G Benefits, Impacts and Barriers](#). In a high 5G adoption scenario, benefits could rise to £37 billion in GVA a year by 2035, with estimates in line with other reports on the 5G benefits ([PWC \(2021\)](#), [Vodafone \(2020\)](#); PwC estimates that 5G productivity and efficiency gains in manufacturing will boost UK GDP by £6.2 billion by 2030.

³⁰ ABI Research (2023), 5G in Asia

³¹ Ibid

³² Ibid

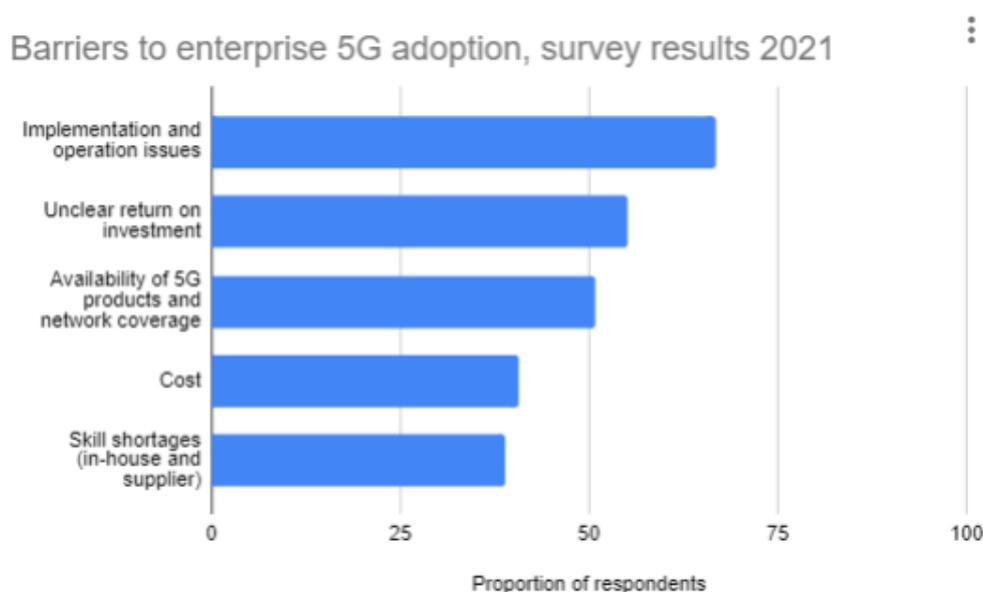
vehicles. Provided by the MNOs as well as a range of new and existing connectivity providers and systems integrators, they offer reliable coverage throughout the customer's site, customer control of sensitive data, ultra low latency communications and the ability to process large amounts of data on site.

5G technology is still very new to the market (the latest advanced features have only been adopted by standards bodies in 2022 and therefore will not come to market at scale until later this decade) and therefore adoption by businesses is still nascent but growing. The 5GTT programme helped kickstart adoption in a range of sectors and has proven some of the significant benefits on offer to businesses. The programme expects to generate benefits of around £2.6 billion over 10 years by accelerating the adoption of 5G technology.

According to analysis from [Berg Insight](#), wider 5G adoption by businesses is likely to increase over the next decade, as the market matures and further products and use cases are brought to the market. However, there are factors which could prevent this from happening quickly, or at scale, including beyond larger business in certain sectors:

- uncertainty around the benefits of 5G amongst businesses
- the high cost of equipment and end-user devices
- the complexity of procuring, installing and maintaining a private network
- the relative immaturity of the supplier ecosystem

Chart 4 highlights implementation and operation issues as the main barrier to successful adoption.³³



³³ Combined evidence from [Capgemini: 5G adoption 2021](#), [NTT: Private 5G here and now](#), and [Omdia EY's 2022 reimagining industry study](#) also ranks implementation and operation issues as the top challenge around 5G.

We will implement a series of measures to address these challenges and accelerate the adoption of 5G, including:

- **engaging with businesses in key sectors on the benefits of 5G adoption**
- **ensuring businesses have the right knowledge and understanding to able to navigate the supplier ecosystem and access the right connectivity for their businesses**
- **improving digital skills**
- **continuing to improve access to spectrum**

Demonstrating the benefits of 5G

We will undertake a nationwide campaign to drive 5G adoption by businesses. As part of the 5G Testbeds and Trials Programme, UK5G undertook activities to publicise the benefits of 5G in key sectors. Through intensive engagement with businesses and providers, UK5G developed a significant base of resources and reports and organised events such as the 5G Showcase that demonstrated the industrial applications of 5G and the significant benefits they bring to businesses.

Additionally, Digital Catapult has developed a detailed [toolkit](#) to help businesses who want to adopt 5G-enabled use cases, and also facilitated the [Made Smarter Technology Accelerator](#) to accelerate and shape the UK's technology solutions directly into industry. TechUK has also published a new [user guide](#) on private networks.

The [Scotland 5G Centre](#) (S5GC)³⁴ is providing both testing facilities and expert advice for companies, academics and the public sector wishing to adopt private wireless communication solutions. Through an established a suite of 5G Connect Hubs located across Scotland, the S5GC provides organisations with an affordable, low risk means of assessing new wireless communication based solutions to current and future business needs. Each hub provides access to a private 5G network, providing local organisations with the ability to understand and realise the benefits of wireless communications. Accessing a hub allows organisations to test and evaluate new applications, focussed on improving/delivering new services and products.

These activities have made a real impact on early 5G adoption, identifying key sectors and the particular barriers they face and how the government can help address these.

We will build on the work of the 5GTT programme, bringing together the telecoms industry and the public and private sector to galvanise adoption of 5G and other advanced wireless connectivity. This work will address market opportunities by further developing resources to help businesses and local authorities understand the benefits of and how to adopt 5G and other advanced connectivity.

³⁴ Funded by the Scottish Government, The Scotland 5G Centre is Scotland's national centre for accelerating the deployment and adoption of 5G connectivity in Scotland's Industry and Public Sectors.

This work will also recognise the growing importance of systems integrators in helping customers overcome the complexities in deploying private networks, which can bring together hardware and software solutions from multiple providers as well as supporting customers with integrating networking and storage.

Improving digital skills

This government has ambitious plans to boost the UK's digital capability and capitalise on the opportunities for growth this will create. We are working closely with industry and academia to drive forward a set of actions to grow the digital workforce, tackle the digital skills gap and support a diverse range of people into digital roles. These actions include founding the Digital Skills Council (June 2022); launching successful AI and Data Science Conversion Courses; and supporting the Home Office with visa routes for digital jobs.

Our work on telecoms skills to support wireless infrastructure will build on the skills plans set out in the [Digital Strategy](#) (2021), [National AI Strategy](#) (2021), [National Cyber Strategy](#) (2022) and upcoming UK Semiconductor Strategy. These strategies all focus on increasing digital skills in the UK as well as creating awareness across broader sectors of the benefits to be gained from these technological advances. Taken together with broader government work on skills led by DfE and DWP they will aim to create a well-established skills pipeline for a workforce to support the UK's wireless infrastructure and broader future telecoms needs. In 2020, the government introduced a digital entitlement for adults with no or low digital skills to undertake specified digital qualifications in essential digital skills, up to level 1, free of charge. The government has also introduced more flexible training routes into digital roles, including the choice of 33 different digital qualifications through "Free Courses for Jobs" and also the 16 week Skills Bootcamp courses which are being rolled out in the UK, with 11k learners expected by 2021/22. Digital Skills Bootcamps courses cover areas such as software development, digital marketing, and data analytics.

A 2020 skills [report](#) from the government-funded Worcestershire 5G Testbed noted that this cross-sector view is key to a successful strategy for wireless infrastructure skills, and called for a 'digital resource backbone' to underpin the telecoms sector. Greater digital literacy across sectors will allow the UK better to leverage the capabilities of advanced wireless connectivity and the innovative uses it enables.

We will continue to ensure that government's focus on digital skills factors in the specific requirements of wireless infrastructure. For example, digital skills for 5G and 6G will require the ability to develop and knit together software and hardware aspects of the network, as well as the security, network operation and maintenance skills to protect mobile networks as part of our critical national infrastructure. The skills to support development, deployment and adoption of advanced wireless connectivity will span a huge range of sectors and environments - from the technical skills needed to lead cutting-edge research and development for future technologies, to the huge

demand for vocational skills for the workforce who will deploy and maintain the physical infrastructure of the network. We will not only build on the well established, and in many cases world-class, network of digital skills providers in the UK, but will also look to enhance the offering of newer providers. For example, five of the nine Institutes for Technology (IoTs) currently under development will specialise in communications technology. Once developed, these five institutions will provide a wide range of relevant skills opportunities across the country to complement other routes into communications and telecoms for talented people. At the same time, these IoTs will provide a unique opportunity for industry to play a direct role in shaping their own workforces of the future – using industry-standard equipment and next-generation technology to avoid skills gaps and drive forward innovation.

With this skills infrastructure in place, we will put in place more robust tools for predicting and preventing potential skills shortages in the sector to ensure that businesses have the workforces they need to grow and support the adoption of advanced wireless connectivity. We will work to form a close partnership between DSIT, DfE and businesses to ensure that policymakers are responding in an agile and effective way to sector skills needs.

Lastly, we will complement and enhance our domestic skills pool by attracting the best tech talent from overseas – both into academia and the sector itself.

Continuing to improve access to spectrum

Ensuring spectrum availability for private networks is a crucial piece of the puzzle to delivering next generation connectivity across the UK, enabling new providers to enter the market and opening up further opportunities for the adoption of 5G and beyond.

As demand continues to grow, we must ensure continuous evolution of our spectrum access mechanisms and improvements in sharing. The introduction of Ofcom's spectrum sharing [framework](#) in 2019 was a welcome and groundbreaking step in catalysing the UK's sharing landscape. The framework marked the UK out as a world leader in making such 5G spectrum available for industrial and other applications.

This framework has enabled localised access to spectrum in bands already licensed to MNOs, via [Local Access Licences](#) (LALs), while also designating specific bands for shared use via [Shared Access Licences](#) (SALs). As of March 2023, approximately 1,600 SALs and 30 LALs had been granted. A number of these deployments have received DSIT funding through the 5G Testbeds and Trials programme (5GTT). However, some users of the framework have identified a number of issues that are potentially serving as a barrier to uptake.

A number of users of the SAL bands have [reported](#) that the licence application process is time consuming and resource intensive. Stakeholders have also reported that the lack of transparency with regard to the availability of particular frequencies

results in wasted applications for unavailable spectrum. This is consistent with feedback provided from the 5GTT project [participants](#).

Stakeholders, including those that took part in the SPF's workshop on spectrum sharing in the UK, have called for the introduction of automation for SAL licence applications, and have recommended that Ofcom publish the scope and implementation timetable for this as a priority.

5GTT participants who participated in the implementations and learning report also called for the introduction of Dynamic Spectrum Access (DSA). America's Citizens Broadband Radio Service (CBRS) band, for which DSA is used to manage access to its spectrum, was highlighted in some of the responses to our Call for Evidence as an example of an automated system that works on both a geographical and temporal basis.

[Ofcom](#) has begun work to implement an automated (though not dynamic) system across SAL bands by April 2024. This will see hundreds of thousands of spectrum licences moved onto an online platform to support more efficient application processes. This platform will give users rapid access to spectrum, providing industry with more transparency and certainty.

In the meantime, Ofcom anticipates that incremental increases in licence automation will be introduced before the full automation of SALs is complete. As outlined in Ofcom's [Call for Inputs on SAL evolution](#), Ofcom will continue to explore the benefits and challenges of a range of automation solutions through engagement with stakeholders over the coming months.

We believe that automating applications for SALs is important for encouraging the rapid deployment of private networks. We have therefore asked Ofcom to explore options to accelerate the planned introduction of licensing automation in the SAL bands specifically, to ensure this is introduced as soon as possible.

The feedback provided by stakeholders has informed Ofcom's and our own thinking about how spectrum sharing in the UK should develop. Ofcom has now [set out](#) updated thinking on the potential role automated assignment databases could play as part of a dynamic or adaptive approach to meeting future spectrum management challenges. Stakeholder feedback on this thinking is encouraged. **We remain committed to the timely introduction of DSA where appropriate to further spur competition and innovation in the provision of telecoms services.**

Ofcom's SAL [guidance document](#) states that SAL bands, including 3.8-4.2 GHz, could be varied to enable DSA in the future. We welcome this and have asked Ofcom to prioritise giving consideration to the introduction of DSA in these bands. **We expect Ofcom to draw on relevant international examples to continue to develop this assessment of the range of DSA type opportunities in the UK, including**

consideration of DSA across the SAL bands. We expect Ofcom to be ready to implement such access in advance of the commercial roll out of 6G.

Spectrum sandboxes, introduced in Ofcom's [spectrum roadmap](#), could provide a useful step towards introducing DSA, by providing an environment in which different sharing partners and dynamic sharing mechanisms can be trialled, and establishing what form DSA in the UK might take. **We are supportive of DSA sandbox trials, which could help demonstrate the viability of introducing greater flexibility of access by time, place and frequency across SAL.**

Ofcom has [stated](#) that for any future implementation of DSA, the specification of the communication between the radio equipment and database would be most effective if carried out in collaboration with industry, particularly equipment vendors. **We welcome this collaborative approach, which is an important step towards the introduction of flexible, dynamic access to spectrum in the UK. We will continue to engage with Ofcom to develop a definition of DSA for the UK that is suited to industry's needs and the government's strategic aims for wireless infrastructure.**

Technical limitations

A number of technical parameters have been identified by stakeholders as barriers to the use of shared spectrum in the UK³⁵ including:

- restrictions on the maximum permissible height of antennas
- restrictions on maximum permissible power levels at a specific location
- the assumption of the use of omni-directional antennas

Ofcom's ongoing work to improve propagation models, highlighted in their [Spectrum Management Statement](#) and the [Spectrum Roadmap](#), will help to address the concerns of stakeholders relating to technical restrictions. Improved coexistence and propagation models, using real world data, will enable Ofcom more accurately to assess the use of the spectrum and introduce less conservative parameters for shared spectrum. Updates and variations to the current propagation models should also account for impacts from local clutter, climate effects and behaviour of higher frequency emissions.

Improved propagation models and the introduction of automation will go a long way to overcoming the technical restrictions currently in place but, in the meantime, we are keen to ensure these factors aren't creating undue barriers to deployment and therefore adoption of private networks. DSIT welcomes Ofcom's work to ensure that the technical conditions are optimal to maximise the efficiency of spectrum use. **We have also asked Ofcom to consider what further steps could be taken relating to**

³⁵ As highlighted in call for evidence responses, the SPF report, the, [n77 market study](#) and in the 5GTT implementation and learning report.

licensing conditions for LALs and SALs, with a view to scaling up deployment of enterprise networks while protecting incumbent services in the same or adjacent bands. We encourage stakeholders to respond to Ofcom's [Call for Input on the evolution of the SAL framework](#) as part of this process. We will continue to work with industry and Ofcom to address the barriers to the uptake of shared spectrum.

Recommendation 22 of Real Wireless and UK5G's [upper n77 market study](#) recommended that Ofcom continue to engage closely with interested industrial users of SALs to ensure that any current and future concerns regarding spectrum sharing, including technical restrictions, are addressed where possible. DSIT and Ofcom have agreed that this would be a useful initiative to ensure that the UK's spectrum sharing landscape is working on the ground and enabling innovation.

The UK Spectrum Policy Forum's (SPF's) position as an independent industry body means it is well placed to host this. Part of the SPF's work focuses on spectrum efficiency and has taken forward this work on behalf of DSIT, establishing a regular forum to consider aspects of the sharing framework and whether they are working as intended. Existing and prospective spectrum users, as well as other affected ecosystem players are invited to the forum to discuss how best to make the sharing framework as effective and accessible as possible.

It is essential that spectrum is used efficiently, without unnecessarily conservative restrictions or other barriers in place to hamper innovation. Next generation technologies will increasingly require a full portfolio of spectrum bands to deliver the low latency, high capacity and speed of 5G and beyond. Spectrum sharing is crucial to helping deliver this portfolio and realising the full potential of private networks in the UK.

Supporting and accelerating the deployment of open networks

Beyond the economic benefits, private networks can also be a proving ground for new entrant vendors and OpenRAN technology. Private networks are smaller, able to be designed to fulfil a specific requirement and specifically applicable to enterprise operation. Therefore, there is an opportunity to build specialisms in industry verticals and design innovative components for network architecture. Supporting the maturation of this market, by accelerating commercialisation of 5G private networks, designed through open principles, will help drive increased diversification of suppliers in the market.

Security of private telecoms networks

To ensure the full benefits of this digital connectivity are realised it will be essential that private telecoms networks are designed, built and managed securely. As referenced earlier in this document, the Telecommunications (Security) Act 2021 will help ensure that public networks are secure and resilient. However, as the

connectivity needs of critical sectors of the economy prompt a greater reliance on dedicated private telecoms networks, we must ensure that these networks prioritise security. **DSIT will publish a call for information on the security of private telecoms networks, which will help us to better understand how dependent critical sectors are on private telecoms networks and consider how the government can help ensure their secure development.**

Emerging demand in key economic sectors

Analysis commissioned by government found that the business case for investment in 5G may be undermined by a “chicken-and-egg” problem³⁶. Industry providers need to see clear demand from consumers and enterprises, and an understanding of their willingness to pay, in order to invest. However, without clear evidence of 5G use cases in practice, potential users of 5G may be unable to see its potential and the benefit of investing in it.

The purpose of this section is to set out some of the most significant areas of emerging demand, in order to spur accelerated private sector investment, and create a virtuous circle of investment, technological advancement, growth and innovation.

Health and social care

The NHS is committed to improving out-of-hospital care and supporting people to age well. The digitalisation of our healthcare system is accelerating and new models of care such as virtual wards are emerging, as are new clinical technologies which have the potential to significantly improve outcomes for patients and efficiencies for staff.

The government’s 2022 [Plan for Digital Health and Social Care](#) sets out plans to accelerate adoption of digital technology within the health and social care system, improving health outcomes for people and their families. This includes a commitment to ensure that all health and social care settings have the right infrastructure and connectivity to work digitally.

Access to consistent, reliable wireless connectivity is vital for ambulance staff, community nurses, care workers, clinicians and people in health and care settings and is a crucial enabler of the ongoing work to digitalise health and care provision and improve public health. It can support a wide variety of services and functions, including:

- remote monitoring of patients through sensors and other connected devices
- video consultations – either between doctor and patient, or between health and care professionals, for example on patient visits or in ambulances
- transmitting high resolution images from scans

³⁶ Analysys Mason and Cambridge Econometrics (2021), ‘Realising the Benefits of 5G’

- ensuring equitable access to internet-connected devices and care records for people drawing on care and support services in rural locations
- high-spec connectivity within clinical environments, connecting people and machines
- drones for transporting medicines

Some of this connectivity will need to be provided over the national public mobile networks; this includes connectivity for patient wearable devices and connectivity for mobile health and care workers. Some of it, such as high-spec connectivity for hospitals and other indoor environments, may be better delivered over a bespoke private network.

NHS England is investigating, including through testbed initiatives, how wireless capabilities can support the delivery of healthcare services and the adoption of wireless technologies in health and care. They will also be publishing advice and guidance and engaging with pilot initiatives, such as virtual wards, to advise them how to underpin their objectives with the right wireless connectivity.

Connectivity requirements should be aggregated across Integrated Care Systems (ICSs) throughout health and social care. The ICS Design Framework requires ICSs to agree a plan for embedding population health management capabilities and ensuring these are supported by the necessary data and digital infrastructure. More funding for digital services is being delegated to ICSs and the government has committed to building digital skills and leadership in the health and social care workforce. **DSIT will work with DHSC, NHS England, ICSs and local authorities to ensure that health and social care providers can benefit from the latest and fastest connectivity.**

Advanced digital connectivity is important to support our ambition for delivering intelligent new hospitals which will use digital tools and services to empower patients and staff. 5G can play a vital role in supporting mission-critical functions within hospitals. **We will ensure that our new hospitals will be equipped with 5G networks or other advanced wireless telecoms technology to support facilities that are on the cutting edge of modern technology and digital innovation.**

Automotive, logistics, freight and trade

Transport networks are likely to be among the first to see a need for consistent, reliable, low latency, high bandwidth wireless connectivity on a wide-area basis. There are a number of emerging use cases for roads, including:

- Connected and Automated Mobility (CAM)
- real time journey information
- AI-enhanced traffic signal optimisation
- digital asset tracking

Self-driving vehicles are fast approaching commercialisation. CAM technologies have the potential to increase UK productivity by allowing drivers to benefit from optimised route planning, improved traffic flow and by giving them more productive time in their vehicles. They could enable more effective monitoring, predicting, and controlling of route demand, enabling the better design and use of public transport and space, and making our communities more attractive and efficient. Transport automation can help achieve society-wide goals, allowing more efficient and sustainable mobility in cities and better availability of services in rural areas as well as to older and disabled members of society.

Through a DSIT-funded 5G Create project, Milton Keynes has built a private (but open) city-wide 5G network that supports self-driving vehicles used for delivering anything from shopping and pizzas to manufacturing components, as well as a service that gets citizens from the railway station to the MK Dons Stadium.

The more road services depend on connectivity, the more connectivity should be considered as a part of the wider road infrastructure. CAM technologies will need good digital and data infrastructure for elements of their functionality and the regulatory framework. For example, routing and efficiency services will require connectivity, though the core functions of self-driving systems are expected to function safely without it; data retention will be essential to ensure proper management of incidents involving self-driving vehicles.

As noted in the government's [Connected and Automated Mobility 2025](#) document, early planning has ensured that our key highways are equipped with substantial capacity for wired communications, but they must continue to evolve to keep pace with the needs of users and the requirements of network safety.

On 1 February the Centre for Connected and Autonomous Vehicles (CCAV) announced it was awarding £81 million of government and industry co-investment to fund seven pilot commercial self-driving passenger and freight services by 2025. This builds on £440 million of previous joint research and development investment in technologies, products and services. The seven chosen projects include V-CAL, which builds on the DSIT-funded Connected Automated Logistics project (5G CAL) which demonstrated the use of self-driving 40-tonne trucks, supported by 5G enables teleoperation where required, to distribute parts and assemblies across the Nissan plant in Sunderland, to deliver operational efficiencies and improve productivity. V-CAL will scale and expand the initial 5G CAL proof of concept, providing two real world industrial use cases for the deployment of connected and autonomous logistics at scale:

- replacing 100% of current heavy goods vehicles (HGVs) on a trail route on private land with zero-emission HGVs retrofitted with CAM technology
- a challenging public road route where the self-driving vehicle will encounter traffic lights, roundabouts, security gates, bridges and other road users

The other projects include self-driving buses, self-driving HGVs for a major supermarket chain, passenger shuttle services and a remote operations centre, among others.

Testing of these projects will be supported by the CAM test facility at Millbrook. Thanks to initial funding from the DSIT 5G Testbeds and Trials programme, the UTAC Millbrook Proving Ground in Bedfordshire now provides a permanent 4G and 5G testbed for the validation of automotive use cases – sustaining 1 Gbit/s communications at 160 mph – on its 70 km of test tracks, thanks to commercial investment with government. The 5G test bed is now an integral part of CAM Testbed UK, jointly funded with industry and government, through the CCAV, and coordinated by Zenzic. Investment in infrastructure, 5G emulation, data storage, vehicles and simulation enables testing to capture all aspects of real-world operation for CAVs and a globally competitive, comprehensive testing offer through virtual, controlled, semi-controlled, and public testing environments.

[National Highways' Digital Roads programme](#) aims to harness data, technology and connectivity to improve the way the Strategic Road Network is designed, built, operated and used, in order to enable safer journeys, faster delivery and an enhanced customer experience. As part of this, National Highways have conducted multiple CAM trials as part of their preparations to ensure the Strategic Road Network is able to accommodate vehicles with varying levels of connectivity and autonomy and are factoring CAM into their long-term planning and investment decisions.

The programme also considers how the potentially large amounts of data from connected vehicles could be collected and used, with uses including in-vehicle messaging and signing, public transport data, traffic signal timing and phasing and parking information.

To prepare the UK for the full potential connected vehicles have to offer, DSIT and the Department for Transport (DfT) will continue to work together with industry and the devolved administrations to understand future connectivity needs on UK roads.

Digital technology and connectivity have a key role in increasing the efficiency of supply chains and digitising borders. The supply chains of the future are expected to be more driven by technology and data, enabling them to be more efficient, reliable, resilient, and sustainable. As part of its Future of Freight Strategy, DfT is working to build awareness of the challenges that can be addressed through technology and digitalisation via the Freight Council, which will connect innovators and the sector and share technology developments in the freight and logistics sector, including results of trials. Industry has begun investing in automated solutions at distribution centres and ports. Use cases include improving workplace safety, automated container terminals,

automated last-mile delivery solutions and connected traffic signals to prioritise HGVs at key junctions.

Ports have been early adopters of 5G private networks. They are used for a variety of applications, including crane operation, ensuring employee safety (by using remote operations to enable workers to stay out of dangerous areas), data sharing for supply chain visibility, asset tracking, environmental monitoring and equipment monitoring to enable predictive maintenance.

The 5GTT programme set out to explore this potential with two projects: '[5G Logistics](#)', led by the West of England Combined Authority and deploying with The Bristol Port Company, and '5G Ports' in the Port of Felixstowe. Commercial deployments have followed, including at the ports of Belfast, Tyne and Southampton.

As set out in the government's [2025 UK Border Strategy](#), the UK aims to lead the way in the digitalisation and automation of its borders. Technology and data can be used to move checks and processes away from the border.

The new Freeport areas will provide another opportunity to develop innovative, technology-driven customs processes. Technology such as geo-fencing could be used to track the movement of goods and parts within the customs zones and between non-contiguous freeport areas - but in order to do so, Freeports will need to ensure provision of adequate digital infrastructure.

Technology is being explored to be used to track the movement of goods and parts within the customs zones and between non-contiguous freeport areas. But in order to do so, Freeports will need to have adequate digital infrastructure.

In the Tees Valley, Dense Air has partnered with the Mayoral and Combined Authority to deploy 5G across the areas benefiting from Teesside Freeport status. Working in partnership with the Tees Valley Combined Authority and with Dense Air, the Centre for Digital Trade and Innovation is developing a new testbed to help industry and companies in the area take advantage of the emerging business opportunities that increased digitalisation brings. Providing a link between the real world movement of goods and the digital representation of that movement in data-based systems, will depend on the presence of reliable, advanced wireless infrastructure in and around the UK's ports of entry and critical distribution points. This new testbed aims to provide a national facility that can provide testing for innovative solutions produced by technology suppliers, designed to exploit the availability and functionality of 5G coverage. The results of such testing will be made public and will inform future work so that the UK can realise the benefits of 5G in its current and future international trading activities.

As set out in the government's [Advancing Airborne Autonomy](#) report, the government's vision is that by 2030, commercial airborne drones, otherwise known as unmanned aircraft systems, will become commonplace in the UK.

Wireless communication technologies are essential to drones for control, authentication and authorisation, and data transmission. Accurate navigation and positioning is essential for effective drone flight beyond visual line of sight. Currently drones typically use global navigation satellite systems supported by onboard sensors. Adoption of current and new mobile phone technology could complement other radio technologies to enhance drone capabilities, including flight control, situational awareness and data exchange.

The government aims to enable safe use of cellular communications for commercial drones. Telecoms providers, including BT and Vodafone, are actively looking to support drone flight with 4G/ 5G mobile technology and Virgin Media O2 has trialled the use of 5G drones to help emergency services patrol national parks. Ofcom is working with the industry and the Civil Aviation Authority to develop technical parameters and commercial licensing arrangements to permit drone operation using cellular technologies. While this work is ongoing, a number of drone companies have been granted trial and research licences by Ofcom to test and demonstrate 4G-enabled capabilities, working closely with network operators. Following a consultation in 2022, Ofcom has introduced a new operating licence for unmanned aircraft systems to authorise the use of radio equipment on drones, to enable them to be operated beyond visual line of sight.

Government's Future Flight Challenge: BT project

As part of the government's [Future Flight Challenge](#), BT is involved in a project to use drones to survey critical infrastructure, including Associated British Ports and Kier (highways construction) assets, to obtain detailed near real-time insights into these dynamic environments. In partnership with BT and RoboK, the project will enhance connectivity using 5G and fibre, and deliver new AI analytics using machine learning to optimise image processing and develop 3D digital twins. A drone-in-a-box solution will use onboard sensing, data and image processing equipment for run three use cases to improve:

- inventory management for ABP ports, focusing on vehicle inventory
- offshore surveillance and maritime operations
- highways assessment, to assure ground surface quality of highways, for Kier

Broadcasting and entertainment

The UK's creative industries sector is a huge driver of growth and jobs, [contributing £109 billion to the economy in 2021](#). The Creative Industries Sector Vision, due to be published in early 2023, will set out the government and industry's shared ambition to continue the creative industries' stellar growth performance until 2030. We are clear

that 5G can play a critical role in this, with our research suggesting it could add £9.8 billion GVA to the sector in the period to 2035.

Private 5G networks are already beginning to play a role in broadcasting and film production. Private networks enable the configuration of the network to support all types of productions and have the potential to revolutionise the production of live events.

During its coverage of the 2022 Commonwealth Games, the BBC used a 5G standalone private network provided by BT to provide live pictures from the centre of Birmingham. In another example, BT Sport and the University of Strathclyde collaborated to build a private shared spectrum 5G standalone network and used cameras connected to it as part of a live matchday broadcast of a premiership rugby match. The 5G network featured a 5G radio and 5G core from university spin-out firm Neutral Wireless.

In addition, through the 5G Testbeds and Trials programme, DSIT supported BT/EE's research and development on virtual and augmented reality experiences to complement BT Sport's services. 5G networks, coupled with cloud graphics processing units, can give sports fans immersive experiences from all angles across a broad range of devices including smartphones, tablets, AR and VR headsets and TVs.

More broadly, the Arts and Humanities Research Council is delivering the new £75.6 million Convergent Screen Technologies and Performance in RealTime ([CoSTAR](#)) programme. CoSTAR will provide a new national infrastructure to drive the next generation of R&D for the creative and digital economies.

Energy

Telecoms plays an important role in the utility sector, for example, for operational communications, remote monitoring and automated control of an increasing array of critical assets, parameters and functions. Utilities use a mix of communications technologies, including fibre, wireless and satellite. Where wireless connectivity is required they will use public mobile networks where coverage, availability and costs permit. Where high levels of availability, power resilience and low latency are required, utilities tend to use private or self-provided networks.

Electricity distribution network operators (DNOs) in the UK and around the world are undertaking major transformations to meet their net zero targets as well as to meet the increasing challenges of reliability and resilience. Networks are evolving from the traditional distribution landscape, with power flowing from a relatively small number of large electricity generators to the consumer premises, to a more complex one with a much larger set of generators. These changes are increasing the need for monitoring, control, protection and automation across the entire network and thus increasing the

overall amount of data which needs to be carried over the supporting telecoms network.

The emergence of 5G could enable useful applications for utilities, particularly when 5G SA is introduced. However, a significant component of the increased connectivity requirement of electricity DNOs is likely to need to be addressed by private wireless networks – particularly to cover critical monitoring, control and teleprotection functions which require high levels of availability and power independence over a number of days. DNOs around the world are in various stages of upgrading their private wireless networks, primarily using 4G now and, potentially, 5G in future.

The digitalisation of energy networks is critical to reaching net zero by 2050 and supporting a smart, flexible energy system. Alongside the Department for Energy Security and Net Zero, and as part of the [Energy Digitalisation Strategy](#), we will continue to encourage collaboration between telecoms and utilities providers to support the digitalisation of the energy sector.

Agri-tech

Helping rural economies grow is a critical part of the Prime Minister’s commitment to growing the economy. The agriculture industry has much to gain from the adoption of digital connectivity and the use of data and AI, as it rises to meet global challenges around food production, food security and climate change. Adoption of technology can improve efficiency and increase yields and productivity, for example by enabling precision irrigation, weed and pest management, livestock monitoring, helping rural businesses realise significant productivity gains.

As part of the DSIT 5GTT programme, the [5G RuralDorset](#) project, led by Dorset Council, looked at how the agricultural sector could benefit from increased 5G connectivity and transform rural communities and businesses. The project found that robots and drones using high resolution imaging can be used effectively to scan fields and crops, enabling identification and location of weeds and analysis of soil conditions. However, this technology relies on more reliable coverage and greater uplink capability than the public mobile networks provide. Hot-spots or private networks could be the answer, but are currently expensive to deploy.

Narrowband IoT networks can also be used to carry smaller amounts of data from sensors, for example to collect data on weather, stored grain temperatures, water leaks, soil health, and environmental conditions for livestock.

DSIT and the Government Office for Science will continue to work with the Department for the Environment, Food and Rural Affairs (Defra), local authorities, rural communities and the telecoms industry to encourage and enable investment in advanced wireless technology to support rural industries

and increase agricultural output, and to support rural communities to benefit from the economic growth opportunities advanced connectivity can offer.

5G can support the UK’s transition to net zero

In 2019, the UK was the first country to set a legally binding net zero emissions target for the UK economy to reach net zero carbon emissions by 2050. In 2021, the government set in law the world's most ambitious climate change target, cutting emissions by 78% by 2035 compared to 1990 levels. Wireless connectivity could play an important role in ensuring the UK meets the net zero target.

The government welcomes the MNOs’ initiatives that contribute towards the legally binding net zero target. It is encouraging to see that three of the UK’s four national MNOs have already announced their commitments to a net zero target, and that Three UK, as part of CK Hutchison Group Telecom Holdings Limited, are in the process of setting a net zero target.

Table 3: MNO net zero ambitions

MNO	Net zero ambitions
EE (as part of the BT Group)	Net zero target for operational emissions by end of March 2031, and end to end emissions (operations, supply chain and customer emissions) by end of March 2041.
O2 (as part of Virgin Media O2)	<p>Net zero target for operational emissions by 2025, and their operations, products and supply chain by 2040.</p> <p>In December 2022, VMO2 became the first UK telecoms provider to be recognised by the Carbon Trust for its action toward achieving net zero carbon across its business - one of only three businesses in the UK to receive the Advancing tier of the certification.</p>
Three UK (as part of the CK Hutchison Group)	In process of setting a net zero target
Vodafone UK (as part of Vodafone Group)	Net zero target for Vodafone UK’s operational emissions by 2027, with Vodafone Group committed to achieving net zero emissions across its full value chain by 2040.

Current research by the telecoms industry indicates that 5G networks consume less energy than previous generations of mobile technology, and can be up to 90% more energy efficient per traffic unit than 4G networks ([Nokia, 2020](#)) ([Ericsson, 2021](#)). The

energy efficiency profile of 5G could provide an additional incentive to encourage sectors across the UK to adopt wireless technology.

However, these gains need to be balanced against the fact that rollout of 5G networks that support this demand for new services is set to significantly increase data traffic, likely resulting in a net rise in energy consumption (despite per-unit efficiency gains), including from data centres.

There are several energy-saving features which can significantly improve the energy efficiency of wireless networks; these include 5G new radio, liquid-cooling at base stations, low-power modes and efficiency gains at data centres. Other features such as network sharing can also have a positive impact; neutral host operators host multiple mobile operators on the same network infrastructure, reducing the amount of infrastructure required and thereby minimising energy consumption. Furthermore, the [sunsetting](#) of 2G and 3G mobile networks will reduce the number of networks running simultaneously.

We recognise the importance of the commitments made by the mobile operators to reduce their carbon emissions in response to the net zero target. **As part of our 6G Strategy set out below, we will work with the sector to develop a net zero strategy, focusing on the development of new, low carbon, sustainable technologies for 6G and future telecoms networks.**

5G can also help reduce overall energy consumption across the economy by increasing industrial energy efficiency and resilience and enabling the transformation of energy networks for generation, distribution and storage of power. Particular technologies likely to drive benefits include industrial IoT, automation, immersive technologies, agri-tech and smart farming tools. Vodafone has estimated that ‘digital solutions’ can reduce CO₂ emissions by 2.7 to 3.3 million tonnes annually in the manufacturing sector, 6.6 million tonnes to 9.3 million tonnes annually in the transport sector and 2.4 million tonnes to 4.4 million tonnes annually in the agriculture sector. As mentioned above, digitalisation of energy networks is critical to meeting our Net Zero targets.

We will work with the Department for Energy Security and Net Zero to commission an independent assessment of the contribution that adoption of 5G and other advanced wireless connectivity by key sectors can make to the UK’s net zero targets and how those benefits can be realised.

The UK Infrastructure Bank

The UK Infrastructure Bank’s mission is to support regional and local economic growth through better connectivity, opportunities for new jobs and higher levels of productivity. The Bank has an initial £22 billion of financial capacity and will aim to deploy up to £3 billion of debt and equity financing and £2.5 billion of guarantees a year, committing

£22 billion over the next five to eight years, subject to the pipeline of investable projects each year.

Digital is one of the UK Infrastructure Bank's five priority sectors. To date, the bank has announced 10 deals worth £1 billion, mobilising £4.6 billion in private finance. Of the 10 deals, four have been in the digital sector supporting fibre-rollout across all nations of the UK. **The Bank recognises that wireless networks have the potential to transform infrastructure sectors and will work with DSIT to identify financing gaps in new and growing infrastructure and business models and consider investment opportunities.**

The National Infrastructure Commission

The National Infrastructure Commission publishes a National Infrastructure Assessment every five years that makes recommendations to the government on the UK's long term infrastructure needs. The recent [Infrastructure Progress Review](#) recognised that government was making progress towards meeting their ambitions and reiterated the need for government to set out a clear vision for 5G mobile networks in the upcoming Wireless Infrastructure Strategy. The second National Infrastructure Assessment is due to be published in Autumn 2023 and will consider the UK's long term strategic goals for wireless infrastructure, with a focus on 5G.

The Commission's second baseline report, published in November 2021, also recognised that higher quality digital infrastructure presents opportunities across the economy, including for other infrastructure sectors within the Commission's remit. Adoption of digital technologies across a range of infrastructure services has the potential to cut costs, enhance service quality, improve resilience, and enable better demand management. As part of the next Assessment, in addition to assessing 5G's strategic value to the UK economy, the Commission will consider what economic infrastructure sectors, such as energy or transport, may create 5G demand in the future.

Chapter 7: Shaping the development of 6G

With 5G rollout well underway in the UK and globally, the next generation of wireless technology is already on the horizon. We are committed to building the UK's position as a science and technology superpower and 6G and future telecoms is an important part of this mission. We want to ensure the UK is helping to set the agenda for 6G.

We don't know what 6G will look like yet but it has the potential to address some of the important challenges of our time, such as how to build sustainability features into telecoms networks to support energy emissions targets and how to integrate terrestrial mobile networks with satellite networks to eradicate coverage not spots. We want to make sure 6G develops in a way that meets the UK's economic and societal needs.

We can already anticipate some of the elements that could shape the next generation of telecoms. We expect 6G to build on the advancements developed in 5G to deliver an ultra-connected world. The next generation of mobile technologies could herald a new, richer generation of internet based services; wearable sensors could give the sensation of being in the same room together with those many miles away. It is hard to overstate the far-reaching extent of the sectors this could benefit, both in industry application and in support of public policy objectives.

As set out in the [Science and Technology Framework](#), future telecoms has been identified by the National Science and Technology Council (NSTC) as a critical technology. The NSTC has identified five critical technologies in total, which the UK should focus on to build strategic advantage. Setting a clear, coherent direction for 6G now reflects our commitment to building this advantage and to maintaining the UK's position as a global leader in science research and innovation. This direction will therefore help guide and encourage investment and research in a way that delivers for UK consumers and the UK economy.

The UK has historically been one of the most influential countries in shaping the direction of new generations of telecoms. Major British companies such as Marconi, GEC and Plessey, Cable & Wireless, BT and Vodafone have had a wide-reaching impact on the development of telecoms technologies. Although it is inevitable that countries such as Japan, South Korea, China and the US will continue to be dominant forces in this area due to the scale of their markets and strength of their telecoms and internet industries, there is an opportunity for the UK to build on our existing expertise and ensure we play a role in early stage and applied research, guiding the development of future enabling systems, technologies and standards.

We are at a critical juncture in the development of 6G networks. By asserting our place at the table of international fora, forging partnerships, developing UK expertise, and supporting our industry and academic talent, we can grow UK capability in this strategically important area. This will drive sustainable and productive growth and guarantee a more secure and resilient supply chain for generations to come.

The decisions that will shape 6G will be made over the next few years, with the global development of 6G likely to follow a similar timeline to 5G. Critical pre-standardisation research is already underway and we expect that 6G standards-setting will have begun by 2025. Commercial deployment is likely to begin towards the end of this decade. This 6G strategy therefore seeks to deliver the following objectives:

- to ensure that the global 6G vision supports the requirements of UK operators and the UK's wider policy ambitions
- to influence the development of 6G technologies: we want to build on the UK's existing research strengths and expertise to influence the development of key areas of 6G technology
- to develop capability in UK telecoms: We want to support and develop UK capability in future telecoms, including 6G - by supporting UK industry and academia we can drive future UK economic prosperity, be at the heart of the growth of this technology and help ensure that the UK's telecoms network is secure and resilient

The next generation of telecoms should support UK industry and government ambitions. UK network operators have called for a smooth transition from 5G to 6G, for software upgrades to be favoured over hardware replacements and for the later stages of 5G to be deployed in a way that enables the introduction of 6G with minimal 'dead end' deployment. Reducing 'dead end' deployment means less wasted hardware and software that cannot be used for future generations of telecoms.

We also want 6G to support wider government objectives, including achieving net zero, delivering economic growth, and ensuring network security and resilience, as well as spectrum efficiency. At the same time, 6G needs to be able to help nations tackle the important societal challenges of the next decade, including digital inclusion, broadcast and entertainment requirements, emergency services, smart cities and future transport networks, environmental management and better access to health and social care.

This strategy sets out a UK vision for 6G, as well as detailing our priorities for the global 6G vision to guide the government, Ofcom and industry's approach to international fora. Advocacy in international fora and collaboration with international partners will be key to ensuring that 6G delivers on these objectives. The key avenues we will use for advocating for these requirements are the International Telecommunication Union (ITU), the European Telecommunications Standards Institute (ETSI), the 3rd Generation Partnership Project (3GPP), and the European Conference of Postal and Telecommunications Administrations (CEPT).

6G standards-setting will begin in 2024 and research in 6G-related technologies, which will form the basis of the standards setting discussions, has been ongoing internationally for two to three years. Whilst UK universities have demonstrated significant strengths in key areas, it is vital we ensure their work and the associated funding streams are focused and coordinated. In the development of 6G, the next 18 months will be the critical period in which promising research programmes can be coordinated towards the 6G standard setting process and long term public policy goals.

Global companies and research institutions are already filing patents in areas of candidate technology for 6G and a proportion of these will become standards-essential intellectual property for 6G. Access to these will be necessary for any UK company to develop 6G technologies and products. In the UK, however, our exceptionally strong telecoms research base has not been consistently carried through to patent filings. As part of this strategy we will therefore consider how best to ensure that intellectual property developed in the UK is protected, supporting international export and adoption opportunities and our ability to develop and deploy 6G as early as possible.

As laid out in the [Science and Technology framework](#) and the [5G Supply Chain Diversification Strategy](#), we are developing plans to build UK capability in future telecoms as a priority to help deliver secure and resilient networks, as well as maximising economic opportunities for the UK.

Telecoms R&D demands large scale investments. Export markets for 6G will therefore be essential to sustaining domestic capability in R&D, and we recognise the need for effective international collaboration to harmonise UK and international requirements wherever possible. Assuring government requirements are prioritised, implemented and attract strong match funding will also be key to securing the scale of investment needed.

The pillars of the UK's 6G Strategy

Meeting these ambitions will require concerted action with the UK telecoms industry and universities as well as other countries, multinational operators and technology vendors. The aim of this strategy is to set out a coherent approach that will guide and direct this action, backed up by targeted measures to ensure that this technology develops in line with the UK's vision and broader objectives.

The actions set out in this document are not exhaustive; as 6G develops so too will the specifics of our approach under each of these pillars. We will continue to review the activity needed to ensure that our approach remains focused and as effective as possible.

In constructing this strategy we have drawn on responses to the Wireless Infrastructure Strategy call for evidence, discussions with industry and academic stakeholders,³⁷ Ofcom, government agencies and departments, and insights from industry and research publications from the UK and internationally.

Through this consultation process, six themes emerged as priority areas of focus (see figure 1). These themes form the pillars of this strategy, setting out the areas of activity that will be a priority for the government in the development of 6G.

Figure 1: the pillars of the 6G Strategy



Pillar 1: a UK vision for 6G

For the UK to achieve its goals from 6G, we need to express our societal and economic requirements in a coherent, influential vision. We must be part of the international 6G conversation, setting out our position clearly for domestic and international stakeholders and advocating that position in the relevant international fora.

³⁷ Including the UK Spectrum Policy Forum's 2021 [6G Research Initiative](#) and a December 2021 [workshop on Future Wireless Systems \(6G\)](#) organised by the Royal Academy of Engineering.

We have set out the UK Vision for 6G later in this chapter. It expresses our current position and expectations of the technologies and aims that will constitute 6G networks. We will continue to maintain and update that position as 6G develops.

Internationally, one of the key fora for setting out the 6G Vision is the ITU Radiocommunication Sector (ITU-R). Ofcom leads the UK delegation to the ITU-R, and has engaged closely in the spectrum-related discussions. Working with Ofcom, we identified that greater UK government and industry engagement would be valuable across aspects of the 6G Vision, requirements and technologies.

To begin this increased engagement, DSIT encouraged inputs from UK researchers to show UK capability and engagement. In the lead-up to the ITU's June 2022 meeting, we then encouraged UK academia to pool their thinking on mobile telecoms beyond 2030. This resulted in two papers from 18 UK research institutions. The papers were well received at the workshop, where we also signalled the UK's intention to participate and contribute more actively in future.³⁸

Building on this input, we submitted formal contributions to the ITU-R International Mobile Telecommunications 2030 (IMT-2030) meetings in October 2022 and January-February 2023 in line with the UK 6G Vision and in consultation with Ofcom. The publication of the agreed ITU-R vision recommendation will set the tone for the development of 6G standards and the focus of R&D globally. We will continue to monitor and seek to influence as part of the process for the IMT-2030 vision recommendation, which is due for publication in 2023.

We will continue to work with Ofcom to advocate for the UK 6G Vision in relevant international groups, with our international counterparts, and will support domestic academia and industry in developing 6G in line with our vision.

Pillar 2: Focusing UK research and development for 6G

The UK has significant strengths as a source of innovation in telecommunications networks. We want to build on these R&D credentials, and ensure that the UK is playing an active role in developing 6G technologies both in UK networks and internationally. To do this it is essential that our universities and research labs are empowered to make the most of their strengths, investing in these areas, and addressing any gaps in technology and capability which may prove crucial in the future.

Achieving this will require coordination across institutions as well as with relevant funding bodies and industry, setting broad themes that will help to maximise the strategic advantage to be gained for the UK, while at the same time recognising that

³⁸ A public summary of the workshop is available: [Summary of ITU-R Workshop on 'IMT for 2030 and beyond' \(aka '6G'\)](#), IEEE ComSoc Blog, June 2022. [Workshop on IMT for 2030 and Beyond](#), ITU-R Study Group WP5D, June 2022.

researchers are best placed to determine the sources of high quality research and innovation.

There is already an excellent base of pre-6G research happening across UK universities. In 2021, the UK SPF provided a report to government on current 6G R&D taking place in UK universities.³⁹ This detailed the existence of a very wide range of high quality activity already in place at institutions. There is also strong collaboration between institutions, as shown by the establishment of the 6G Futures research collaboration between [UK universities](#), the [5G/6G Innovation Centre](#), and academic cooperation on the 6G Vision.

In 2020-21 the UK produced the third highest number of research publications related to future telecoms, after China and the US – greater than the combined output of France, Germany, and the Netherlands. The impact of that research, as measured by citations, is ahead of both US and China, confirming the quality of the research output.⁴⁰

Yet, despite these research strengths, UK research does relatively poorly in terms of creating patents which could lead to UK advantage and economic growth.⁴¹ The UK's existing cohort of academic research would be more likely to achieve significant advances in technology, yielding Standards Essential Patents (SEPs), spin outs and licensing deals, if it were targeted and coordinated towards the attainment of specific goals, defined with reference to the government's digital infrastructure ambitions.

The UK government supports a vibrant research and innovation community. UK Research and Innovation (UKRI) and the Engineering and Physical Sciences Research Council (EPSRC) currently support over 130 live grants (close to £300 million investment) in telecoms-related research. To deliver our ambitions in future telecoms, including 6G, we need to create an environment that enables the discovery, development and deployment of the necessary technologies.

As identified in the [Science and Technology Framework](#), the Government has established future telecoms as one of five critical priority technologies in our goal to be a science superpower by 2030. **As such, we are launching a new, long-term national mission, with initial funding of up to £100m, to ensure the UK is at the leading-edge of future telecoms and 6G technologies.**

A key element of this mission will be a series of Future Telecoms Research Hubs, where early stage and applied research will be funded and coordinated through UKRI

³⁹ [SPF 6G wireless R&D initiative: A report for DSIT](#), UK Spectrum Policy Forum, 2021.

⁴⁰Source: GO Science Technology and Science Insights (TSI) - Future Telecoms, Jan 21.

⁴¹ By contrast with the UK's strong showing in research activities, the number of patent families filed including UK inventors was 12th globally (only 37 patent filings) and no UK-headquartered companies featured in the top 30 companies. Source: GO Science Technology and Science Insights (TSI) - Future Telecoms, Jan 21

and EPSRC via the Technology Missions Fund (TMF), which will use similar models to fund other priority areas including Quantum and Artificial Intelligence.

These Hubs will build on the springboard provided by EPSRC's [£6 million investment](#) for three federated and connected platforms in the communications technologies space. Supported by the UK Telecoms Innovation Network (UKTIN), these platforms will engage with the telecoms industry, catapults and internationally around three broad themes: (1) a network of networks; (2) wireless and wired systems and spectrum; (3) cloud and distributed computing. The platforms will draw together the existing portfolio of EPSRC investments in telecoms-related areas into a coordinated approach and will inform any future investment in mission-focussed research hubs.

Support for early-stage research will be complimented by funding for application focussed 'challenges' - delivered via Innovate UK - supporting companies to accelerate innovative solutions to market and encourage disruptive collaboration across the UK's diverse Future Telecoms landscape. This aims to cement early UK market leadership, additionally attracting follow-on investment for companies to scale-up and grow in the UK.

We will work closely with our allies to deliver this Future Telecoms mission - ensuring we are influential in shaping the global landscape, embedding our values into future telecoms technology, and protecting our security interests. This is just an initial investment: to inform our next steps, we are commissioning a feasibility study to explore the potential for new infrastructure provision to improve competitiveness and drive growth in the UK telecoms sector and foster UK capability.

DSIT has also directly invested into future telecoms research and activity through the government's 5G Supply Chain Diversification Strategy backed up by the £250 million Open Networks R&D Fund. This includes investing £36 million for the Future RAN Competition, £28 million for [Future Open Networks Research Challenge](#) (FONRC), and up to £80 million in the [Open Networks Ecosystem Competition](#) as well as funding for bodies such as the SmartRAN Open Networks Interoperability Centre (SONIC), UK Telecoms Innovation Network (UKTIN), and UK Telecoms Lab (UKTL). For FONRC, the winning bids were led by three UK universities - Bristol, Surrey and York - to team up with major telecoms companies to design and build networks of the future, such as 6G. Furthermore, £80 million is being invested in the UK Telecom Lab in Solihull. The lab will research and test the security, resilience and performance of 5G and, in the future, 6G network technology.

Additionally, the UK Space Agency (UKSA) has made [£1 million available](#) for up to five projects from industry and academia to utilise the 5G/6G Hub at Harwell to test and demonstrate their devices or applications.

Direct industry investment into the UK's R&D landscape will also underpin the ambition set out in this Pillar, with significant progress already secured in this area. In 2022, both [Ericsson](#) and [Samsung](#) publicly announced significant investments in UK 6G R&D activity over the next 10 years. This 6G R&D and associated collaboration lays the groundwork for the activity in Pillar 2 and allows us to hit the ground running in the race to develop 6G technologies and associated standards.

The UK's industry ecosystem, including innovative new companies and those that are established players, will be supported in navigating these R&D opportunities through UKTIN. This streamlined approach will also encourage industry to identify opportunities to invest and offer match funding where appropriate.

In line with the UK's Science and Technology Framework, we are also working to ensure that the UK's existing pool of talent and skills in future telecoms R&D is nurtured and developed so that the UK continues to have the expertise necessary to develop, deploy and maintain telecoms systems, including those that will form the basis of 6G.

We will continue to work with researchers and adjacent bodies to deliver a coordinated approach to 6G-related research, and initiatives to ensure greater translation of research into commercial benefits and products.

Pillar 3: Patents and standards

Telecoms relies heavily on the role of international standards and intellectual property, especially patents. Patents protect and reward R&D investment for innovators. Standards ensure that equipment, including user devices such as mobile phones, is compatible with networks around the world. They also help ensure that networks can be built from equipment from multiple suppliers without sacrificing performance and while preserving innovation and resilience.

Major telecoms standards organisations usually require that patents that are essential for implementing compliant equipment are available to others on a fair, reasonable, and non-discriminatory basis. Without such an obligation, a single patent holder could refuse to license and prevent companies from implementing the standard.

Patents – and particularly standard-essential patents (SEPs) – can also sometimes act as a barrier to investment in innovation, as indicated by some [responses](#) to the UK Intellectual Property Office's (IPO) call for views on SEPs. As of 2020, around 95,000 patents had been declared essential for the 5G standard.

While the development of 6G is still at an early stage, global suppliers are already very active. A 2021 survey identified over 20,000 global patents in nine technologies of relevance to 6G. Of these, only 9% were filed in Europe including the UK.⁴² The

⁴²Source: [China accounts for 40% of 6G patent applications: survey](#), Nikkei Asia, 2021.

global trend in telecoms patent filings is well in excess of overall global trends on patent filings.

Indeed, in contrast to the UK's strong showing in research activities described under Pillar 2, the number of future telecoms patent families filed by the UK was 12th globally (only 37 patent filings) and no UK-headquartered companies featured in the top 30 companies.⁴³

As well as the challenges presented by patent filing, participation in standards-setting can also be difficult to access and influence. Participation can be a resource-hungry process, excluding smaller innovators. We believe that it is important that UK researchers and early-stage companies participate at an appropriate level in both patents and standards to maximise the impact of their work. We will therefore be working across government, including with UKRI colleagues, to consider how best to ensure that R&D funding in the UK incentivises the involvement of new suppliers in the creation of both relevant patents and international technical standards.

For example, the FONRC aims in part to target R&D towards the strengthening of UK standards activities. We will also seek to ensure that UK companies have access to relevant patents for their work by aligning with any policy or regulatory proposals arising from the IPO's review of SEPs and ensuring they reflect the needs of the [telecoms sector](#). This will strengthen the negotiating position of UK companies, improving the terms, and yielding direct benefits. Filing of such patents should be encouraged via the exploitation terms of research grants, and support for such patents should be provided to UK companies in qualifying technology areas.

We are working to ensure that adequate support is given to UK companies to more effectively monitor and participate in standards bodies, as proposed by the [Diversification Task Force](#). The relevant standards bodies include not only the formal Standards Developing Organisations (SDOs), such as 3GPP, but also the industry groups which increasingly form consensus on specifications amongst like-minded organisations in advance of formal standards.

As part of our vendor diversification programme we have announced the creation of [UKTIN](#) to guide businesses to success in telecoms innovation. We expect UKTIN to provide opportunities to coordinate and advance patent and standards activity, whilst remaining industry owned and led. Further assistance for UK companies involvement in standards activities will be forthcoming.

We have also worked with partners in industry by convening a stakeholder forum focused directly on UK standards activity. The forum informs DSIT policy development and delivery, particularly by identifying emerging areas of focus in the development of telecoms standards upon which government should focus.

⁴³Source: GO Science Technology and Science Insights (TSI) - Future Telecoms, January 21.

Pillar 4: Spectrum

Any wireless network depends on the availability of suitable radio spectrum in order to function. For 6G in particular, spectrum needs to be identified and made available in a timely fashion to support research, development and innovation. Spectrum must be aligned and harmonised, at least regionally, to take advantage of the international economies of scale and avoid issues of spectrum fragmentation.

It will be for Ofcom to ensure that suitable frequency bands are available for use by 6G, but we set out here, and in the Vision below, some important considerations, particularly where these are broader than Ofcom's specific duties. Further details of our core spectrum principles are provided in the [Spectrum Statement](#).

6G will require a portfolio of spectrum bands to achieve the coverage and capacity likely needed for the use cases it will enable. This portfolio will therefore consist of a combination of low, mid and upper spectrum bands using existing and new frequency bands. We note that there is emerging interest in the centimetric bands. For the upper bands, future use of millimetre wave and sub-terahertz spectrum opens up new possibilities. Ofcom has [confirmed](#) that it will make millimetre wave spectrum across the 26 GHz and 40 GHz bands available for new mobile technology, including 5G services, and has committed to using its role in international regulatory groups, such as the ITU and CEPT, to encourage greater collaboration and cooperation between different types of emerging spectrum uses in these bands.

We welcome this early engagement. It is crucial that the UK takes the opportunity of the relatively low current use of this spectrum to consider a new approach to spectrum access in the sub-terahertz range. We know that the golden window of opportunity in which to do this is small, with those who want access to the band already giving consideration to future standards and allocation. That is why we will work with Ofcom to ensure that holistic consideration is given to the future use of these bands, including consideration of drivers that sit outside of Ofcom's duties, such as the UK's position of leadership in science and technology.

Ensuring access to spectrum for 6G trials will be a key step in fulfilling the UK's ambitions in [science and technology](#). To help provide this access, we will work with Ofcom and UKRI to help ensure that 6G researchers and innovators have access to suitable spectrum for developmental activities and a path to commercialisation beyond that. Ofcom's innovation and trial licences could provide a well-suited initiative through which 6G technologies are tested.

For 6G a variety of spectrum access mechanisms, from exclusive allocations to shared access, will be important, with the latter playing an increasing role. Given that spectrum is a finite resource, and 6G systems will likely need to access wider bandwidths, sharing between International Mobile Telecommunications (IMT) and non-IMT systems will be needed to facilitate the use cases that will be made possible through 6G while also being resilient to interference. Ofcom's [plans](#) to improve

propagation and coexistence models, and to introduce automated sharing systems, are an important step in facilitating a network of networks. We expect that spectrum sharing will increasingly involve database-driven automated access and UK support for database-driven spectrum access should be an integral feature of 6G. We therefore welcome Ofcom's [Call for Input](#) on the SAL framework and the thinking Ofcom has [begun](#) regarding adaptive or dynamic spectrum access.

Spectrum sharing, with spectrum available on a localised geographic basis, is a logical step for the use of higher frequency spectrum such as millimetre wave and sub-terahertz spectrum. Consistent with our vision to ensure that 6G supports a wide range of innovative business models, 6G spectrum access should encompass a wide range of access models (licensed, licence-exempt and shared/local spectrum) and suitable award approaches, taking full account of progress in automated and dynamic access alongside traditional award mechanisms such as auctions. We welcome Ofcom's [decision](#), further consultation, and work to licence 26 GHz and 40 GHz spectrum on a shared basis, with auctions proposed for high density areas, and will work with the regulator and crown users of spectrum, including the Ministry of Defence, to ensure a suitable approach continues to be taken across the portfolio of spectrum for 6G.

While the millimetre wave and sub-terahertz ranges offer great potential for new use cases such as sensing (as highlighted by research by [Nokia](#) and [Ericsson](#)), these new higher ranges should not be identified as mandatory features of 6G or as defining characteristics of 6G. Other approaches, including free-space optical access, provide a complementary approach with similar use cases to sub-terahertz and should be considered alongside radio frequency approaches within 6G. We will work closely with Ofcom to ensure that a balanced portfolio of spectrum bands for 6G is available, based on industry demand. This will be crucial to ensuring that 6G can be available to all and deliver on its promise, and provide for cost-effective deployment and efficient use of spectrum.

International harmonisation of 6G spectrum will be vital to ensuring a developed ecosystem for UK verticals and other users of this technology. As international harmonisation progresses, the UK influence in, and appropriate alignment of our 6G spectrum portfolio with, it are priorities. Key decisions will be taken at World Radiocommunication Conferences (WRC) in 2023 and 2027 and in the preparatory conferences leading up to these. We are liaising with industry and other relevant stakeholders to support Ofcom's development of UK positions at WRC. We want to promote decisions that ensure the spectrum availability that will be needed to enable the full potential of future telecoms.

International collaboration on spectrum allocation and management will also be an important piece in strengthening UK competitiveness and showcasing UK capability in spectrum-focused 6G technologies. We are also working with the UK SPF on their Global 6G Open Dialogue Series, which will facilitate knowledge sharing between UK

stakeholders and other telecoms leading markets. We will continue to work with partners, such as UKRI, to encourage international collaboration between industry and academia.

Pillar 5: International alliances

Our focus for international activity will be:

- 1) to build broad international consensus on requirements for 6G, including aspects of the emerging 6G Vision
- 2) to establish deep bilateral cooperation with the most like-minded partners to pursue joint aims, share best practice and work together on tangible initiatives such as creating and publishing demand and market scenarios, and advocating for these associated requirements within the ITU and standards and industry associations
- 3) to promote UK thought leadership on 6G on the international stage, attracting collaboration and investment in relevant global R&D

We will build on alliances established through existing multilateral fora, including CEPT, and within the international component of our Telecoms Diversification strategy, with priority partners such as the US, Australia, Japan, India and South Korea. For example, the UK's [joint statement](#) with Australia, Canada and the USA in December 2022 saw international allies commit to ensuring the resilience and security of global telecoms supply chains and future 6G networks, consistent with our vision for this next generation of telecoms. We have also already [announced](#) an R&D collaboration with the Republic of Korea on radio network power efficiency and will build on existing partnerships, such as the UKRI-funded UK-India Future Networks Initiative (UKI-FNI), a £1.4 million project led by the University of East Anglia in collaboration with other UK and Indian universities.

Regarding the US in particular, the [New Atlantic Charter](#) identified 6G as an important area for UK-US cooperation. The US National Science Foundation has established the [Resilient & Intelligent NextG Systems](#) (RINGS) initiative with leading companies to accelerate 6G research and will seek to establish appropriate links with our proposed UK 6G R&D network.

Pillar 6: A roadmap and governance approach

To ensure effective and strategic coordination of the activities across the other five pillars of our 6G Strategy, we have set out an anticipated roadmap for the development of 6G (see figure 2). This roadmap will be used to keep activity on track via an appropriate governance framework.

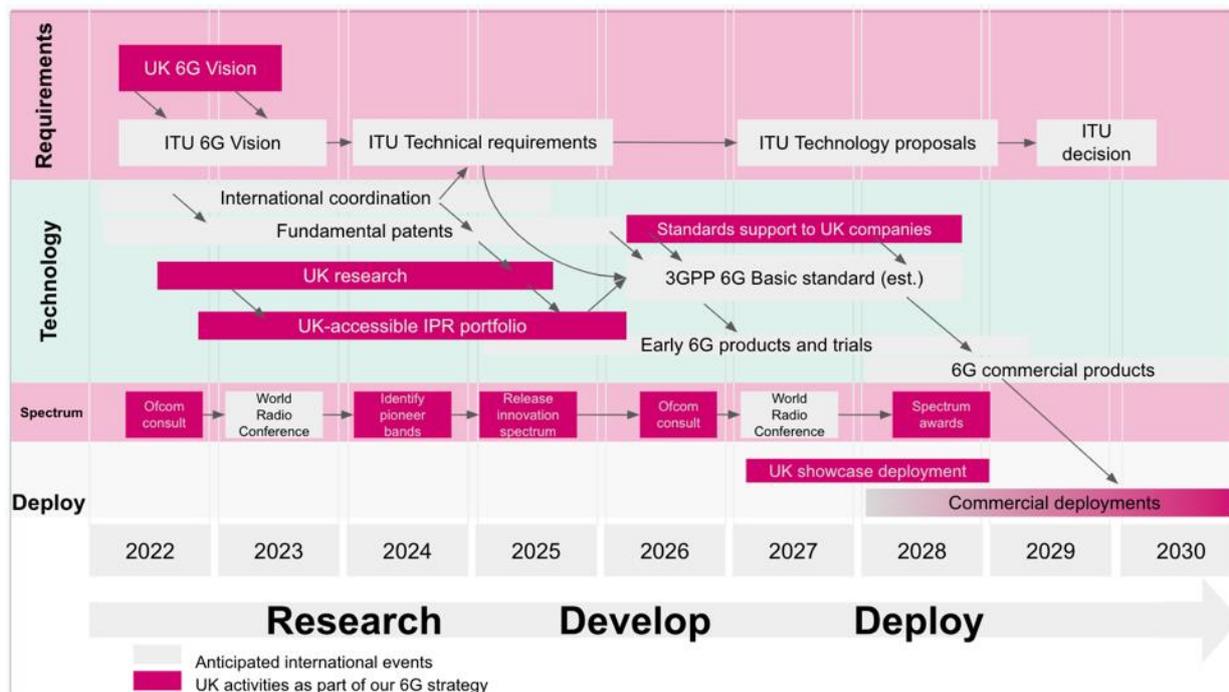
The strategy set out in this chapter aligns with each stage of this roadmap, with each pillar informing our approach over the next ten years. As identified in Pillar 1, the implementation of this strategy begins immediately, with the Vision we detail here informing the UK's approach to vision and standards setting.

This strategy will feed into and influence broader international developments including:

- 2020-25: international 6G research and development is carried out
- 2021-23: ITU develops vision for mobile telecoms beyond 2030
- 2022-26: fundamental patents for 6G are developed and filed
- 2023: World Radiocommunication Conference initial consideration of spectrum for mobile services, including 6G
- 2024-25: ITU sets technical performance requirements
- 2026-2028: standards bodies (such as 3GPP) establish 6G basic standards
- 2027: WRC considers identification of spectrum allocations for 6G (if agreed at WRC-23)
- 2028 and beyond: early commercial deployments expected
- 2030 and beyond: large scale commercial deployments

Figure 2 sets out how work relevant to this strategy is likely to be phased relative to significant 6G milestones. We have indicated three broad phases of research, development, and (early) deployment, with wider scale rollout and adoption likely to take place beyond 2030.

Figure 2: Indicative UK roadmap for 6G



To elaborate, maintain, and coordinate this roadmap, we will establish an appropriate governance framework of relevant authorities and stakeholders across the public and private spheres. For the first few years, during the research phase, governance of UK 6G activities is likely to be via similar steering arrangements as will be set up for the 6G R&D network, with strong representation from the research community.

In the develop and deploy phases, as attention turns towards planning for commercial deployment, the structure and representation would evolve accordingly, with increased representation from industry groups including operators, industrial sectors contemplating the use of 6G and representatives of regional and consumer groups.

The UK's 6G vision

As set out in Pillar 1, it is important that we develop a UK Vision for 6G now so as to coordinate activity and provide a clear, coherent indication as to our ambitions for this next generation of mobile technology. This Vision provides the first pillar of our 6G Strategy on which subsequent pillars can be based and their relevant activities can be guided.

We will therefore use the Vision set out here to inform UK positions in international fora, areas of focus for 6G R&D, and our development of related domestic policy. We have developed this Vision following input from UK researchers and in line with existing broader government policy objectives, with the aim of ensuring that this Vision will help guide and focus the 6G activity not only of the government but also of UK industry, academia, and Ofcom. This Vision will therefore be used to steer our 6G engagement with these stakeholders, to ensure that the UK is speaking with one voice on the development of this technology.

We have already begun delivering on pillar 1, using this Vision to inform the UK's submissions to ITU-R regarding IMT-2030 and beyond. The contributions the UK has made to the ITU used the areas of focus we set out here as a basis from which to develop specific suggested text.

Desired outcomes

We want to ensure that the UK benefits from timely deployment and adoption of 6G and that this next generation technology is developed in a way that maximises the benefits for UK business and people right across the country. Our vision for 6G therefore sits on a foundation of crucial national priorities including network security, supply chain diversification, digital inclusion, working towards net zero, and support for growth via a wider range of business models. We will continue to work to advocate and promote these internationally, through the ITU and other relevant fora, to ensure that the development and deployment of 6G is consistent with and supports the acceleration of government strategies and objectives.

The UK's position on 6G is well-aligned with the emerging international consensus. However, it is vital that we do all we can to ensure these priorities are woven throughout the development of next generation wireless technologies, including 6G. Here we set out some key areas in which 6G can be moulded to ensure that this technology will deliver benefits for the whole of the UK.

Digital access

Inclusivity: A central aim of 6G should be to deliver the benefits of this next generation technology to those across the globe. Irrespective of location, environment, or economic circumstance people should be able to access the improvements in our everyday lives that this technology will enable. 6G should be designed to support economical and efficient coverage, even in challenging geographical conditions. While coverage is more challenging in remote and rural areas, and in environments such as indoors, this should not be taken to mean that a bare minimum of service availability is appropriate in these areas, and wherever possible 6G should be designed to deliver reliable coverage and consistent quality of experience.

Reduced digital divide: In terrestrial networks, users in challenging radio conditions have frequently experienced poor service levels even when they are located in nominally covered areas, due to their environment and position with respect to the deployed network (the 'cell edge' problem). 6G should be designed to minimise the disparity in service levels wherever possible, exploiting emerging technologies such as cell-free networks and reconfigurable surfaces.

Three dimensional topology: 6G should also continue to enable non-terrestrial network segments to play a full role in delivering economical, high quality services to all. These segments include the role of satellites, high altitude platforms, and unmanned aerial vehicles, both to deliver wireless access directly to end users and as a transport segment to extend the reach of the terrestrial network. 6G standards and spectrum should consider these segments as a fully integrated element of 6G from the beginning of standardisation.

Network sharing: Sharing of relevant portions of network infrastructure in challenging locations may also assist in ensuring service in challenging locations. The UK government has provided strong support for [Shared Rural Network](#) initiatives between operators. Multi-tenanted networking, while still allowing service choice and differentiation between operators and customers, should be a capability of 6G wherever possible.

Open, secure, and resilient networks

Open and interoperable networking: Market diversity in network and user devices is essential to promote innovation, protect supply chains, and ensure security and resilience. The UK's 5G Supply Chain Diversification Strategy identified open networking as one route to diversification. Previous IMT standards have embraced

open interoperable networking in the air interface, but have been limited in their support for interoperability beyond this. 5G did not include this from the beginning, necessitating rectifying actions such as Open RAN to open up markets and ensure security and resilience. We have set out four Open RAN [Principles](#) as guidance:

- open disaggregation
- standards-based compliance
- demonstrated interoperability
- implementation neutrality

We would like to see such principles adopted as basic principles of 6G from the beginning, extending not only to the radio access network (RAN) but throughout the network architecture, in both hardware and software.

Security: The UK has demonstrated its commitment to the security of 4G and 5G networks in the passing of the [Telecommunications \(Security\) Act 2021](#) which has introduced a strengthened telecoms security framework within the UK. We now have an opportunity to ensure that this security framework is considered throughout the development of 6G networks. As 6G develops, it will be essential for UK networks to continue to be designed, built and run securely.

Spectrum

Inclusive, balanced spectrum options: Spectrum is the lifeblood to any wireless technology and 6G is no different. With 5G and previous generations, a mix of frequencies is providing both coverage and capacity. This approach will likely be consistent in 6G, with a combination of low, mid and upper spectrum bands using both existing and new frequency bands. For 6G, both millimetre wave and sub-terahertz ranges could play an important role in new applications including joint sensing and highly accurate positioning to aid self-driving vehicles. However, overemphasis on these frequencies, especially in the early stages, could hamper 6G deployment and adoption.

Spectrum supporting business model innovation: Increasingly, wireless networks are being deployed by a wider range of entities other than national mobile operators. This includes private networks deployed by enterprises, vertical industries and system integrators, shared neutral host networks, and community networks. Spectrum access mechanisms should cater for these approaches in addition to conventional licensed national public networks. This should include native combinations of licensed, licence-exempt (unlicensed) and lightly licensed models, with localised and flexible options included where possible.

Spectrum sharing with other IMT and non-IMT systems: To facilitate seamless connectivity between networks, sharing between IMT and non-IMT systems may be required. This could involve scenarios with different 6G operators sharing the same spectrum on a geographical basis and/or 6G sharing spectrum with different services.

This sharing should facilitate the low latency, high bandwidth use cases, while also being resilient to interference. To provide flexibility and efficient use of spectrum, automated means for supporting sharing which varies by time, location, and frequency, driven by databases setting acceptable sharing configurations should be included in 6G standards.

Spectrum harmonisation: To ensure a global market for the developers of 6G network equipment, enable consumers and businesses to freely roam between networks, and encourage the development of a sustainable device ecosystem, spectrum for 6G should be harmonised in terms of frequency ranges and technical conditions on a regional and global basis wherever possible, without reducing the freedom for individual administrations to set spectrum access terms to suit their local needs.

Spectrum support for innovation: Ensuring access to spectrum for 6G trials will be an important step in the UK maintaining its position as a science and technology superpower. Spectrum should be an enabler of, rather than a barrier to, innovation. The process of spectrum management should itself maximise the opportunities for efficiency through developments in technology and market structures.

Network of networks

Local and private networks built by a wider range of entities: Increasingly, wireless networks are being deployed for local and private needs, with denser networks of cells both indoors and outdoors, deployed by shared infrastructure companies (neutral hosts) and by enterprises for their own needs. 6G should be designed from the onset to fully reflect these new usage and deployment scenarios.

Integrated, converged networks: There are several dimensions in which 6G could bring together previously separate technologies and deployment styles:

- **non-terrestrial networks:** Networks increasingly use a combination of terrestrial infrastructure with non-terrestrial network segments, including satellites, airborne base stations on unmanned aerial vehicles ('drones') and high altitude platforms (balloons), plus base stations on moving platforms such as trains, buses and ships
- **cellular and short range technologies:** In the past, mobile cellular technologies and short-range technologies such as Wi-Fi developed on predominantly separate paths. The expanded range of applications for wireless technology however suggests an even greater role for converged integration and interworking between these technologies than we are seeing today
- **incorporate local area and indoor applications:** The use of spectrum such as sub-terahertz and millimetre wave, as well as applications such as sensing, suggest that 6G should explicitly take greater account of local area and indoor applications, some of which may not even be connected to a wider network

6G should natively support all of these use cases with full integration to maximise the

options for cost-efficient deployment and to extend the reach of networks to all environments. It should allow different network segments – terrestrial, satellite, indoor, licensed, unlicensed, public and private – to be interconnected seamlessly and securely.

Sustainability

Wireless networks supporting sustainability in other sectors: Wireless networks have an important role to play in enabling many other sectors of society and the economy to meet their net zero and wider sustainability goals, including the energy and transportation sectors.

Network sustainability: Networks should aim to be sustainable in their own deployment and operation, including striving for net zero carbon emissions and mitigating supply chain challenges arising from the use of rare minerals and other raw materials, and paying attention to the full life-cycle of materials. Regard should be paid to the recyclability, repairability, production emissions, and environmental impact of wireless networks and the devices which connect to them.

Networks achieving absolute energy and carbon savings: Wireless networks have achieved enormous reductions in energy consumption per bit, and this progress should continue into 6G. However, simply reducing energy per bit without regard to overall absolute energy consumption is insufficient for both carbon reduction and for the economic operation of networks. 6G performance metrics should therefore target stabilising and reducing overall energy consumption in addition to efficiency. 6G should also incorporate features both to ensure the overall network and user device carbon footprint stabilises and reduces in both absolute and relative terms over time.

6G development process

Backward compatibility: 6G should strive to offer support for continuous evolution of features including both network and radio elements, removing the need for excessive disruption between generations. It should provide native support for essential features such as voice.

Continuous evolution: The cycle of generational upgrades to wireless networks has brought great advancements in performance and features, but also risks driving excess costs that are not necessarily aligned with the rate of change of demand or services. As networks are increasingly defined in software, it becomes both possible and necessary to move the process of upgrades to a more continuous evolution. As such, continuous technological evolution should be explored as part of 6G development, avoiding future generational upgrades where unnecessary.

Minimise standards fragmentation: The development of advanced technology requires large markets to justify the associated large-scale R&D. While early generations developed along separate national and regional paths, since 3G there has been common international standardisation via 3GPP, which brings together regional

standardisation bodies – including the European Telecommunications Standards Institute (ETSI) – into a common global effort. Whilst acknowledging the relative importance of individual fora to develop specific ideas, it is important that governments support a strong core standards system (ITU, 3GPP, ETSI etc) to minimise fragmentation.

This delivers the global economies of scale that have enabled the development of advanced technologies, low cost devices, and global mobility of devices and services in previous generations. 6G should continue this and avoid regional fragmentation, while accommodating the varying requirements and expectations of different economic and social circumstances.

Chapter 8 - conclusion

This government has a clear priority to build a better, more secure, more prosperous future for the UK. This includes a commitment to grow the economy, and create better-paid jobs and opportunity right across the country. In this strategy, we have set out the role that wireless technologies can play in this.

We have set an ambitious and clear approach to supporting the development, adoption and success of next generation networks in the UK. By doing so we can make access to these transformative networks and technologies a reality for people across the country - driving growth and helping us to maintain our position as a leading economy, and benefitting society more broadly.

We have outlined in this strategy both a policy framework and a series of measures to implement it. Our focus will now be on implementation - we are clear this will take a concerted effort by the government, the industry and others to achieve.

We will do this by:

- **ensuring that Ofcom continues to hold the MNOs to account by improving the accuracy of coverage reporting, particularly in rural areas and on the rail networks to help policy makers and industry understand where coverage improvements are needed**
- **supporting the telecoms industry to deliver our new ambition that all populated areas have standalone 5G by 2030 by confirming our openness to market consolidation and reducing regulatory barriers to investment and innovation by:**
 - **ensuring that net neutrality rules are fit for purpose and support operators' ability to innovate and invest in infrastructure**
 - **asking Ofcom to review and set out a clear evidenced-based and forward-looking rationale for its approach to setting spectrum fees by the end of 2023**

- maximising the UK's influence at international spectrum negotiations, with alignment of international and domestic spectrum frameworks where possible
- ensuring eligible mobile network operators benefit from the relief available in Freeports and other economic areas with similar regimes
- taking a new approach to supporting places to attract commercial investment in 5G networks in their areas and encouraging adoption of 5G-enabled use cases by businesses and the public sector - our £40m 5G Innovation Regions programme will help accelerate the realisation of these benefits for places across the UK, by promoting investment in and encouraging the adoption of 5G technologies and services
- We will also:
 - ensure digital connectivity requirements for future users of infrastructure are at their heart of major infrastructure projects
 - bring the full purchasing power of government to support public sector adoption, and working with the Crown Commercial Service to drive demand for 5G use cases
 - ensure new hospitals are equipped with 5G or equivalent
 - establish a Digital Infrastructure Advisory Group to advise the government on how places can act to promote investment in and adoption of digital connectivity
- driving adoption in key economic sectors, undertaking a nationwide campaign to drive 5G adoption by business, working with Ofcom to continue to improve access to spectrum
- ensuring wireless connectivity delivers wider government objectives, working with the telecoms industry and other sectors to assess the role 5G and advanced wireless connectivity can play in delivering net zero to the UK
- and ensuring the UK can shape the development of 6G by:
 - investing up to £100m in future telecoms, including through new, interconnected hubs aiming to put the UK at the forefront of the diverse 6G research agenda
 - developing and promoting a UK 6G vision through international fora
 - forging international alliances to conduct joint research and expand our influence in the development of next generation technologies

As advanced wireless connectivity evolves and is deployed, we will continue to engage with a broad range of stakeholders - including both providers and adopters of

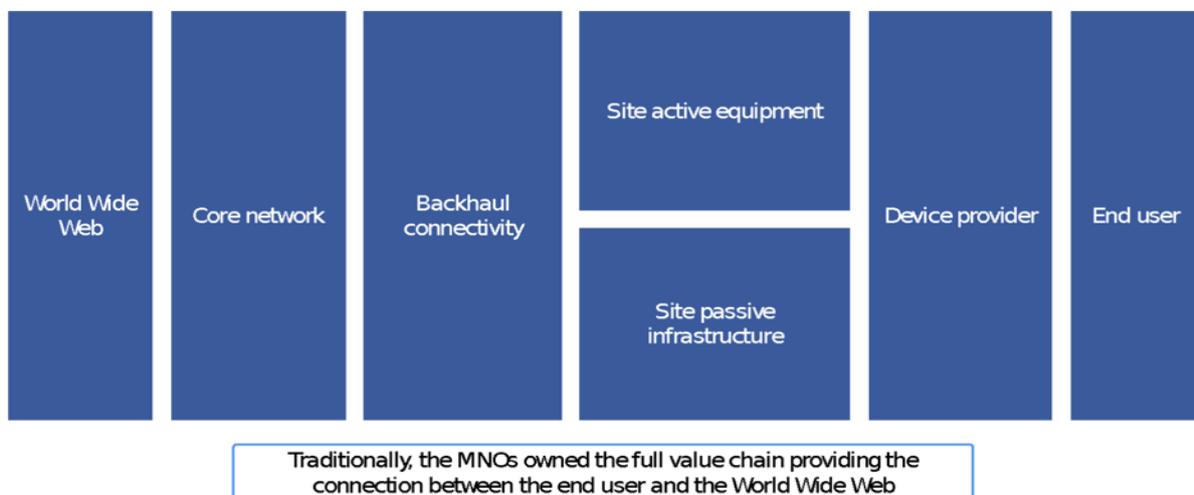
these new technologies - to understand the challenges and opportunities, and where more can be done to support deployment and take-up.

Finally, we would like to thank all the organisations and individuals that have provided evidence and ideas that have supported the development of the strategy.

Annex - The evolution of wireless networks

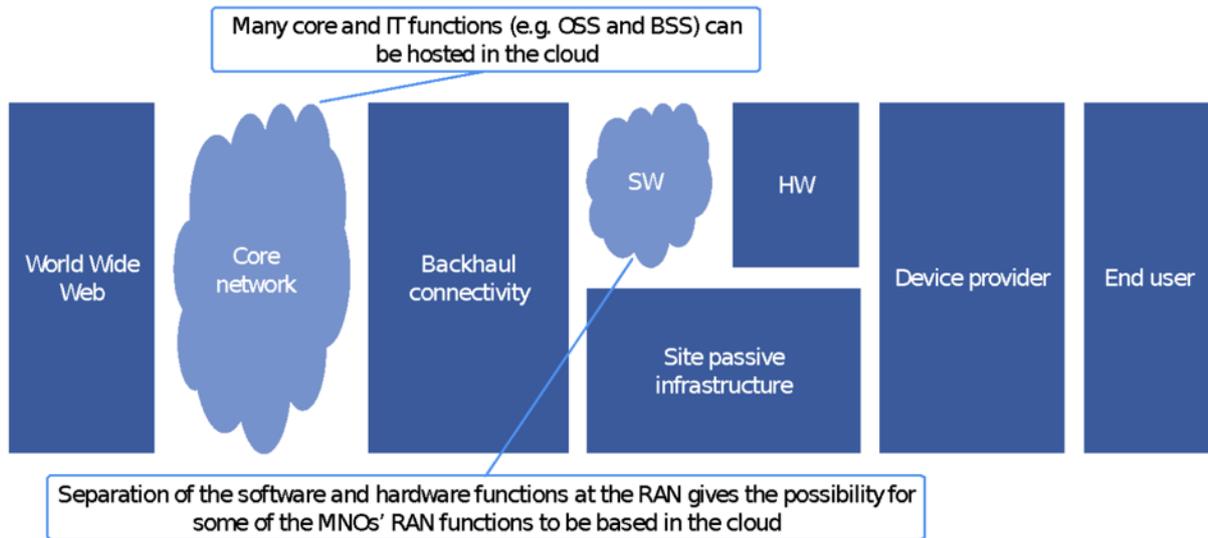
Technological advancements across the wireless ecosystem which have allowed connectivity providers to reconsider how their networks and services might be delivered and optimised. Traditionally, mobile connectivity has been delivered according to a well-defined value chain. MNOs own the equipment from the core network to the radio access network (which comprises the active and passive site equipment).

Figure 4: The mobile market value chain in the UK



However this is changing. Many of the core network functions and active site equipment are moving online. The virtualisation of telecoms infrastructure means that dedicated network hardware is replaced by software able to perform the same functions on generic servers, and could be run from a separate location. Cloudification extends virtualisation to allow operators to make use of distributed software orchestration technologies developed for the public cloud, to make more flexible use of processing and storage distributed over multiple locations and managed to maintain high resilience and performance while evolving features more rapidly and flexibly.

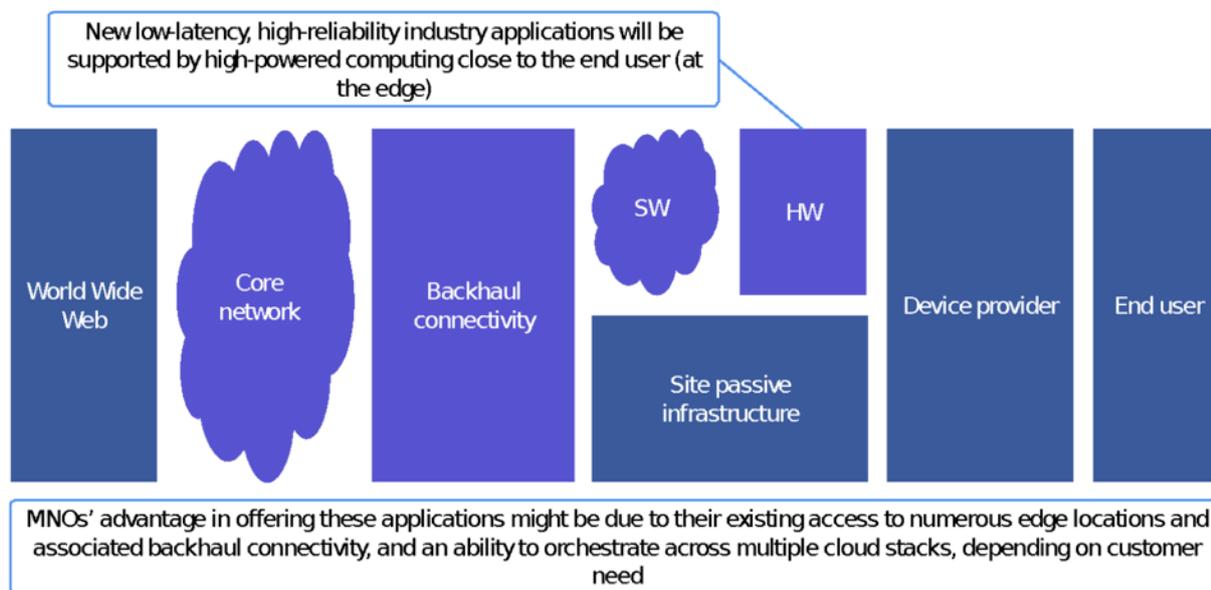
Figure 5: The move to software-based and cloud-native functions in the mobile value chain



For MNOs this means that upgrades can be done more cheaply and quickly. Virtualisation allows for more frequent, piecemeal upgrades to telecoms infrastructure and is more flexible, adaptable and scalable than one that depends solely on physical hardware. Virtualisation also lowers the barriers to entry for alternative networking models, allowing smaller players to offer networking services online. Similarly, improved orchestration enables more dynamic capacity provision, allowing coverage to become more fluid and flexible.

Cloudification will be taken even further through multi-access edge computing, which will allow new low-latency, high-reliability industrial applications supported by data processing and storage close to the end user.

Figure 6: Use of edge-native services in the mobile value chain



Virtualisation and cloudification are leading to the rise of open networking, and the increasing deployment of Open RAN technology. Open RAN enables the software and hardware components of the Radio Access Network to be built to industry-wide specifications, ensuring interoperability between components, increasing innovation and vendor diversification. Through our 5G Supply Chain Diversification Strategy we are removing barriers to OpenRAN deployment and investing in open and interoperable telecoms technologies and, to drive OpenRAN deployment, have set an ambition that 35% of UK network traffic should pass through interoperable architectures by 2030.

There have also been technical developments that significantly improve end user experience such as Massive Multiple-input and multiple-output (mMIMO), which uses multiple antennas to enhance the data rate for mobile transmissions, and network slicing which uses a dedicated 'slice' of a 5G signal to provide specialist provision for certain services. This means operators will be able to offer reliable quality of service and bespoke connectivity for enterprise and industry customers over public networks. Network slicing can also improve the efficiency of mobile infrastructure through improved traffic management, and widen customer choice for services. In March 2022 Ericsson and Vodafone announced the successful completion of the UK's first 5G standalone network slicing trial.

There has been a significant increase in the number of Internet of Things devices. It is expected that this trend will continue over the next decade to 2030 however, the traffic generated from existing use cases are expected to remain small compared to other components of traditional public cellular demand.

All MNOs in the UK can support IoT devices over 4G and 5G but IoT can also be delivered via technologies such as Wi-Fi, Zigbee, Bluetooth and several others. BT/EE is exploring proof-of-concept deployments using LoraWAN (Long Range Wide Area Network) which can transfer small amounts of data over long distances.

Developments in Wi-Fi technology could further improve indoor connectivity, where the full capabilities of low latency and high bandwidth 5G offers are not needed. Wi-Fi 6 and 7 have been developed to provide high throughput of data over licence-exempt spectrum. Wi-Fi 6 was launched in 2019 and offers faster, more secure connectivity and an increase in the number of devices that can be connected to a router. Wi-Fi 7 will launch in 2024/25 and offer vastly higher speeds and lower latency than Wi-Fi 6. We acknowledge the potential benefits that Wi-Fi 7 could bring and will continue to consider this critical technology in spectrum allocation and management activities.

Future wireless technologies

Technological development on future mobile and other wireless technologies continues at pace. The features that will distinguish 6G technologies from previous generations are not yet known and will be the subject of study and standardisation over the coming years but emerging themes we expect to see will include:

- joint communications and sensing, extending human senses in a fusion of the virtual and physical worlds;
- cell-free network technologies, which combine the signals between different base stations intelligently to provide a more consistent service for users moving between base stations; and
- increased use of AI and Machine Learning to optimise network performance.

This is considered in further detail at Chapter 7, which outlines the UK's 6G strategy and Ofcom's [technology futures](#) paper sets out their view on the evolution of wireless technologies.

Market dynamics are changing

Since the 2010s, the UK mobile market has been characterised by four national mobile networks who use network sharing arrangements (primarily through the

Cornerstone and MBNL joint ventures)⁴⁴ to deploy and operate their Radio Access Networks.

There is a trend towards the separation of tower assets from network services taking place in the UK and across Europe. For example, in 2021, Vodafone and Telefonica transferred 50% of Cornerstone Telecommunications Infrastructure Limited to the tower company Vantage Towers. Across Europe, similar activity has taken place as operators have sold off their tower assets in deals with private equity firms or independent tower companies. For operators, the rationale has been to raise money for future investments, whilst private equity firms state that towers represent a reliable and steady return.

The neutral host model allows mobile network operators to share infrastructure provided by an independent “host”. Sometimes known as “infrastructure as a service”, this model is likely to become more popular as a cost-effective solution to the need to densify cell sites. For example, having acquired the telecommunications tower assets of Arikva in 2020, Cellnex has a significant wireless infrastructure estate and positions itself as a “Neutral Host” provider, alongside other wireless infrastructure providers such as Freshwave, Wireless Infrastructure Group, Dense Air and BAI Communications.

In addition to offering their own retail services, MNOs also offer wholesale services to mobile virtual network operators (“MVNOs”). Some MVNOs have deepened their offering in the value chain by taking control of further aspects of the customer experience. There may also be opportunities for MVNOs to meet the growing enterprise demand for specialised services, including for wireless IoT or machine-to-machine connectivity.

Other players are looking to enter the mobile value chain through adjacent markets. Hyperscalers (large tech companies which offer cloud and internet services to customers), for example, are both providing valuable services and potential competition to mobile operators. Many of these companies are already present in the mobile ecosystem, primarily in the device and operating system markets. Some provide MNOs with cloud infrastructure to perform network functions. In this case, virtualisation and cloudification are enabling hyperscalers to deepen their offerings to MNOs. At the same time, there is potential for hyperscalers to provide private networks to enterprise and industrial customers.

Network convergence is the merging of connectivity technologies and can occur at different layers of the supply chain. The UK fixed and mobile telecoms markets have

⁴⁴The four national MNOs are engaged in two infrastructure sharing arrangements - Mobile Broadband Network Limited (MBNL) is a joint venture between EE and Three and Cornerstone Telecommunications Infrastructure Limited is a joint venture between Virgin Media O2 and Vodafone. MNOs also deploy and manage infrastructure outside of these arrangements.

largely converged at the retail level, where services are sold in a product bundle creating efficiencies in the costs of customer acquisition, reflecting a market shift towards customer-centric differentiation.

Convergence of network infrastructure can occur a layer deeper in the telecoms value chain by deploying single ducts for mobile backhaul and fixed-line services for example. Infrastructure convergence has the potential to minimise duplication in costs of infrastructure deployment, and to reduce disruption to local residents. Currently, there are no large-scale projects taking advantage of these synergies, although investment in fibre-to-the-premise could provide opportunities for infrastructure convergence.