5G in the UK

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Summary

What is 5G?

5G is the next generation of wireless communications technology. Compared to 4G, it is capable of providing faster speeds with much higher capacity and very fast response times. This will allow many more users and devices to access fast internet connections and large amounts of data at the same time.

5G has the potential to enable various 'smart' applications, for example in e-healthcare, smart cities, connected vehicles, and automated manufacturing. However, the technologies and business models that would support them are still developing. Most peoples' experience with 5G to date is faster mobile broadband.

When and where will 5G be rolled out?

5G is primarily being rolled-out by private companies called mobile network operators. These are EE, O2, Vodafone and Three. The first commercial networks went live in major UK cities in 2019. Ofcom, the telecoms regulator, estimated that in September 2023, 85 to 93% of UK premises could get 5G coverage outdoors from at least one operator.

5G networks are initially being built on top of legacy 4G equipment. This is called 'non-standalone' 5G. While it can deliver enhanced mobile broadband, the more advanced uses envisioned for 5G will require 'standalone' networks. Deployment of standalone 5G, which utilises dedicated 5G equipment in all parts of the network, is at an early stage.

Government targets, policy, and funding for 5G

The government's target is for "all populated areas" in the UK, including rural communities, to have standalone 5G coverage by 2030.

The government's broad strategy for the 5G roll-out was set out in the 2018 Future Telecoms Infrastructure Review. The Review opted for a market-led approach to deploying next generation digital infrastructure (5G and gigabit broadband). Since then, policy focus has been on:

- Making it cheaper and easier to build 5G infrastructure, for example by reforming planning and land access rules.
- Supporting competition and investment.
- Trials to demonstrate how 5G can be used in different sectors.
- Releasing additional spectrum, which enables mobile operators to offer more and better services.

Funding for 5G has focused on [projects to test advanced 5G use cases](#). The government has not provided direct funding to support the deployment of 5G infrastructure.

5G policy challenges

5G deployment will require significant investment from mobile operators and other stakeholders. However, there is uncertainty around 5G use cases and adoption rates. The government calls this the 'chicken and egg problem': mobile operators need to know there is demand for 5G services in order to invest, but without real-world evidence, potential users are still uncertain about its costs and benefits.

Other challenges relating to 5G include:

- Practical deployment barriers such as gaining planning permission and permission to access private land.
- Public opposition due to concerns about the health impact of 5G.
- Security concerns regarding 5G networks as part of the UK's critical national infrastructure.
- Mobile operators' access to sufficient spectrum to offer new 5G services.

1   5G in the UK

1.1   What is 5G?

5G is the fifth generation of wireless network technology. It follows on from the development of 2G, 3G and 4G mobile technology:

- **2G** was the first digital mobile technology. It is suitable for making calls, sending text messages and supports very-low speed data connections.
- **3G** made it possible to access the internet more effectively through a mobile phone (called mobile broadband), supporting voice, text and data services. 3G provides typical download speeds of around 5 Mbps.
- **4G**, launched in 2012, made it much quicker to surf the web on mobile phones, tablets and laptops, supporting faster upload and download speeds and faster response times. 4G supports download speeds of around 10 Mbps.

5G technology is expected to have three main differences compared to 4G: faster data speeds, high capacity and faster responsiveness (low latency):

- Faster data speeds: means very high data upload/download speeds. Ofcom states that peak speeds of 10–20 gigabits per second will be possible with 5G.
- High capacity: means the ability to connect very large numbers of devices. Ofcom states that 5G could support up to one million devices per square kilometre.
- Low latency: latency is the delay time for a communications signal, that is, the time between when you click something and when you see a response (such as a website beginning to load). Low latency means fast signal response times. Ofcom states that 5G is expected to have latency in the order of 1 millisecond, which means that 5G response times will feel instantaneous. This is important for real-time communications applications such as virtual reality and driverless cars (see below).[1]

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[1]   Ofcom, What is 5G, undated [accessed 8 January 2024]; Ofcom, Enabling 5G in the UK, 9 March 2018, para 2.6.

1.2

What can 5G be used for?

The above listed features mean that 5G can potentially support a variety of uses beyond mobile broadband. Use cases for 5G can be grouped into three broad categories:

- **Enhanced mobile broadband (more data)**: this means an evolution of the 4G services already used, including improved consumer experience (such as a more reliable service), more connected devices and faster connection speeds. 5G may also be used for wireless home broadband and could support virtual and augmented reality technology.
- **Massive Machine Type Communications (more devices)**: this means that 5G is expected to support many internet-connected devices and applications – known as the Internet of Things (see Box 2). This could include applications from e-health, transport and logistics, environmental monitoring, smart energy networks and smart agriculture.
- **Ultra-reliable and low latency communications (instant response)**: this means that 5G will be able to support near real-time communications applications with high reliability. Applications may include driverless vehicles, drone delivery, smart manufacturing, remote healthcare and emergency response and management.[2]

The UK Telecoms Innovation Network (a collaboration between government, industry, and academia) has webpages discussing 5G applications in key sectors including healthcare, manufacturing, and agriculture.

1 The Internet of Things

The Internet of Things (IoT) refers to a network of connected devices that talk directly to each other without needing to interact with human beings. 5G is likely to be the networking technology that supports the Internet of Things in the future, due to its low latency and capacity to support many devices at one time.

Examples of possible uses include smart energy meters, wearable health sensors, driverless cars, smart bins that send warnings when they are full, and smart fridges that can tell you how much food you have left or even order replacement items when you run out.

Most of these applications are still developing in terms of technology and businesses cases. The uncertainty around use cases and adoption rates means that the impact of 5G is difficult to predict. For example, a study by Analysys Mason, commissioned by the Department for Science, Innovation

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[2]   Ofcom, What is 5G, 9 March 2018; [accessed 6 September 2019]; Ofcom, Enabling 5G in the UK, 9 March 2018; ITU, Setting the Scene for 5G: Opportunities & Challenges report; 10 September 2018.

and Technology (DSIT), projected a cumulative gross value added (GVA) ranging between £41 billion and £243 billion over 2021 to 2035 depending on how widely 5G is adopted.[3]

1.3   Standalone and non-standalone 5G

At present, almost all 5G in the UK is delivered using non-standalone (NSA) technology. NSA 5G uses new 5G equipment for the Radio Access Network (RAN, which transmits wireless signals to user devices such as smart phones) but relies on 4G infrastructure for the 'core' network (which enables connectivity to the wider internet). As it utilises existing infrastructure, NSA 5G is relatively quick to deploy.

'Standalone' 5G will be needed for advanced 5G use cases, but it is not yet widely available.

The limitations of the 4G core network means that NSA 5G is not capable of providing the mass connectivity and ultra-low latency required for more advanced 5G use cases. In practice this means that most peoples' experience with 5G to date is limited to faster mobile broadband, and some industry commentators have criticised mobile companies for the 'hype' around the impact of 5G on society.[4]

5G standalone (5GSA) will be required for advanced 5G use cases.[5] SA 5G has a dedicated 5G core network in addition to 5G RAN infrastructure. One key feature enabled by 5GSA is 'network slicing'. This is where multiple distinct networks are provided using the same equipment. Different network 'slices' can be configured and optimised for different users:

> With network slicing, a carrier could tailor a network to meet several requirements like low latency, higher throughput or increased capacity.
>
> Manufacturers could, for example, use a network slice to facilitate the communication of industrial IoT devices with minimal latency and real-time operational response within their facilities. A hospital could tailor a 5G network to have ultra-high reliability and ultra-low latency, ushering in an era of remote surgery.[6]

Ofcom reported in December 2023 that the rollout of 5GSA in the UK is "at an early stage", with around 2,000 sites deployed commercially (compared to 18,500 deployments in total).[7]

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[3]   Analysys Mason, Realising the benefits of 5G, August 2021, chapter 8.2. £243 billion is the GVA of £159 billion in the 'general purpose technology' scenario, where around 70% of firms adopt 5G, plus up to £84 billion from addressing market barriers. £40.7 billion is the GVA for the 'advanced technology' scenario where adoption is lower.

[4]   Washington Post, 5G was an overhyped technology bust. Let's learn our lesson, 13 June 2023; Telecoms, The telecoms industry needs to break out of the rut set by 3G hype, 26 April 2023; Wall Street Journal, Techmonitor, The 5G hype cycle is cooling enthusiasm for 6G, 23 December 2022

[5]   5G.co.uk, What is a 5G Standalone network and what benefits does it bring?, 31 January 2023

[6]   Forbes, The Era Of 5G Disillusionment And The Path To Monetization, 8 December 2023

[7]   Ofcom, Connected Nations 2023: UK report, 19 December 2023, p37-38

2 The next generation: 6G

The wireless technology that will eventually succeed 5G is called 6G. It is not yet a clearly defined technology and Ofcom does not expect commercial deployments to begin until around 2030.

In some ways 6G will be an evolution over 5G: faster speeds, lower latency, and greater capacity will enable 5G use cases to be done more efficiently and on a larger scale. This is also expected to open up new uses.

Nokia, one of the companies researching 6G, envisions a network that, through the mass deployment of small cell infrastructure, is able to "sense" its surroundings. Networks would carry not just traditional wireless communications data but also situational information about objects around them: location, velocity, size, material properties. This will, in turn, enable the creation of a "digital twin" of the physical world:

> By interacting with this digital twin, we could extend our senses to every point the network touches. We could avoid traffic accidents by sensing unseen cars driving around a corner. We could interact directly with machines and robots remotely, seeing what they see, hearing what they hear, while directing their actions through simple hand gestures captured by the network. The new applications for this kind of network sixth sense are limited only by our imaginations.[8]

1.4 Who is deploying 5G in the UK?

The roll-out of 5G is primarily led by commercial mobile network operators (MNOs) who choose when and where they will roll-out services. There are four MNOs in the UK: EE (owned by BT), Three, Vodafone, and O2 (a joint venture with Virgin Media). Companies called mobile virtual network operators (MVNOs, such as Tesco Mobile and Giffgaff) pay to access an MNO's network and offer mobile services to customers.

5G infrastructure can also be delivered by so-called 'neutral hosts' or 'towercos'. These companies build infrastructure (such as masts) then lease access to MNOs, but do not offer mobile services themselves.[9]

Finally, private 5G networks can be provided by network operators other than the MNOs (who are regulated as providers of public communications networks). A private network is a bespoke, non-public telecoms network. Private 5G networks work in largely the same way as the public 5G network,

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8   Nokia, Building a network with a sixth sense, 19 April 2021
9   Ofcom, Conclusions: Ofcom's future approach to mobile markets, 6 December 2022, p54-55

but they allow the owner to control features such as access and coverage.[10] They are increasingly used to provide high capacity, low latency, and reliable coverage in, for example, industrial settings such as factories and ports.[11]

1.5 Where is 5G available?

In its annual Connected Nations report, Ofcom estimated that as of September 2023, between 85% and 93% of premises in the UK had 5G available outdoors from at least one operator. This was up from between 67% and 78% in 2022. Between 16% and 25% of premises had 5G available outdoors from all operators, up from between 11% and 20% in 2022.[12]

Data on coverage indoors, which would be lower, is not available for 5G.

5G network deployments have initially focused on urban areas. The percentage of the UK's geographical area covered by 5G is therefore lower than the percentage of premises covered. Between 41% and 55% of the UK landmass has 5G coverage from at least one operator.

Ofcom's data on 5G is based on predictions provided by mobile network operators. Information on how Ofcom calculates coverage is available as part of the Connected Nations methodology annex.[13]

The table below shows data for England, Wales, Scotland and Northern Ireland on 5G coverage for premises (outdoors) and geographical area.

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[10]   TechUK, Private networks: a new user guide, 17 May 2022
[11]   Ofcom, Conclusions: Ofcom's future approach to mobile markets, 6 December 2022, p50
[12]   Ofcom, Connected Nations 2023, main report, p37
[13]   Ofcom, Connected Nations 2023, methodology annex, p12

5G coverage in UK countries					
Ofcom-predicted coverage based on mobile network operator submissions					
		Premises Outdoors		Geographic area	
		All operators	At least one operator	All operators	At least one operator
England	High confidence	27%	94%	4%	74%
	Very high confidence	17%	87%	2%	56%
Scotland	High confidence	22%	88%	1%	24%
	Very high confidence	11%	80%	0%	17%
Wales	High confidence	10%	83%	0%	48%
	Very high confidence	6%	72%	0%	35%
Northern Ireland	High confidence	20%	80%	1%	59%
	Very high confidence	8%	70%	0%	46%
UK	High confidence	25%	93%	2%	55%
	Very high confidence	16%	85%	1%	41%

"High confidence" refers to a signal strength of -110dBm, with an 80% probability of coverage. "Very high confidence" is a higher standard, referring to a signal strength of -100dBm and a 95% probability of coverage.

Source: Ofcom, Connected Nations 2023, Interactive report, page 12

2 Targets, policy, and funding

The government's strategy for next-generation digital infrastructure, including 5G, is set out in the Future Telecoms Infrastructure Review (FTIR), published in July 2018, and the April 2023 UK Wireless Infrastructure Strategy (WIS).

The Government had published two 5G strategies prior to the FTIR, in March and December 2017.[14]

2.1 5G coverage targets

The 2023 WIS set a target of "nationwide coverage of standalone 5G to all populated areas of the UK by 2030". Populated areas includes villages and rural communities.

Previous targets

In the FTIR the government had set a target that "the majority" of the population would be covered by a 5G signal by 2027.[15] It did not specify that this should be standalone 5G.

The government's Levelling-Up White Paper, published in February 2022, expressed the same ambition with a target date of 2030. The 2030 date aligned with the timeframe for the white paper's twelve levelling up 'missions', although the government confirmed that it intended to stick to the 2027 timeframe.[16]

The 2027 target was regarded by some industry commentators as unambitious: Mark Jackson, of industry news site ISPreview, said it was "always likely to be a fairly easy target to hit". [17] EE had announced in July 2021 that it aimed to extend its 5G network to over half of the population by 2023.[18] It achieved this aim in May 2022, five years before the government's target.[19]

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[14]   DCMS, Next Generation Mobile Technologies: A 5G Strategy for the UK, 8 March 2017; and Next Generation Mobile Technologies: An Update to the 5G Strategy for the UK, 19 December 2017.

[15]   DCMS, Future Telecoms Infrastructure Review, 23 July 2018, para 158. This target was also contained in the 2017 Conservative and Unionist Party election manifesto.

[16]   PQ 116941 – Broadband, 7 February 2022

[17]   ISPreview, EE Become First UK Mobile Operator to Hit 50 Percent 5G Cover, 10 May 2022

[18]   ISPreview, EE and BT Aim to Offer 5G Mobile Anywhere in the UK by 2028, 14 July 2021

[19]   ISPreview, EE Become First UK Mobile Operator to Hit 50 Percent 5G Cover, 10 May 2022

2.2 Policy approach

Future Telecoms Infrastructure Review (2018)

The government's strategy in the FTIR was to support a "market expansion model" for 5G in the UK. This meant supporting a competitive market of mobile network operators, as well as promoting innovation by new providers that could deliver solutions to challenges such as rural coverage.[20]

The FTIR identified four priority areas for government to support the market expansion model:

- Make it easier and cheaper to build mobile infrastructure, such as reforms to planning rules and land access rights. The Library briefing, Building mobile and broadband infrastructure (December 2022), covers these reforms in detail.
- Supporting the growth of infrastructure models that promote competition and investment.
- Funding 5G trials through the Testbeds and Trials programme (see section 2.3 below).
- Promoting new 5G services through the release of additional spectrum, including more flexible, shared spectrum models (see section 3.5 below).

The FTIR was broadly welcomed by industry stakeholders as a statement of Government ambition to facilitate digital infrastructure build.[21] Mobile UK, the trade body for mobile operators, said that the FTIR was a "step in the right direction" but argued that the strategy lacked urgency and clear deadlines for action.[22]

The Confederation of British Industry (CBI) commented in a report published in December 2018 that a "step-change" in Government action was required to meet the mobile and broadband coverage targets set in the FTIR.[23] Rural stakeholder groups have raised concerns about rural areas being left behind in the 5G roll-out.[24]

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[20]   DCMS, Future Telecoms Infrastructure Review, 23 July 2018, para 187

[21]   Wireless Infrastructure Group, Wireless Infrastructure Group welcomes DCMS Future Telecoms Infrastructure Review (FTIR), July 2018; Mobile UK, Government published its Future Telecoms Infrastructure Review, July 2018; techUK, initial response to Future Telecoms Infrastructure Review, 23 July 2018. [Accessed 11 February 2019].

[22]   Mobile UK, Future Telecoms Infrastructure Review is a positive step but it is deadlines that will achieve its goals, Gareth Elliott, July 2018 [accessed 11 February 2019].

[23]   Confederation of British Industry, Ready, Set, Connect, 7 December 2018 [accessed 11 February 2019].

[24]   Country Land and Business Association, Rural areas still lacking 4G at risk of being side-lined amid 5G rollout, says CLA, 9 August 2019, [accessed 11 June 2019].

3 Competition and consolidation: the proposed Vodafone-Three merger

In June 2023, Vodafone and Three UK announced their intention to merge.[25] The merger between the two smaller MNOs would create a company comparable in size to EE and O2.

Whether the merger would be good for competition and consumers has been debated in Parliament.[26] An overview of the arguments for and against can be found the Library briefing, General debate on the potential merger of Three UK and Vodafone (December 2023).

In their press release, Vodafone and Three argued that they are currently too small to compete effectively with the two larger MNOs. They said that the deal would therefore be good for competition, despite reducing the number of MNOs. They also promised to invest £11 billion over 10 years "to create one of Europe's most advanced standalone 5G networks".

Critics say the deal would raise consumer prices, have no impact on investment, and that it poses national security concerns (due to Three's Hong Kong-based owners).[27]

The government and Ofcom have both said that they are open to mobile market consolidation and would assess proposed mergers on a case-by-case basis.[28] The UK's competition regulator, the Competition and Markets Authority, will decide whether to approve the merger.[29]

Wireless Infrastructure Strategy (2023)

The government published a new UK Wireless Infrastructure Strategy in April 2023. The overall policy approach remains the same as in the FTIR.

The WIS states that significant investment will be required to meet its headline ambition for all populated parts of the UK to have standalone 5G by

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[25] Vodafone, Merger of Vodafone UK and Three UK to create one of Europe's leading 5G networks, 14 June 2023

[26] HC Deb 19 September 2023 vol 737 c587WH-503WH; HC Deb 14 December 2023 vol 742 c1078-1096; Business and Trade Committee, Oral evidence: Three-Vodafone merger: implications for competition [PDF], HC 1869, 17 October 2023

[27] See for example Unite the Union, Vodafone-Three merger: consumer dossier (PDF), June 2023 and Unite the Union, Three UK -Vodafone merger: national security implications (PDF), July 2023

[28] DSIT, UK Wireless Infrastructure Strategy, 11 April 2023

[29] CMA, Vodafone / CK Hutchison JV merger inquiry, 11 October 2023

2030. The investment will come from private industry: the WIS contains no direct funding for 5G deployment. Instead, the government says in the WIS that it is:

> committed to creating an environment where commercial investment can thrive, increasing competition, driving down costs and improving demand for MNO services.[30]

The WIS covers policy measures to support a national rollout of 5G in four broad areas:

- Ensuring good connectivity for all: the government says that it has asked Ofcom to improve the accuracy of its mobile coverage reporting, so that it can provide better data on rural coverage, indoor coverage, and coverage on transport networks.
- Strengthening the investment climate: the government says that it will continue to tackle practical and regulatory barriers to network deployment.
- Realising the full benefits of 5G: the government says that it will support local authorities to attract local investment in and uptake of 5G connectivity.
- Driving adoption: the government says that it will encourage the adoption of 5G by private industry and the public sector, including by launching a nationwide 5G adoption campaign and addressing barriers to private network uptake.[31]

The WIS also sets policies for shaping the development of 6G (see section 2.4 below).

Industry stakeholders broadly welcomed the WIS. Trade association Mobile UK noted the importance of a policy framework that incentivises investment, calling the WIS an "encouraging first step along that road".[32] Telecoms company Freshwave said that it was "good to see mobile private networks featuring in the government's strategy, as they will provide huge benefits to both private and public sector organisations". Virgin Media O2 said the emphasis on 5G was "promising" and called for a "clear action plan" to implement the strategy.[33]

The Digital Poverty Alliance, a digital equality campaign group, said that it was "fantastic to see the government recognising the importance of connectivity for all, which in the long run will benefit the whole nation".[34]

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[30] DSIT, UK Wireless Infrastructure Strategy, 11 April 2023

[31] For example, the government has sought views on whether intervention is needed to improve the security and reliability of private networks: DSIT, Private Telecommunications Networks: call for information, 5 July 2023

[32] Politics Home, Mobile UK welcomes the publication of the government's Wireless Infrastructure Strategy, 11 April 2023

[33] Comms Business, UK connectivity companies welcome new wireless strategy, 12 April 2023

[34] IoT Insider, UK Gov't unveils £150m strategy to boost 5G and 6G capabilities, 14 April 2023

However, some commentators questioned the level of funding. The only new funding for 5G was £40 million to support the creation of 5G 'innovation regions' (discussed in the next section). Tony Eigen, of telecoms company Baicells, contrasted this with the $9 billion invested by the US government.[35] The Rural Services Network said that the WIS failed to address the 'market failure' holding back investment in rural connectivity, arguing that it could only be addressed with "significant government investment".[36]

2.3 Funding for 5G

Government funding for 5G has primarily focused on supporting small-scale trials to demonstrate innovative 5G use cases and deployments. The main investment has been £200 million for the testbeds and trials programme, which supported 5G trial projects across a range of sectors to identify opportunities for 5G, develop business models and improve understanding of potential deployment challenges.[37]

Funding has also been allocated to diversify 5G supply chains and to address barriers to hosting 5G equipment on publicly owned land, buildings, and street furniture.[38]

The government announced in the Wireless Infrastructure Strategy that it would build on the testbeds and trials programme with a further £40 million investment in '5G innovation regions'. Groups of local authorities could apply for a share of the funding to help them drive the adoption of 5G. According to the government, the funding will support projects 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.[39]

The government announced in November 2023 that ten regions across the UK had been awarded funding.[40]

Rural and industry stakeholders have previously called for funding to support the deployment of mobile network infrastructure.[41] Analysis by consultancy

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35 Networking+, The Wireless Infrastructure Strategy – a drop in the ocean?, April 2023

36 Rural Services Network, Rural Lens review on the government wireless infrastructure strategy, 9 May 2023

37 DCMS, 5G testbeds and trials programme webpage lists projects funded under the programme. The 5G Testbeds & Trials Programme Update (September 2018) states the total funding for the programme is £200 million.

38 DSIT, Future RAN: Diversifying the 5G Supply Chain, 2 July 2021; DSIT, Digital Connectivity Infrastructure Accelerator, 9 September 2021

39 DSIT, UK wireless infrastructure strategy, 11 April 2023

40 DSIT, 5G Innovation Regions: successful regions, 16 November 2023

41 Rural Services Network, Rural Lens review on the government wireless infrastructure strategy, 9 May 2023; Mobile UK, Budget 2018: Fibre progress welcomed but mobile infrastructure cannot be

Frontier Economics found that there is an investment gap between what private industry can deliver and what is needed for a full rollout of advanced 5G by 2030.[42] The report, commissioned by the Digital Connectivity Forum, estimated that the mobile industry will invest £9 billion in 5G by 2030. Deploying a 5G network capable of enabling advanced use cases in all urban and suburban locations would, it estimates, cost up to £34 billion by 2030, implying an investment gap of up to £25 billion.

In its Second National Infrastructure Assessment, the National Infrastructure Commission estimated that it would cost £9 billion to deploy 5G to all urban and suburban areas, which it said the industry could deliver commercially. It concluded that "there is not yet a case for public funding" due to a lack of certainty about advanced 5G use cases:

> Many uses can currently be supported by other telecoms technologies (such as 4G or WiFi), although this may change as later 5G standards are released and if new use cases emerge. Without clear indication of future demand, government intervention too early in network rollout risks delivering a 5G network that may not be suited to the UK's future needs.[43]

However, it noted that the government should be prepared to "act fast" if funding is required to deliver nationwide 5G coverage.

The National Audit Office (NAO) reported in February 2024 that DSIT has "not yet determined" whether funding will be required to meet its targets for standalone 5G as the commercial case for investment is still not clear.[44] It recommended that the government learn from previous digital infrastructure rollouts, "including the risk that advances in technology coupled with the practical and commercial barriers to deploying infrastructure in remote areas could perpetuate the rural urban divide."[45]

2.4 Policy and funding for 6G

While 6G is still in its early stages, the government notes in its Wireless Infrastructure Strategy that important decisions about the 6G will be made over the next few years: "Critical pre-standardisation research is already underway and we expect that 6G standards-setting will have begun by 2025". The WIS stated that the government will seek to "shape the global debate" on 6G and committed up to £100 million to support research and development.

forgotten, 29 October 2018; Confederation of British Industry, Ready, Set, Connect, 7 December 2018, page 7 [Accessed 11 February 2019]
42 Frontier Economics, The investment gap to full 5G rollout (PDF), 7 September 2022
43 NIC, Second National Infrastructure Assessment, 1 October 2023
44 NAO, Supporting mobile connectivity, 22 February 2024, p44
45 NAO, Supporting mobile connectivity, 22 February 2024, p13

A £70 million fund for future telecoms research, administered by UK Research and Innovation (UKRI), opened for applications in October 2023.[46] At the same time the government announced a Global Coalition on Telecommunications with Australia, Canada, Japan, and the United States. The coalition will coordinate initiatives to "foster diverse supply chains, secure and interoperable standards, and innovation - including for the development of future telecommunications technologies such as 6G".[47]

[46] UKRI, UKRI to invest £70m in new future telecoms technologies, 5 October 2023
[47] DSIT, Global Coalition on Telecommunications: joint statement of intent between UK, Australia, Canada, Japan and US, 5 October 2023

3 5G policy challenges

The rollout of 5G is a significant investment in UK critical national infrastructure. This section discusses the government's approach to some key policy challenges involved in the deployment of 5G:

- The uncertain business case for investing in 5G, both for MNOs and potential adopters.
- Practical barriers to infrastructure deployment, such as planning and land access rules.
- Concerns about the health impact of 5G signals.
- The security and resilience of 5G networks.
- Ensuring there is enough spectrum available for MNOs to offer 5G services with sufficient capacity and coverage.

3.1 Investment uncertainty

The government highlighted in its 2018 Future Telecoms Infrastructure Review that the large-scale roll-out of 5G presents commercial risks for mobile network operators as business cases and demand were still developing, describing this uncertainty as a "policy puzzle".[48] Five years later, in the 2023 Wireless Infrastructure Strategy, the government said that investment in 5G was still being held back by the 'chicken and egg' problem:

> 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.[49]

A 2021 report for the Department for Science, Innovation and Technology discusses various barriers to 5G adoption, mainly involving a lack of understanding and evidence around the costs and benefits of adopting 5G.[50] Demand-side barriers include:

- Lack of evidence about use cases.
- Uncertainty around the business case and return on investment.
- Concern about upfront and ongoing costs.
- The wider technology ecosystem (for a smart factory, for example) being too costly.
- Security and data privacy concerns.

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[48] DCMS, Future Telecoms Infrastructure Review, 23 July 2018, p53
[49] DSIT, UK wireless infrastructure strategy, 11 April 2023
[50] Analysys Mason, Realising the benefits of 5G, August 2021, chapter 5

- Uncertainty about the benefits of 5G over existing technologies (4G/wifi).

Ofcom similarly said in a 2022 report that low demand for private 5G networks "may in part be due to a limited understanding of what private networks can offer".[51]

Rural stakeholder groups have noted that the investment case for MNOs is particularly difficult in rural areas due to higher infrastructure costs and lower population density.[52] The House of Lords Committee on the Rural Economy stated in an April 2019 report that "it is important that rural areas, and businesses within them, are not left behind during the rollout of 5G for mobile services".[53]

As discussed above, government funding for 5G has generally focused on trials to demonstrate 5G uses cases. The government argues that this will help drive adoption of 5G and improve the business case for investing in networks. Some funding has been earmarked for rural projects. In August 2019, for example, the Government launched a new competition as part of the testbeds and trial programme, called the Rural Connected Communities Project, which has funded projects trialling 5G in rural communities.

3.2   Local barriers to building 5G infrastructure

Mobile networks are made up of 'base stations'. These are sites that contain radio communications equipment that sends and receives mobile voice/data signals over the surrounding area and connects them to the operator's network. Broadly, there are two types of base station:

- Macro cells are antenna placed on tall mobile masts or rooftops that can provide mobile coverage for miles around. To do this, they need to be taller than nearby obstacles such as trees and buildings that could interfere with the signal.
- Micro cells (or small cells) are low-powered base stations that provide coverage over a smaller area than macro cells. As they are much smaller and lighter, they can be mounted in more places, such as on street lights.

Initially, 5G is primarily being deployed by upgrading existing macro sites used for 3G and 4G. In the longer term, 5G networks are also likely to require a greater number of small cells to provide the speeds, latency, and capacity that will enable advanced 5G use cases.[54]

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51   Ofcom, Conclusions: Ofcom's future approach to mobile markets, 6 December 2022, p50

52   Country Land and Business Association, Rural areas still lacking 4G at risk of being side-lined amid 5G rollout, says CLA, 9 August 2019, [accessed 11 June 2019].

53   House of Lords Committee on the Rural Economy, Time for a strategy for the rural economy, Report of Session 2017–19, HL 330, 27 April 2019, para 258.

54   Ofcom, Conclusions: Ofcom's future approach to mobile markets, 6 December 2022, p16-17

To deploy 5G networks, telecoms operators may need:

- Planning permission from the local planning authority (LPA).
- Permission from a landowner to use land/structures to house equipment.
- A permit from the local highway authority to undertake street works.

Obtaining consents can increase the time and cost involved in building mobile infrastructure. The government has sought to facilitate the rollout of digital infrastructure by introducing reforms to planning rules and the Electronic Communications Code (ECC, which governs the rights of telecoms operators to access land). In each of these areas, the rights of telecoms operators need to be balanced with the rights of local residents and landowners. The government's reforms, designed to support the rollout of new infrastructure, have been controversial, as explained below.

Planning permission

Installing infrastructure and equipment for 5G networks would normally count as 'development' and therefore require planning permission from the relevant LPA. However, some forms of telecoms infrastructure are classed as 'permitted development'. This means that full planning permission is not required.

The government extended permitted development rights for communications infrastructure in April 2022. For example, telecoms operators can now build masts up to 30 metres in height in most areas, or 25 metres in protected areas such as conservation areas, without full planning permission (an increase of 5 metres over the previous limits). They must still apply for 'prior approval' from the LPA, which is a slimmed-down planning application process. In addition, existing masts can have their width extended by up to two metres and their height increased to up to 25 metres. This can be done without prior approval. The government said that this would allow existing masts to be more easily upgraded to fit 5G equipment.[55]

The Scottish Government has similarly increased the maximum size of mobile masts allowed under permitted development.[56] The Welsh Government has not.[57] New ground-based masts are not covered by permitted development in Northern Ireland.[58]

Planning rules also govern how LPAs determine applications for new 5G infrastructure. The National Planning Policy Framework (which applies to England only) states that planning decisions "should support the expansion of electronic communications networks, including next generation mobile technology (such as 5G)". LPAs are not allowed to impose general bans on the development of telecoms infrastructure in certain areas (around schools,

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[55] DCMS, New laws to end mobile coverage 'no bar blues', 7 March 2022
[56] Scottish Government, Planning circular 2/2015: non-domestic permitted development rights, 1 April 2021
[57] Welsh Government, Barrier Busting Taskforce: Report, 10 November 2022
[58] Planning (General Permitted Development) Order (Northern Ireland) 2015, Part 18, A.1(e)

for example) and, when making decisions, must not question the need for a 5G network. As discussed in section 3.3 of this briefing, they are also not allowed to set health safeguards that differ from those set by the International Commission on Non-Ionizing Radiation Protection.

For development subject to prior approval, LPAs must make their decisions based on the conditions set out in legislation. For mobile masts, the main condition is that their visual impact is "so far as practicable, minimised".

4 Local opposition to 'ugly' 5G masts

Proposals for new 5G masts often attract opposition from local residents, in part because of the perceived detrimental visual impact on the surrounding area.[59]

The government's code of practice for wireless network development in England states that masts should be designed in a way that:

> appreciates the context of its location by fitting with both the site and the wider setting. … [W]hen possible, operators should look to use sympathetic designs, materials and colour (including camouflage where appropriate) to minimise the contrast between infrastructure and the area.[60]

Network operators have used camouflage in various ways but there are limits to how far 'sympathetic design' can be taken without impairing the mast's function. For example, a mast placed near trees will need to be taller than the surrounding trees to avoid interference with the signal. Operators' efforts at camouflage have therefore not always been successful: residents complained that a mast in South Queensferry looked more like a toilet brush than a tree.[61]

Vodafone has highlighted that mobile masts are functional items, designed to be "sturdy and cheap to build".[62]

Permission from property owners

A telecoms operator needs an agreement with the landowner/occupier to build infrastructure on public or private land.

Access agreements are private legal agreements. They are governed by the Electronic Communications Code (ECC), which is contained in Schedule 3A to the Communications Act 2033. The ECC sets out the rights that operators

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59   See for example Peterborough residents call for 'ugly' 5G phone mast to be relocated, BBC News, 27 October 2023; and New Quay: Plans for 5G mast withdrawn after objections, BBC News, 24 October 2023

60   DSIT, Code of practice for wireless network development in England, 7 March 2022, para 28

61   ISPreview, Mobile Operator Tries to Hide UK Mobile Mast.. As a Toilet Brush?, 6 September 2022

62   Vodafone, Mobile phone masts: Everything you need to know, 29 September 2021

must be granted as part of an access agreements, and conditions for the exercise of those rights.

Access agreements are usually entered into consensually between the parties. If such an agreement cannot be reached, however, the ECC allows network operators to apply to the courts to have one imposed.[63]

Reforms to the ECC: 2017-2022

Reforms implemented through the Digital Economy Act 2017 have sought to make it easier for operators to build infrastructure. The 2017 Act introduced an automatic right for operators to upgrade existing equipment (for example by adding 5G equipment to a mast). The right is 'automatic' in the sense that site providers cannot impose terms that restrict it or require additional money to be paid to include it in the access agreement.

More controversially, the 2017 Act changed the way that rent for hosting telecoms equipment on private land is calculated when the court is imposing an agreement. Following the reforms, rent is now calculated based on the value of the land to the landowner, rather than to the operator. This is a system based on compulsory purchase principles ("no-scheme valuation") and is used for utilities such as electricity.[64]

The government said that the reform was needed "to reduce the cost to network operators of rolling out infrastructure".[65] Operators welcomed the proposals.[66]

On the other hand, they were opposed by landowner groups. The Country Land and Business Association called it a "massive concession to the mobile industry" that "remove[s] fairness from the system".[67] The change in approach to valuation strengthens the negotiating position of operators over site providers and has led to reduced rents even in consensual agreements. Research by the Centre for Economics and Business Research, commissioned by site providers' campaign group Protect and Connect, estimated that the 2017 reforms had cost site providers £209 million per year in revenues.[68]

In response to concerns that the 2017 reforms had caused a 'freeze' on the market, with landowners less willing to engage with operators, the government introduced further reforms through the Product Security and

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[63] Communications Act 2003, Schedule 3A Part 4
[64] House of Commons Library, Building mobile and broadband infrastructure, 7 December 2022, p29
[65] DCMS, Electronic Communications Code Impact Assessment, 12 May 2016, p6
[66] Mobile Today, Networks react to mobile mast reforms, 18 May 2016
[67] ISPreview, Gov Moot Tricky Land Access Changes to Boost Mobile and Broadband, 17 May 2016
[68] Cebr, Response to 2021 DCMS consultation on changes to the Electronic Communications Code: factsheet and executive summary, April 2021

[Telecommunications Infrastructure Act 2022](#).[69] The main changes introduced by the Act are:

- New provisions to encourage alternative dispute resolution rather than legal proceedings.
- A new procedure to allow operators to gain access to land in circumstances where an occupier is unresponsive.
- Allowing expired agreements to be renewed on terms more closely aligned to the 2017 reforms, including on land valuation.
- Extending the reformed ECC's automatic rights to upgrade apparatus to apply retrospectively to code agreements entered into before 2017.[70]

The Law Society commented that the government's 2022 ECC reforms focus more on the symptoms of the problems encountered, rather than addressing the "root causes", which they say stem from the balance of rights in the 2017 ECC being "too heavily in favour of operators".[71]

5 Deploying small cell 5G equipment on street furniture

Ofcom expects that mobile operators will have to deploy "several thousand" small cells to meet demand for 5G, mainly in high-traffic urban areas.[72] As small cells are relatively small and light they can be deployed on 'street furniture' such as streetlights and bus stops, rather than masts.[73] Operators do not need planning permission or prior approval to do this, but they do need the consent of the owner of street furniture. This is usually the local authority.

Operators have reported difficulties in identifying suitable sites and obtaining consent from local authorities to use street furniture.[74] Local authorities may own street furniture through private finance initiative (PFI) contracts, which can limit their ability to use them for wireless connectivity.

The government has sought to address these barriers through its [Digital Connectivity Infrastructure Accelerator](#) (DCIA) programme. The DCIA has four workstreams:

- Creating digital maps of public assets and digitalising the process of securing rights to use them.
- Developing contractual solutions for local authorities to facilitate deployment on sites held through PFI contracts.

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69   According to the Centre for Policy Studies, the average time to negotiate an access agreement was 11 months, almost double the 6 months envisaged in the ECC. See Centre for Policy Studies, [Upwardly Mobile: How the UK can gain the full benefits of the 5G revolution](#), 1 October 2021

70   For more detail see House of Commons Library, [The Product Security and Telecommunications Infrastructure Bill](#), 25 October 2022

71   Law Society, [Changes to the Electronic Communications Code – Law Society response](#), 20 April 2021

72   Ofcom, [Discussion paper: Ofcom's future approach to mobile markets](#), February 2022

73   VMO2, [Virgin Media O2 accelerates industry's largest rollout of small cells to deliver cleaner, greener and more flexible 5G network solutions](#), 30 June 2022

74   Ofcom, [Conclusions: Ofcom's future approach to mobile markets](#), 6 December 2022, Annex 2

- Drafting standardised contracts for local authorities to use when negotiating terms with telecoms operators.
- Developing a British Standard and a code of practice for 5G smart streetlights.[75]

Separately, in September 2023 the government launched the Smart Infrastructure Pilots Programme (SIPP). The SIPP awarded a share of £1.3 million to 6 local authorities to help them trial 'multi-purpose street columns' – streetlights that also house equipment such as 5G and electric vehicle chargers.

Local authority digital champions

To help address local barriers to deployment the mobile industry has recommended that local authorities should appoint 'digital champions'. Their role would be to:

> coordinate with the industry, promote understanding and awareness about mobile connectivity within the local authority, and to assist in smoothing the rollout of mobile equipment.[76]

In a report commissioned by the Digital Connectivity Forum, telecoms consultancy FarrPoint, argued that digital champions with a "strong degree of internal influence" are "essential" to improving engagement between local authorities and industry.[77]

A separate survey conducted by FarrPoint found that in 2023, 23% of local authorities have a dedicated digital champion. A further 47% have a person with the responsibilities of a digital champion added on to their existing role.[78] Mobile UK's report calls on the government to provide funding to help more local authorities appoint digital champions.

Government guidance to local authorities on how to encourage investment in digital infrastructure sets out the benefits of digital champions.[79] However, the government does not provide specific funding for this.

3.3   Public health concerns

Concerns about radio waves from communications technology such as those emitted from mobile phone masts have been a source of local opposition to 5G deployments. A survey of local authorities by FarrPoint found "lingering

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[75]   DSIT, Digital Connectivity Infrastructure Accelerator programme, 23 June 2022
[76]   Mobile UK, Building mobile Britain: the case for local authority digital champions, May 2022
[77]   FarrPoint, Local authorities as connectivity enablers [PDF], July 2023
[78]   FarrPoint, Digital Connectivity Survey 2024 [PDF], 31 January 2024, p8
[79]   DCMS, Digital strategy and leadership, 20 December 2018

hesitance from Local Authorities to actively support 5G deployment due to ongoing public hostility towards 5G masts".[80]

Public health guidance

Radiocommunications systems convert data into electromagnetic waves, which radiate outwards from one antenna and are picked up by another antenna, where they are converted back into data. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) explains how electromagnetic (EMF) radiofrequency fields affect the human body:

> Radiofrequency fields have the ability to penetrate the human body (though the higher the frequency, the lower the depth of penetration), with the main effect of this being a rise in temperature in the exposed tissue. The human body can adjust to small temperature increases in the same way as it does when undertaking exercise and performing sporting activities. This is because the body can regulate its internal temperature. However, above a certain level (referred to as the threshold) depending on the duration, HF exposure and the accompanying temperature rise, can provoke serious health effects, such as heatstroke and tissue damage (burns).[81]

ICNIRP sets exposure limit guidelines that it says "will provide a high level of protection for all people against substantiated adverse health effects from exposures to both short-and long-term, continuous and discontinuous radiofrequency EMFs".[82] The guidelines were most recently updated in March 2020. The ICNIRP webpage on 5G provides further information about the 2020 changes.[83]

The UK Health Security Agency (UKHSA) is responsible for assessing public health risks in the UK, including from EMF radiation from telecommunications infrastructure. The UKSHA's main advice, in its guidance on Mobile phone base stations: radio waves and health, is that the exposure limit guidelines published by ICNIRP should be followed. The guidance includes an overview of scientific studies on radiowaves and public health, which it says supports the view that "health effects are unlikely to occur if exposures are below ICNIRP's internationally agreed guideline levels".[84]

Researchers at the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) published a systematic review of the evidence on 5G networks and health in 2021.[85] It concluded that there is no confirmed evidence that exposure levels below the ICNIRP guidelines are hazardous to human health:

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80   FarrPoint, Digital Connectivity Survey 2024 [PDF], 31 January 2024, p27
81   ICNIRP, Base stations, undated [accessed 16 February 2024
82   ICNIRP, RF EMF guidelines, March 2020
83   ICNIRP, 5G, undated [accessed 23 January 2024]
84   UKHSA, Mobile phone base stations: radio waves and health, 27 August 2021
85   Ken Karipidis and others, 5G mobile networks and health—a state-of-the-science review of the research into low-level RF fields above 6 GHz, Journal of exposure science & environmental epidemiology, Vol 31, pp585-605, March 2021

> This state-of-the science review examined the research into the biological and health effects of RF fields above 6 GHz at exposure levels below the ICNIRP occupational limits. The review included 107 experimental studies that investigated various bioeffects including genotoxicity, cell proliferation, gene expression, cell signalling, membrane function and other effects. Reported bioeffects were generally not independently replicated and the majority of the studies employed low quality methods of exposure assessment and control. … This review showed no confirmed evidence that low-level RF fields above 6 GHz such as those used by the 5G network are hazardous to human health.

The World Health Organisation has convened a Task Group on Radiofrequency Fields and Health Risks. The group will assess the available evidence on EMF radiation and health.

Regulation by Ofcom

Mobile operators are legally required to comply with the ICNIRP standards and to hold records demonstrating their compliance.[86]

Ofcom's EMF calculator helps telecoms operators calculate the safe distance between antenna on phone masts and the general public based on an antenna's power output and frequency. Exposure levels will depend on numerous factors, including the height and direction of the antenna and interference from objects such as trees and buildings. According to Ofcom's guidance on EMF exposure, most masts will be compliant by virtue of the antenna's location (which is at the top of a tall mast). If there is a risk of the public coming within the minimum separation distance, operators would be required to prevent this, for example by erecting a barrier.[87]

Ofcom has enforcement powers if it finds that operators have breached their licence obligations: it can issue fines, launch criminal proceedings, and revoke licences.[88]

Ofcom tests EMF emissions at mobile mast sites across the UK. It publishes the results on its website.[89] In April 2020, Ofcom released the results of testing at mobile sites in 10 UK cities, focusing on sites likely to see high mobile phone use. The study found that emissions were far below the ICNIRP limits:

> EMF emission levels from 5G-enabled mobile phone base stations remain at small fractions of the reference levels for general public exposure in the ICNIRP Guidelines, with the highest level recorded being approximately 1.5% of the reference level. The base stations we visited all support a range of mobile technologies in addition to 5G, including 2G, 3G and 4G. In all locations, the largest contribution to the measured levels comes from previous generations

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86 Ofcom, Ofcom's rules on EMF exposure, May 2021
87 Ofcom, Guidance on EMF compliance and enforcement, 3 November 2021, para 5.20
88 Communications Act 2003 sections 94 to 104
89 Ofcom, Electromagnetic field measurements near mobile base stations, undated [accessed 23 January 2024]

of mobile technology (2G, 3G, 4G). The highest level we observed in the [3.4-3.8GHz frequency] band used for 5G was just 0.039% of the reference level.[90]

Planning rules

The government's National Planning Policy Framework (NPPF), which is a material consideration for all planning decisions in England, states that local planning authorities must not set health safeguards other than the ICNIRP guidelines.[91]

The NPPF also states that planning authorities are not allowed to prohibit the building of mobile masts in specified areas, such as near schools.[92]

Further reading

Information on 5G and health is also provided in the following sources:

- The government and Ofcom's Guide to 5G mobile technology provides information about 5G technology and safety tailored for politicians and local authorities.
- UKSHA, 5G technologies: radio waves and health
- The Institute of Engineering and Technology, Allaying health concerns regarding 5G and exposure to radio waves (July 2020)

3.4   Security concerns

Telecommunications networks, including 5G, are part of the UK's critical national infrastructure. As 5G is adopted more widely, including in other critical sectors such as healthcare, utilities, and transport, the potential impact of a successful cyber attack will increase.

5G networks have technical characteristics that increase the risk of attacks. For example, networks are typically built using 'off-the-shelf' equipment supplied by third-party vendors, rather than proprietary hardware. The government's Telecommunications Supply Chain Review, published in July 2019, identified four key security risks associated with telecoms supply chains:

- National dependence on one vendor supplier, especially ones deemed high risk;
- Unintended faults or vulnerabilities in network equipment;
- Malicious functionality deliberately added to equipment that creates a 'back door' allowing hostile actors to access the network;

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[90]   Ofcom, Electromagnetic Field (EMF) measurements near 5G mobile phone base stations: summary of results [PDF], 17 April 2020, p8

[91]   DLUHC, National Planning Policy Framework, 20 December 2023, para 122

[92]   DLUHC, National Planning Policy Framework, 20 December 2023, para 120

- Vendors may have administrative access to the network for the purpose of providing technical support, which could be exploited.[93]

This section focuses on two security issues of particular relevance to 5G: high-risk vendors (such as Huawei) and supply chain diversity. A broader overview of the cybersecurity requirements on telecoms companies can be found in section 3.2 of the Library briefing, Cybersecurity in the UK (June 2023).

Restrictions on high-risk vendors

The government introduced powers to restrict the use of equipment produced by 'high risk vendors' in the Telecommunications (Security) Act 2021. The 2021 Act added new sections 105Z1 to 105Z29 to the Communications Act 2003 allowing the Secretary of State to issue 'designated vendor directions'.

The National Cyber Security Centre (NCSC) has published advice to telecoms companies that includes a list of non-exhaustive criteria for identifying vendors in their supply chains who may be high risk.[94] Factors include the strategic position of the vendor in the UK and other telecoms markets, the quality and transparency of the vendors engineering, and factors relating to the ownership and operating location of the vendor (such as domestic security laws).

Huawei ban

Three of the UK's Five Eyes intelligence partners, the US, Australia, and New Zealand, placed restrictions on Huawei in 2018 and 2019.[95] The US reportedly lobbied the UK government to ban Huawei from the 5G network.[96]

Various parliamentary committees considered whether the UK should introduce a ban in 2018 and 2019. The Intelligence and Security Committee and the Digital, Culture, Media and Sport Select Committee both heard evidence that, from a technical standpoint, banning Huawei would not be a proportionate response.[97] This was in part due to the existence of the NCSC's Huawei Cyber Security Evaluation Centre (which since 2010 had evaluated the security of Huawei products) and the fact that without Huawei the market would be dependent on two suppliers, Nokia and Ericsson. However, both

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93   DCMS, UK Telecoms Supply Chain Review Report, 22 July 2019, p24

94   NCSC, NCSC advice on the use of equipment from high risk vendors in UK telecoms networks, updated 14 July 2020

95   CNET, Huawei says Trump's ban will hurt US 5G deployment, 16 May 2019; BBC News, Huawei and ZTE handed 5G network ban in Australia, 23 August 2018; BBC News, Huawei: NZ bars Chinese firm on national security fears, 28 November 2018. The remaining Five Eyes member, Canada, has since also banned Huawei: Guardian, Canada to ban Huawei and ZTE from 5G network, risking China tensions, 19 May 2022

96   BBC News, Using Huawei in UK 5G network 'madness', says US, 14 January 2020

97   Intelligence and Security Committee of Parliament, Statement on 5G suppliers [pdf], 19 July 2019; Letter from House of Commons Science and Technology Committee Chair to Secretary of State for DCMS, dated 10 July 2019 [PDF]

committees noted that there were geopolitical and ethical reasons for excluding Huawei.

The government initially announced, in January 2020, that equipment from high-risk vendors, including Huawei, would be banned from the 'core' 5G network. They would, however, be able to supply equipment for up to 35% of the non-core network.[98]

This position changed in July 2020 following a technical review by the NCSC of the impact of US sanctions on the security of Huawei products.[99] The government subsequently said that it would require a complete, phased removal of Huawei equipment from the UK's 5G network.[100] In October 2022, following a consultation, the government issued a designated vendor direction to UK mobile and broadband operators which put the announcement on a legal footing.[101] The direction restricted the use of Huawei equipment, including:

- A ban on installing new Huawei equipment.

- A restriction on Huawei equipment to 35% of the 5G network by 31 July 2023 (6 months later than previously announced).[102]

- A ban on the use of Huawei equipment in the 'core' 5G network from 31 December 2023 (11 months later than previously announced).[103]

- A ban on the use of Huawei equipment in any part of the 5G network from 31 December 2027.

The government estimated that removing Huawei equipment could cost £2 billion across the industry and add 2-3 years to the rollout of 5G.[104] The cost will be borne by the telecoms industry: the government is not subsidising the removal of Huawei equipment.[105]

Supply chain diversification

One of the security concerns highlighted in the Telecoms Supply Chain Review was a lack of diversity in 5G supply chains. Following the decision to exclude Huawei, there are just two major suppliers of radio access network (RAN) equipment in the UK market: Nokia and Ericsson.

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[98] HC Deb 28 January 2020 vol 670 c709-711
[99] NCSC, Summary of the NCSC analysis of May 2020 US sanction, 14 July 2020
[100] HC Deb 14 July 2020 vol 678 c1375-1378
[101] DCMS, Huawei legal notices issued, 14 October 2022
[102] IPSreview, Gov Tightens Huawei 5G Mobile and FTTP Broadband Restrictions, 30 November 2022
[103] BBC News, Two Huawei 5G kit-removal deadlines put back, 13 October 2022
[104] HC Deb 14 July 2020 vol 678 c1375-1378
[105] PQ 103501 – Huawei: 5G, 20 October 2020

The government published a 5G Supply Chain Diversification Strategy in November 2020 which sought to address what it called an "intolerable resilience risk". The strategy set out activities in three areas:

- Supporting incumbent suppliers;
- Attracting new entrants into the UK market;
- Promoting the development and deployment of open-interface (rather than supplier-specific) equipment, called Open RAN.

The House of Commons Science and Technology Committee heard evidence that the threat from market concentration has been known about for "many years".[106] The committee said that it was "disappointing" that the government had not previously developed a diversification strategy, and that the new strategy lacked specific actions and spending plans.

In December 2021, the government announced a "joint ambition" with the UK's four mobile network operators for 35% of mobile network traffic to be carried over Open RAN equipment by 2030.[107] To support this, the government announced that it had agreed with the industry that 2G and 3G would be phased out of UK mobile networks by 2033. Equipment suppliers will then not need to support these older technologies, removing a barrier to entry for new suppliers. 'Sunsetting' 2G and 3G was a key recommendation of the Telecoms Diversity Taskforce, set up to advise on actions to implement the Supply Chain Diversification Strategy.[108]

The government also announced investments in Open RAN research and development, including:

- £36 million for the Future RAN competition (FRANC), which sought to support the development of Open RAN products.
- £15 million for the SmartRAN Open Network Interoperability Centre (SONIC) Lab. SONIC is a laboratory run jointly by Digital Catapult, DSIT, and Ofcom designed to test the interoperability of RAN products from different vendors.

The government has also sought to influence global standards for Open RAN, publishing a set of Open RAN principles in April 2022. The principles were endorsed by the governments of the US, Australia, and Canada in a joint statement on telecommunications supplier diversity in December 2022.[109]

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[106] Science and Technology Committee, 5G market diversification and wider lessons for critical and emerging technologies, Second report of session 2019-21, HC 450, 4 February 2021, para 14
[107] DCMS, New measures to boost UK telecoms security, 8 December 2021
[108] Telecoms Diversification Taskforce, Findings and report, 20 April 2021
[109] DSIT, Joint statement on telecommunications supplier diversity, 8 December 2022

3.5   Access to spectrum

To provide wireless telecoms services, operators need to have a licence to use a part of the radio spectrum. With more spectrum, they can offer more services to more users. However, spectrum is a scarce resource and there are many other potential users.

What is spectrum?

The electromagnetic spectrum is a continuous band of electromagnetic radiation, made of photons (pockets of energy) that travel in waves. Waves travel at a certain frequency, expressed in Hertz (Hz), which refers to the number of wave cycles they complete in one second. The 'radio spectrum' refers to the parts of the spectrum that are useful for wireless communications.

Ranges of different frequencies are called 'bands'. Bandwidth means the size of the band. For example, the frequency band 700–800 MHz has a bandwidth of 100 MHz. The band 2–3 GHz has a bandwidth of 1 GHz (1000 MHz). The bandwidth determines how much data a portion of spectrum can carry.

Wider bandwidths are available at higher frequencies, so they can carry more data. However, lower frequencies can travel further and are less susceptible to being blocked by physical obstacles.

Spectrum management

The spectrum is a scarce natural resource: it is not possible to create new frequencies. Ofcom regulates the use of the radio spectrum to ensure that it is used efficiently and signals sent by different users do not interfere with each other. Users must either have a licence to use the spectrum or be covered by an exemption.

In the mobile sector, licences have typically been awarded on a nationwide basis by auction. The four MNOs bid for national licences that authorise them to use parts of the bands allocated to mobile.

While spectrum cannot be created it can be reused by clearing the band of existing users. For example, before it was allocated for mobile use, the 700 MHz band was used for digital terrestrial TV services. The industry's move to switch off 2G and 3G networks will also free up spectrum for 5G.

Spectrum sharing

Spectrum can be shared. Spectrum sharing is when the same spectrum band is accessed by multiple users. This needs to be coordinated in some way to avoid interference. In the Future Telecoms Infrastructure Review the

government identified "flexible, shared spectrum models" as one of four priority areas to support investment and innovation in 5G.[110]

Ofcom introduced a new framework for spectrum sharing in 2019.[111] It announced that it would make two types of licence available:

- Shared Access licences: Ofcom has designated four bands for local wireless connectivity, outside the bands allocated on a national basis. Users bid for licences to use a specific bandwidth in a specific location. Ofcom then assesses whether the proposed use in the proposed location will interfere with any existing uses.[112]
- Local Access licences: users can apply for access to parts of the spectrum that have been allocated nationally to one of the MNOs, in locations where the MNO is not utilising its spectrum.[113]

6 Spectrum: use it or lose it?

Spectrum for mobile has typically been licenced by Ofcom to MNOs on an exclusive national licence. This can leave spectrum unused in areas where the MNO has no network coverage.

The 2018 European Electronic Communications Code (the EU Directive that established the regulatory framework for the telecoms sector) allowed national governments to impose a 'use it or lose it' rule. MNOs would be required to make use of the spectrum allocated to them in a timely way or risk having it taken away, allowing other, local operators to step in in those areas.

The UK government was initially supportive of this principle and asked Ofcom to consider including it in the auction for the 5G 3.6-3.8 GHz spectrum.

Ofcom decided not to include a "use it or lose it" for the following reasons:

- Such conditions are very difficult in practice because of the difficulty of defining what constitutes 'use' and therefore what the trigger for an enforced trade or revocation would be;
- There may be entirely legitimate reasons for spectrum remaining unused – the licensee may be holding back until it sees a suitable commercial opportunity or until the technology it wishes to use is ready; and
- Imposing such an obligation also has the potential to distort and/or chill the incentives to invest in the spectrum, and so reduce the benefits for consumers and citizens which the award would otherwise create.[114]

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[110]   DCMS, Future Telecoms Infrastructure Review, 23 July 2018, p12

[111]   Ofcom, Enabling wireless innovation through local licensing, 25 July 2019

[112]   Ofcom, Shared access licences, accessed 13 November 2023

[113]   Ofcom, Local access licences, accessed 13 November 2023

[114]   Letter from Katie Pettifer (Government and Parliament Director, Ofcom) to James Heath (Director of Telecoms, DCMS), dated 13 December 2018; Ofcom, Consultation: Award of the 700 MHz and 3.6-3.8 GHz spectrum bands, 18 December 2019, para 10.19 [accessed 8 February 2019].

> Instead, Ofcom introduced new types of shared spectrum licences.[115]
>
> The government opted not to transpose the 'use it or lose it' requirement. It considered that Ofcom's framework of local and shared licences was preferable to a mandatory sharing requirement.[116]

Spectrum management policy

The government set out its views on efficient spectrum management in the UK Wireless Infrastructure Strategy and accompanying Spectrum Statement. The government welcomed Ofcom's introduction of shared and local licenses, and said that it had asked Ofcom to:

- Review its approach to setting spectrum licence fees. According to the WIS, the four MNOs are projected to spend around £3 billion on spectrum fees between 2022 and 2030.
- Identify opportunities to reallocate spectrum where it is not being used efficiently.
- Automate the Shared Access licensing process.

Ofcom published a Spectrum Strategy in July 2021, which sets out how it intends to manage the spectrum in the 2020s. Its Spectrum Roadmap covers progress to date and future projects.

In the Spectrum Strategy, Ofcom says that intends to increase its focus on the following areas in the next decade:

- Supporting wireless innovation by making it easier for a broad range of users to access the spectrum and making more of the spectrum available on a trial basis before its long-term use is certain.
- Licensing to fit local and national services by considering options for localised spectrum access, for example at smaller sites such as factories, airports, and farms.
- Promoting spectrum sharing.

Ofcom's approach to spectrum for 5G

Ofcom has identified three bands available for 5G:

1. **Low frequency spectrum** to enable 4G and 5G mobile coverage to wide areas (the 700 MHz band).
2. **Mid-frequency spectrum** with large bandwidths to provide capacity to support many users accessing large amounts of data with high speeds (the 3.4–3.8 GHz band).

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[115] Ofcom, Enabling wireless innovation through local licensing, 12 March 2019 [accessed 28 August 2019].

[116] DCMS, Government response to the public consultation on implementing the European Electronic Communications Code, July 2020, p32-35

3. **High frequency spectrum** with very large bandwidths, providing ultra-high capacity and speed and very low latency. Spectrum in this region (above 25 GHz) is also known as millimetre wave (mmWave).

National licences in the low and mid-frequency bands were auctioned in two groups in 2018 and 2021.

Ofcom has said that the first auctions for mmWave spectrum – for the 26 GHz and 40 GHz bands – will not take place until the Competition and Markets Authority has made a decision on the proposed merger between Three and Vodafone. The regulator does not expect to start the auction process until winter 2024/25.[117]

The International Telecommunication Union, the UN agency that works to standardise international telecoms, determined in December 2023 that additional mid-frequency spectrum, the upper 6 GHz band, should also be allocated to mobile.[118] The MNOs have called on Ofcom to make it available to them.[119] Ofcom is exploring a hybrid approach that would enable access to this spectrum for both mobile and wifi users.[120]

mmWave spectrum

In May 2022 Ofcom consulted on making the 26 GHz and 40 GHz bands available for mobile use. Frequencies in mmWave bands can carry very large amounts of data at high speeds and ultra-low latency. However, they have a short range and are easily blocked by obstacles such as trees and buildings.

Based on these characteristics, Ofcom expects demand for mmWave spectrum to come from use cases including the following:

• Densely populated areas with high data demands.
• Smart city applications.
• Fixed wireless broadband, especially as an alternative to fibre broadband in rural areas.
• Localised industrial applications. [121]

In contrast to other frequency bands, Ofcom opted not to offer national licences for mmWave spectrum:

> National licences would create barriers for other potential users of mmWave spectrum, resulting in fewer services for people and businesses, and sub-optimal use of spectrum. […]

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[117] Ofcom, September 2023 Statement: Enabling mmWave spectrum for new uses [PDF], 27 September 2023, p4
[118] ITU, World Radiocommunication Conference revises the ITU Radio Regulations to support spectrum sharing and technological innovation, 15 December 2023
[119] Ofcom, Conclusions: Ofcom's future approach to mobile markets, 6 December 2022, para 5.36
[120] Ofcom, Hybrid sharing: enabling both licensed mobile and Wi-Fi users to access the upper 6 GHz band, 13 October 2023
[121] Ofcom, Enabling mmWave spectrum for new uses: statement and further consultation, 13 March 2023, p15-17

> [T]he technical characteristics of mmWave spectrum mean that it is unlikely to be used to provide wide area coverage. Therefore, there is a significant risk that if we offered national licences, a large portion of spectrum would be unused, especially in rural areas.[122]

Instead, Ofcom will split the UK into high- and low-density areas. It has designated 68 high density areas, covering 6.4% of the UK landmass and 52.5% of the population.[123] Ofcom will take a different approach to licencing in each category:

- In high density areas Ofcom will:

  - Auction citywide licences in the top 2.4 GHz of the 26 GHz band and all of the 40 GHz band. Following feedback from stakeholders, licence holders will be permitted to offer services in any high density area rather than bidding for licences for specific locations.
  - Make 650 MHz of the 26 GHz band available on a first come first served basis through local Shared Access licences.
  - Reserve the bottom 200 MHz of the 26 GHz band for the Ministry of Defence.

- In low density areas Ofcom will:

  - Make most of the 26 GHz band and all of the 40 GHz band available on a first come first served basis through local Shared Access licences.
  - Reserve the bottom 200 MHz of the 26 GHz band for the Ministry of Defence.

Reaction to Ofcom's approach

Two MNOs, EE and Vodafone, said that they would have preferred an auction for nationwide licences. Industry group GSMA has argued that the certainty afforded by exclusive licences has historically been a "critical component of mobile networks, to support huge investments in high quality, wide area mobile networks worldwide."[124] However, Vodafone did acknowledge in its response to Ofcom's consultation that the likely uses of mmWave would leave spectrum unutilised in large parts of the country.[125]

Another MNO, Three, already holds spectrum in the 40 GHz band, although it is not permitted to use it for mobile services. In its May 2022 consultation, Ofcom expressed concern that allowing Three to keep its spectrum and use it for 5G would risk an inefficient allocation of spectrum, be a barrier to investment from other users, and be unlikely to promote competition. Instead,

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[122] Ofcom, Enabling mmWave spectrum for new uses: statement and further consultation, 13 March 2023, p30-31

[123] Ofcom, Enabling mmWave spectrum for new uses: statement and further consultation, 13 March 2023, p52

[124] GSMA, Spectrum sharing: GSMA public policy position, June 2021, p5

[125] Vodafone, Vodafone Response to Ofcom Consultation: Enabling mmWave spectrum for new uses, accessed 14 November 2023, p6

it proposed to revoke all 40 GHz licenses and allow users to bid for it from scratch.[126]

Three argued that this would be a "very intrusive" intervention that would "undermine property rights, commercial security and investment without good cause".[127]

Ofcom rejected Three's representations and announced that existing licences in the 40 GHz band would be revoked from June 2028.[128]

126   Ofcom, Enabling mmWave spectrum for new uses, May 2022, p78
127   Three, Three's response to Ofcom's consultation on enabling mmWave spectrum for new uses, August 2022
128   Ofcom, Update on revoking licences in the 40 GHz band, 30 May 2023

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