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for everyone

Connected Nations 2020

UK report

Strong, Secure Networks

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Overview

This is Ofcom's annual Connected Nations report, which measures progress in the availability and capability of broadband and mobile services in the UK. It also highlights the work we are doing, alongside UK and devolved governments and communications companies, to improve these services.

This year's report is being published as the UK continues to address the challenges of the coronavirus (Covid-19) pandemic; a time when people, families and businesses have come to rely on their phone and broadband connections as never before. We report on how the networks have performed during this period and how the availability of services has evolved.

Alongside this, we have published separate reports on broadband and mobile availability in each of the UK's nations. Our interactive dashboard allows people to easily access data for different areas of the UK and specific types of services. We are also releasing the International Broadband Scorecard 2020, which compares the UK's recent position on broadband availability with a number of other European nations.

What we have found:

- **The UK's fixed and mobile networks have generally coped well with increased demands during the pandemic.** A shift to more people being at home drove increased demand on broadband networks during the day, although peak usage remained in the evening. Mobile networks also experienced increases in voice traffic.
- **Gigabit-capable broadband is available to 7.9 million homes (27%).** As well as delivering download speeds of up to 1 Gbit/s, these services offer faster upload speeds and are more reliable than older broadband technologies.
- **Full-fibre broadband is available to 5.1 million homes (18%). This** is 2.1 million more premises (8 % points) than a year ago, and represents the highest year-on-year increase seen so far.
- **Superfast broadband is available to 96% of homes, up from 95% last year.** We now estimate that around 60% of premises that are able to get superfast broadband now take up this service.
- **The universal broadband service is helping some people unable to get decent broadband**. Factoring in coverage from both fixed and fixed-wireless networks, we estimate that around 190,000 homes and businesses (0.6%) are still without access to a decent broadband connection. These properties may be eligible for a connection under the universal service, with no costs to the customer unless these exceed £3,400. We expect around 16,000 properties could receive a universal service connection, without additional costs needing to be met by the customer.

- **The number of mobile base stations providing 5G services has risen ten-fold, to around 3,000 across the UK.** 87% of these are in England, 7% in Scotland and 3% in both Wales and Northern Ireland.
- **Mobile coverage is generally stable.** The four mobile network operators (MNOs) – EE, O2, Three and Vodafone - each estimate they provide outdoor coverage to 98%-99% of premises. Their networks' coverage of the UK landmass ranges from around 79% to around 85%. The Shared Rural Network programme agreed in March 2020 will extend coverage beyond this by 2025.
- **A small, but significant number of properties are still struggling to get connected.** We estimate that 43,000 premises cannot access either a decent fixed broadband service, or good 4G coverage, indoors.

Being connected has never been more important to the UK

People have been relying on phone and broadband services more and more over recent years, and the Covid-19 pandemic during 2020 has brought this reliance into even sharper view. In March 2020, life changed suddenly for millions of people across the UK. Fast, reliable broadband and mobile connections were essential to allow them to work from home, keep up with schoolwork, access medical appointments and public services, stay in touch with friends and family, order shopping online, and keep themselves entertained.

The UK's fixed broadband networks have seen significantly more demand, with average monthly data usage increasing almost 80% in two years. It now stands at 429 GB per connection, up from 315 GB last year (itself up from 241 GB in 2018). As well as an increase in traffic, the Covid-19 lockdown period has also seen a shift in how people use their services. While peak broadband use is still in the evenings and has continued to grow, daytime traffic has increased significantly. Upload traffic has also increased, driven by more use of video calling for work and to keep in touch with friends.

Networks had the capacity to meet these user demands and stayed well within capacity limits. Our research shows average broadband speeds only dipped slightly in March 2020, as much of the nation turned to working, learning and socialising from home.

Mobile networks also successfully coped with the increased demands and changes in network traffic patterns during the lockdown period. There was an increase in call volumes and average call duration when the national lockdown was introduced, which networks successfully handled. As restrictions continued, mobile hotspots shifted away from the city centres to the suburbs and residential areas. Worryingly, 170,000 cumulative hours of service were lost as a result of attacks on mobile base stations - based on false conspiracy theories incorrectly linking 5G to Covid-19 and other health concerns - during this period.

The UK continues to invest in faster, better networks

Gigabit-capable broadband coverage is gathering pace

Coverage of faster, more reliable broadband services is improving across the UK. Gigabit-capable broadband – able to provide speeds of 1 Gbit/s - can be delivered over full fibre networks and the

latest versions of hybrid fibre/coaxial cable networks. Gigabit speeds are now available to 7.9 million (27%) homes. In most UK nations, gigabit-capable coverage is higher in urban areas than in rural ones.

Just over five million (18%) UK homes now have access to full fibre connections – an increase of 8 % points or just over 2 million premises in the past year. This is the largest year-on-year increase in full fibre coverage that we have seen so far. Full fibre and gigabit-capable availability is highest in urban areas in Northern Ireland, and lowest in rural areas of Scotland.

5G services available at around 3,000 sites

EE, O2, Three and Vodafone first started rolling out 5G in the UK last year and have continued to extend their networks across the UK. Many 5G sites are in busy areas and are providing enhanced capacity to existing mobile data services.

Of all 5G sites that have been deployed, 87% are in England, 7% in Scotland and 3% in both Wales and Northern Ireland. This split broadly reflects the national distribution of all mobile traffic across the UK.

Good connections are available to most people across the UK

96% of UK premises have access to a superfast broadband connection with speeds of at least 30Mbit/s. A 30 Mbit/s connection is sufficient to stream a 4K/UHD video or download a one hour long HD TV episode in under 5 minutes, and allows for several devices to work simultaneously. Although most people have superfast broadband available to them, they do not always choose the fastest speeds. We estimate that only around 60% of premises who are able to get superfast broadband actually take it.

Mobile operators provide a high level of 4G coverage outside of premises, with coverage from each mobile network ranging between 98-99% of premises. Indoor 4G coverage ranges between 90% and 95% of all premises. However, coverage levels remain lower in rural areas, and across the extent of the UK landmass. Individual operator coverage ranges between 79% and 85% of all UK geography.

How Ofcom is supporting investment in new networks

Our aim is to support investment in gigabit-capable networks. From April 2021, we will have in place a longer-term regulatory framework for competition and investment for the five years to March 2026, with the aim of supporting investment in full fibre and other gigabit-capable services.

We are also supporting the rollout of new wireless services – including 5G – for people and industry to use. This includes making sure a diverse range of companies can access the spectrum they need to develop innovative new services, bringing a better mobile experience to consumers and delivering economic benefits for the UK.

Ofcom is also working with UK and nations governments to help improve access to mobile and broadband across the UK. Those governments are supporting rollout by investing public money in networks in areas which are unlikely to be covered commercially. We will work closely with the UK Government as it develops plans to invest in full-fibre and gigabit-capable broadband through its UK Gigabit programme. We are also supporting programmes in the nations – Superfast Cymru in Wales,

R100 and the Scottish Broadband Voucher Scheme in Scotland, and Project Stratum in Northern Ireland.

Some people are still struggling to get connected

A small – but significant – number of UK properties still cannot access decent broadband

Around 190,000 premises cannot get a decent broadband service from either fixed or fixed wireless networks. Most of these – 119,000 – are in England; 34,000 are in Scotland, 19,000 are in Northern Ireland, and 18,000 are in Wales.

These premises may be eligible to be connected under the universal broadband service, which came into force in March 2020. This gives homes and businesses the right to request a broadband connection that delivers a speed of at least 10Mbit/s download speed and 1Mbit/s upload speed. Where the costs to provide the connection are below the cost threshold set by Parliament (£3,400), the customer can be provided a service at standard connection and rental charges without having to pay any additional installation charges. Where the cost of connection is above the cost threshold, these premises can still receive a service if the customer pays the additional costs. Around 16,000 premises are likely to fall below the threshold. For many remote premises, costs could be significantly higher, meaning some premises will continue to be without access to a decent service, even with the universal service in place.

So, we will work with the UK Government and industry, to explore technology options and possible ways to fund providing connections to these properties so they do not get left behind.

There are still 4G mobile not-spots

The Shared Rural Network programme agreed in March 2020 will extend 4G coverage, particularly in rural areas, by 2025. Under the agreement, each mobile network operator (MNO) is committed to reaching 88% coverage of UK landmass by 2024, and 90% of landmass within 6 years from 2020 (subject to certain conditions), with an expectation that this will see the 'at least one MNO' footprint (i.e. the area where there is mobile coverage but not necessarily from the same MNO) will reach 95% of UK landmass by 2025. MNOs have now moved into a detailed planning phase and we expect to report on more significant progress as the programme moves into the delivery phase in the year ahead. Other public policy interventions such as the Scottish Government's 4G (SG 4G) Infill programme are also supporting increased rural coverage.

A small number of premises lack decent fixed broadband and 4G

We estimate that around 98% of UK premises can receive both decent fixed and good mobile services, but 43,000 (0.1%) cannot access either.[1] Providing connectivity to these premises is a particular challenge that we will draw to the attention of government and industry when exploring how to connect the most remote premises across the UK.

[1] Premises are considered to have access to a decent fixed connection if the broadband speed is above a download speed of at least 10 Mbit/s and an upload speed of at least 1 Mbit/s and to have access to an indoor 4G mobile service if a connection speed of at least 2 Mbit/s is available.

The UK's networks have generally been resilient, while plans to further increase resilience, and greatly improve security, are underway

The network security incidents reported to Ofcom this year do not show that the pandemic resulted in a noticeable increase in telecoms outages, despite increased demands on the networks. One major incident affecting O2's mobile phone users at the start of the first national lockdown does not appear to have reoccurred. However, it has highlighted some important lessons for the industry about how the latest network technology responded to these unprecedented demand peaks.

The work we started last year with telecoms providers to better understand the most common causes of major outages has identified several themes, and work to tackle them is ongoing.

Ofcom has also been working closely with the Department for Digital, Culture, Media and Sport, and the National Cyber Security Centre, in preparation for the Telecommunications (Security) Bill. The Bill, which has now been introduced into Parliament, will bring new rules and duties for Ofcom on network security.

Fixed broadband and voice

We want everyone to be able to access fast and reliable voice and broadband services, wherever they live and work. These communications services have never been more important than in 2020. The Covid-19 pandemic has highlighted the importance of connectivity for UK consumers as a vital part of how businesses and people communicate and consume information and entertainment.

The steps taken by the UK and devolved governments in response to Covid-19 meant that, during 2020, people relied even more than before on fast, reliable broadband connections in their homes. The networks coped well with the increased demand.

Connectivity in the UK continues to improve, as existing networks are being upgraded and new fixed infrastructure is being built. We support the investment in gigabit-capable and full fibre networks – as do the UK and devolved governments – which give people fast, reliable and future-proofed connections. We report on gigabit-capable coverage for the first time this year.

Most homes and businesses benefit from a choice of broadband connections, which deliver superfast or faster speeds. But there are areas in the UK, and in areas within each nation, where faster services are not available yet. We are concerned about the small number of premises that still do not have access to decent broadband given the importance of connectivity to participating in an increasingly digital society.

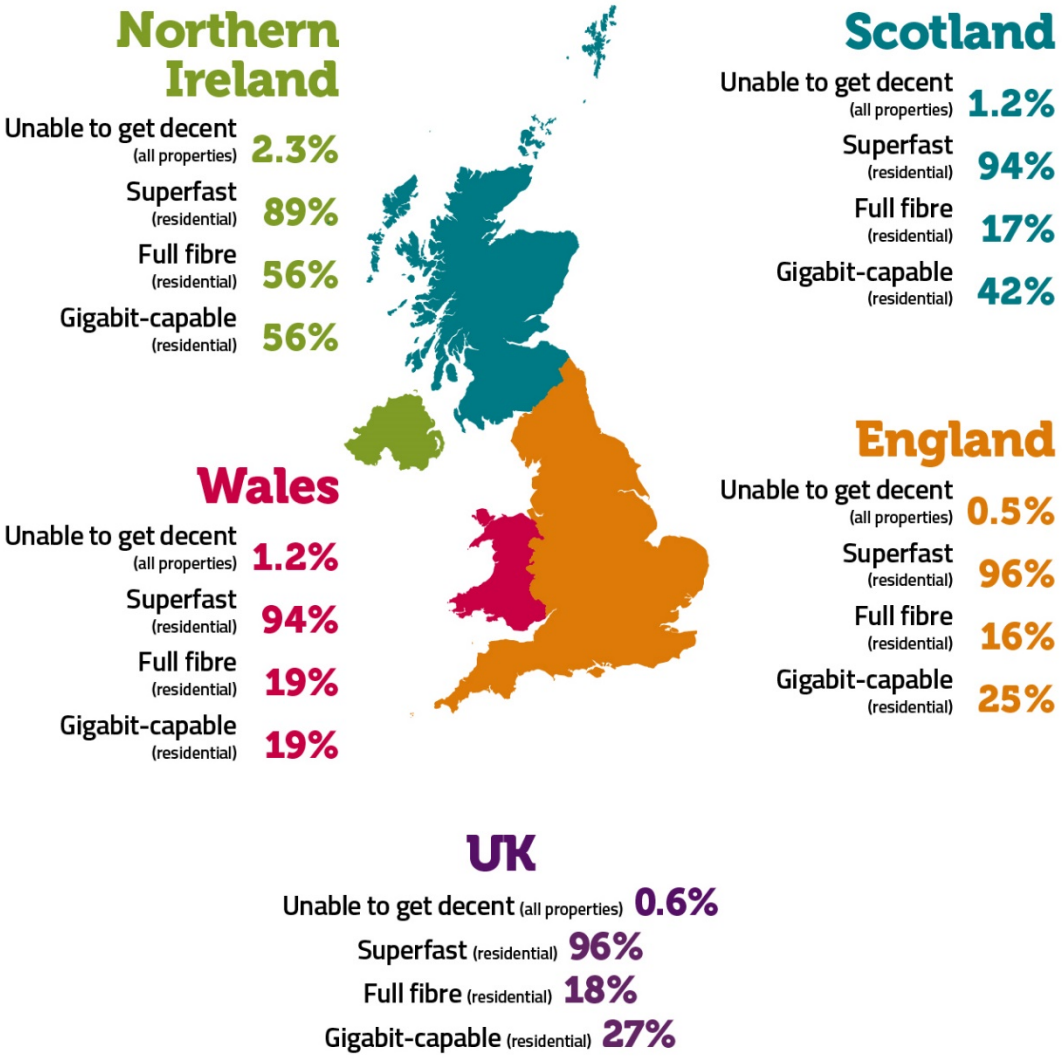
For this report, we have refined our approach to include data from around 20 additional full fibre communications providers and, for reporting on fixed wireless coverage, we have gathered, and include, data from both mobile network operators (MNOs) and a larger number of fixed wireless network operators.

Key highlights:

- **Fixed broadband networks coped well with increased demand during 2020**. While peak data usage continued to occur in the evening, usage during the day and upload usage grew significantly as many people worked from home rather than going into offices and as education moved online.
- **Coverage of faster networks is increasing. Gigabit-capable coverage is at 27% / 7.9m premises. Full fibre coverage is at 18% / 5.1m premises -** an increase of 8 % points /2.1 million premises since our 2019 report. **Superfast coverage has increased to 96%**

- Almost **99.4% of UK premises have access to a decent broadband connection**.[2] Those premises without access to decent broadband remains at around 0.6% / 190,000. The **Broadband USO launched in March 2020** and will provide a connection to some of these premises.
- Average monthly data use has continued to grow, and now stands at **429 GB per connection.**
- **Consumers are upgrading to higher speed packages, but do not always take the fastest packages available to them.** We estimate that around 60% of premises who are able to get superfast broadband actually take a superfast or faster service.

Summary of fixed broadband coverage across the UK and Nations



[2] Unless otherwise specified, coverage figures for decent broadband count all UK premises (residential and commercial). Coverage for all other speed tiers counts residential premises only, unless otherwise specified.

In this section, we report on the following key areas of fixed connectivity:

- the impact that Covid-19 has had on UK fixed networks;
- the rollout and upgrading of networks across the UK (including, for the first time, a summary of investment in fixed networks), as well as the take-up of services on these different networks;[3]
- progress of the broadband USO, which launched in March 2020; and
- progress in replacing the UK's public switched telephone network.

The UK's fixed access networks have been able to meet increasing user demand during Covid-19

Data usage during Covid-19

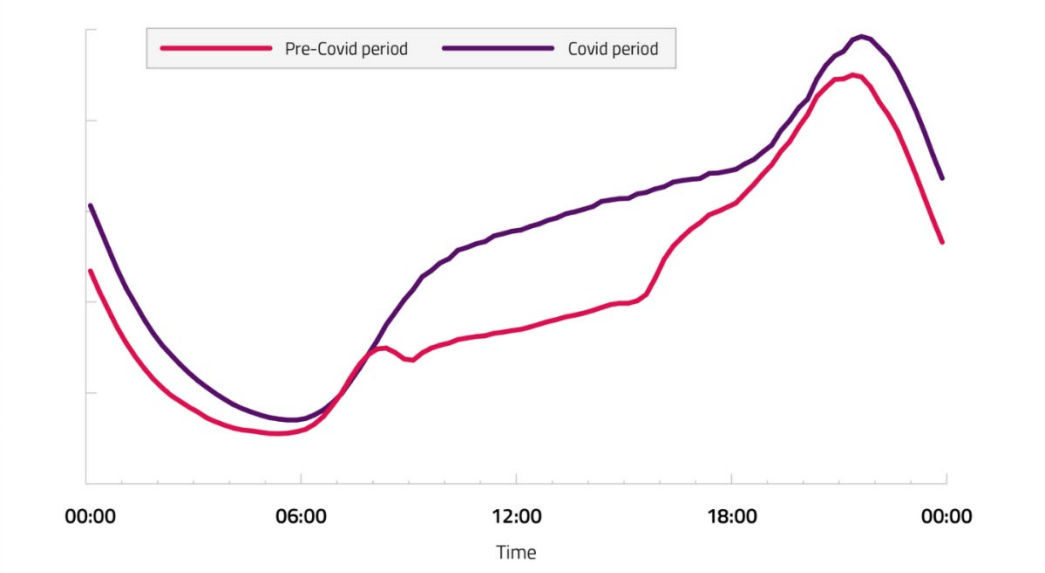
During 2020, the UK's fixed access networks have seen significantly increased demand from users. The nationwide lockdown, and subsequent restrictions, due to the Covid-19 pandemic saw many more people using their home broadband connections for work, for keeping in touch with friends and family, for accessing essential services, and for leisure. Networks generally had the capacity to meet user demands.

To understand how traffic on fixed broadband networks from residential and business customers changed during this time, we gathered data from a range of communications providers. We requested data spanning the period from February to July 2020 to capture the period immediately before and immediately after the first national lockdown, and the period as these restrictions were lifted. In addition to traffic volumes, we also asked for any analysis of the main applications driving any change in traffic levels or distribution.

Some communications providers were able to provide detailed reports covering the entire period, whereas others had higher level analysis, or data for only part of the requested period. Figures 1 and 2 show the typical traffic profile for weekdays and weekends before and after lockdown was imposed in mid-March.

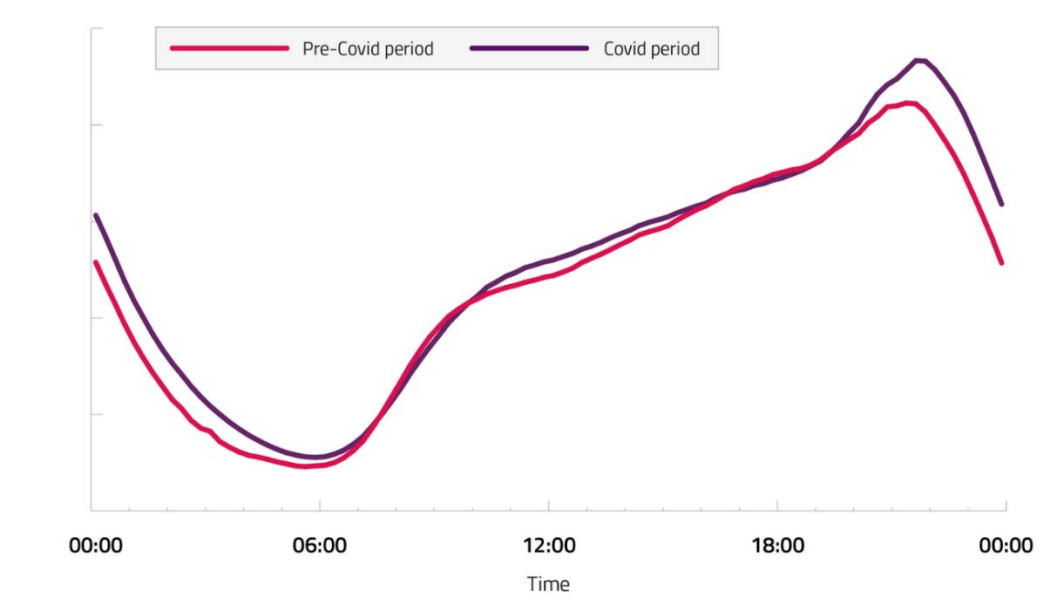
[3] Coverage data in this report is from September 2020; further deployments have been made since then.

Figure 1: Average traffic profile (Gbit/s) on weekdays before national lockdown (27 Jan to 22 March) and during national lockdown and subsequent restrictions (23 Mar to end July)



Source: Ofcom analysis of provider data.

Figure 2: Average traffic profile (Gbit/s) on weekends before national lockdown (27 Jan to 22 March) and during national lockdown and subsequent restrictions (23 Mar to end July)



Source: Ofcom analysis of provider data.

The charts show that:

- **Peak traffic was in the evening**: The peak of downstream traffic continued to be in the evening.
- **There was a significant increase in traffic during the day**: the shift to people being at home during the day, home working and home schooling drove significant increases in daytime traffic.

- **There were significant increases in upstream traffic:** Whilst this was true for both the daytime and in the evening, daytime increases were most significant. In some cases this meant the peak time for upstream data use shifted to during the day. This is consistent with the shift to home working and the use of business services from home, such as video conferencing. One provider suggested traffic spikes at the start of each hour were related to the use of video conferencing using applications such as Microsoft Teams.
- **Weekend traffic remained more consistent in pre- and post-lockdown periods:** There was less difference in traffic profiles at the weekend compared to during the week. This aligns with the largest shift in traffic being driven by home working and home schooling.
- **There were a number of large traffic spikes:** Traffic spikes were seen through the period, sometimes coinciding with the evening peak but also during the day. These were generally attributed to gaming downloads when new games or updates were released. Gaming downloads which coincide with the evening peak have been attributed with producing the highest loads on networks even prior to the pandemic and continue to be a major driver of unusually high traffic loads.[4]
- **ISPs, content providers and Ofcom worked together to effectively manage demand:** At the start of the lockdown period, major streaming sites including Netflix, YouTube, Amazon Prime and Disney+ (which launched around the start of lockdown in the UK) took action to reduce the streaming rates of their services. These controls were slowly lifted during the lockdown period as traffic on the networks became stable and ISPs were confident in the capacity available to carry streaming traffic with higher definition. In addition, we worked with the gaming industry, the Content Delivery Networks (CDNs) that distribute gaming downloads and the major ISPs to manage games releases so as not to adversely impact network congestion.

Overall the networks coped well. For major networks, peak traffic increased during the early phase of the first lockdown in late March and April. However, this generally remained below the spikes in peak traffic seen immediately prior to lockdown when major gaming releases coincided with the peak times. After this initial increase, peak traffic remained largely constant on average, meaning traffic levels remained higher than prior to lockdown, though this varied across different networks.

Providers plan their networks to have spare capacity to cope with year on year traffic growth and spikes associated with especially busy events. This has provided sufficient headroom to cope with any increased peak demand during the pandemic.

Impact of Covid-19 on availability of services

Telecoms engineers were designated as key workers so were able to continue building networks during the lockdown and during the restrictions that followed. As we report below, coverage of fixed networks has improved since last year. However, different approaches in different regions of the UK meant that new network build, and provisioning new connections, were impacted in some areas more than others.

[4] See for example, ISPreview, Broadband ISP TalkTalk Breaks Own UK Internet Traffic Record, 15 November 2020 and ISP Review, Openreach Reports High UK Data Traffic on PS5 Launch Day, 20 November 2020

Like other businesses and organisations, restrictions as a result of Covid-19 meant that communications providers needed to change their own working patterns and priorities. On 24 March 2020, in response to restrictions on its engineering workforce, Openreach declared 'Matters Beyond Our Reasonable Control' (MBORC), which meant taking action to prioritise only essential work and minimise work that required engineers to enter customers' homes.[5] Whilst Openreach engineers continued to provide essential in-home services to vulnerable customers, to ensure they stayed connected, this declaration of MBORC particularly impacted the provision of new full fibre connections on Openreach's network, which require engineers to enter the customer's premises.

This did not have as much of an impact on customers switching between retail providers on the Openreach network, or upgrading between services provided on Openreach's fibre to the cabinet (FTTC) network as these typically do not need an engineer visit.

Again, in common with other businesses, retail communications providers needed to rapidly shift their working patterns. Many staff moved to remote working. Call centres came under increasing pressure as customers sought to ensure they had fixed broadband connectivity. Some communications providers who use overseas call centres based in countries with strict Covid-19 restrictions found their capacity came under particular pressure.

Impact on customer demand

Despite the pandemic, providers have not reported a clear or consistent pattern of increased demand from customers seeking faster or more reliable broadband connections. Analysis of provider data shows that some providers saw increased demand from their customers for faster connections, while others did not observe such demand changes (and others did not specifically track this). One provider offering full fibre services saw a small shift in demand towards slower (but still at least superfast) speeds, perhaps reflecting increased price sensitivity.

Constraints on sales capacity (in-store and call centres) may have meant that consumers wanting to request faster broadband were unable to do so.

Full fibre connections typically require an engineer to enter a customer's home, which was restricted during the initial UK-wide Covid-19 lockdown. Customer demand for these connections – whether from customers seeking a new connection, or from existing customers seeking to upgrade their services – may not have been possible to fulfil during the period in which in-home visits were significantly restricted.

We report on take-up of different services later in this section.

[5] See for example ISP Review, COVID-19 – Openreach Limit UK Broadband ISP and Phone Work UPDATE, 24 March 2020

A variety of fixed broadband networks and services are available in the UK

Fixed broadband in the UK is available at a variety of speeds, delivered over different technologies

Different technologies used to deliver fixed broadband connections

- **Copper (ADSL) -** Copper from the exchange to the premises (also known as 'standard broadband'). Maximum download speed is up to 24 Mbit/s. Actual speeds delivered by copper connections diminish with distance. Copper can also be affected by weather. Since the copper network is old, it can be susceptible to faults. [6]

- **Fibre to the cabinet (FTTC)** - Fibre to the cabinet, with copper used to connect from the cabinet to the premises. Maximum download speed is up to 80 Mbit/s (except for G.fast). [7] As with ADSL, actual speeds diminish with distance, and the network can be affected by weather and is susceptible to faults.

- **Hybrid fibre coaxial cable (HFC)** – The cable TV network. [8] It uses fibre to a street cabinet and coaxial cable from the street cabinet to the premises. There is decreased signal loss which means co-axial cables are capable of delivering much higher speeds than copper wires. Broadband is supported using the DOCSIS standard, which shares the capacity downstream and upstream between multiple customers. [9] The latest standard of cable technology, DOCSIS 3.1, is capable of delivering download speeds of up to 10Gbit/s and upload speeds of up to 1Gbit/s, although in practice speeds average out significantly below this – and since capacity is shared among users, it may not be the case that each user can simultaneously receive gigabit speeds. Depending on the configuration of the access network in any particular area, this can lead to localised congestion. This may be particularly acute in the upstream direction where total capacity is more limited.

- **Full fibre or 'fibre to the premises' (FTTP) –** The connection from the exchange to the premises is provided entirely over optical fibre. Generally, distance to the premises does not affect the speed delivered. Full fibre is less susceptible to faults and is not usually impacted by weather. Most full fibre implementations utilise Passive Optical Network (PON) approaches where capacity in the downstream and upstream direction is shared. [10] Congestion can more easily be avoided on this shared network by limiting the number of customers connected to each shared PON and by managing the maximum guaranteed throughput provided to each customer. PON technology has an upgrade path that allows for speed to increase from a shared 2.5 Gbit/s down/1 Gbit/s up to

[6] ADSL: Asymmetric Digital Subscriber Line.
[7] Openreach deploys G.fast at some cabinets. It uses fibre to the cabinet, and copper from the cabinet to the customer. By using a higher frequency signal on the connection to the customer, G.fast can offer higher speeds than normal FTTC deployment, with Openreach offering wholesale services at up to 330 Mbit/s. But the signal degrades more quickly so the customers able to get ultrafast speeds are limited to those closest to the cabinet.
[8] Most cable broadband in the UK is provided by Virgin Media.
[9] DOCSIS: Data Over Cable Service Interface Specification.
[10] Virgin Media is also deploying some full fibre networks as part of its network expansion. Currently this uses a technology called Radio Frequency Over Glass (RFOG) which allows the DOCSIS signals to be carried over fibre end to end. This deployment is capable of also supporting PON technologies.

10 Gbit/s in both directions, and future generations will expand this further. This allows for services offering 1 Gbit/s both download and upload, with customers choosing a speed package to suit them.

Figure 3.1: Summary of characteristics of different types of broadband

Type of broadband	Speed	Use cases
Decent[11]	10 Mbit/s download; 1 Mbit/s upload	Making a high definition video call using applications like Zoom, Teams, WhatsApp or Facetime. Download a 1 hour HD TV episode (1GB) in almost a quarter of an hour.
Superfast	At least 30 Mbit/s download, up to 300 Mbit/s	One person streaming 4K/UHD video; downloading 1 hour HD TV episode in under 4 and half minutes. Several devices working simultaneously.
Ultrafast	At least 300 Mbit/s download, up to 1 Gbit/s	Multiple people streaming UHD video; downloading a 1 hour HD TV episode in under 30 seconds. Improved upload speeds better for internet gaming and video conferencing.
Gigabit	1 Gbit/s and above download	Provides quicker downloading than most ultrafast packages (and may offer greater upload speeds). Can download a full 4K film (100GB) in under 15mins. May be delivered over technologies that give greater reliability and that are future proofed as more high demand services are developed.

Figure 3.2: Technologies that can deliver different types of broadband

Type of broadband	Copper (ADSL)	Fibre to the Cabinet	Hybrid fibre coaxial cable	Fibre to the Premises
Decent	Yes	Yes	Yes	Yes
Superfast	No	Yes	Yes	Yes
Ultrafast	No	No[12]	Yes - DOCSIS3.0 can provide ultrafast speeds.	Yes
Gigabit	No	No	Yes - Cable that has been upgraded to DOCSIS 3.1 can deliver gigabit speeds.	Yes

[11] The UK government defines a decent broadband service as one that delivers at least 10 Mbit/s download speed and 1 Mbit/s upload speed. This is the level of connection deemed necessary for consumers to participate in a digital society.
[12] See footnote 7.

Broadband to fixed locations can also be delivered wirelessly, providing an alternative to wired connections

Some premises may be served by broadband provided over a wireless network (known as fixed wireless access, or FWA), using either a mobile network or a dedicated network. As the capacity in the wireless access network is shared between multiple users, the service needs to be managed appropriately to meet user demand, particularly in areas with capacity constraints. As coverage predications are based on predictive modelling tools, localised issues may mean that particular premises may not be able to receive a service despite being predicted to do so.

Fixed wireless access on mobile networks is offered on licensed 4G and 5G networks, usually to an indoor router. These services share the network capacity with mobile users, meaning that the capacity of the network has to be carefully managed between the demands of existing mobile users and FWA customers. There may be areas of high mobile demand where a reliable FWA service cannot be offered.

Broadband services to a fixed location are also provided by Wireless Internet Service Providers (WISPs). The majority of these services are delivered over wireless networks that communicate via a wireless link between a provider's mast site and an external antenna fixed to a customer's premise. These networks generally use license exempt or light licensed spectrum. Due to the frequencies where this spectrum is available, performance may be limited by line of sight issues.

Fixed broadband coverage has continued to increase across the UK

Gigabit-capable broadband is now available to 27% premises, including 18% full fibre connections

Full fibre (FTTP) broadband is now available at 18% / 5.1m premises

Our data shows that 18% / 5.1m residential premises in the UK are now served by full fibre connections – an increase of 8 percentage points, representing over 2 million premises in the past year. This increase is largely due to the continued investment in the rollout of fibre networks in the UK from providers included last year, such as BT, CityFibre and KCOM. However, we are now including coverage data from many more, predominantly smaller, fibre network providers. Whilst these providers do not significantly alter the national figures, they are important in providing full fibre coverage at the local level.

Gigabit-capable broadband is now available at 27% / 7.9m premises

We are reporting on gigabit capable broadband for the first time in this report. The UK Government has set a target of at least 85% gigabit coverage by 2025, alongside an ambition to get as close to 100% as possible.

When all technologies are combined, our data shows that 27% / 7.9m residential premises now have access to gigabit-capable broadband. Some of these premises have access to more than one gigabit-capable network: 2% / 615,000 residential premises have access to a gigabit-capable broadband service over both cable and full fibre technology, and 1% / 335,000 have a choice of two full fibre networks.

Figure 4: Residential gigabit-capable and full fibre coverage

	Full fibre	Urban	Rural	Gigabit-capable	Urban	Rural
England	16%	16%	17%	25%	26%	18%
Northern Ireland	56%	71%	17%	56%	71%	17%
Scotland	17%	18%	12%	42%	47%	13%
Wales	19%	19%	19%	19%	19%	19%
UK	18%	18%	17%	27%	29%	17%

Source: Ofcom analysis of provider data.

In Wales and Northern Ireland, all gigabit-capable services that were live at the time of collecting this data used full fibre as their underlying technology, which means coverage was the same for both. In November 2020, Virgin Media announced that it had made gigabit-capable cable services available across its network in Northern Ireland.[13] This will be reflected in future updates next year.

Rollout of full fibre and gigabit-capable networks

Full fibre and gigabit-capable networks are still at a relatively early stage of rollout. Different providers are taking different approaches to their business models for deploying these networks:

- Openreach is the incumbent wholesale infrastructure provider for almost all of the UK.[14] It has the largest network and connects the most premises. It has plans to reach 20 million premises with full fibre by 'the mid-to-late-2020s', 'including a significant build in rural areas.'[15] This includes 3.2 million homes in harder to reach areas by 2025/26.
- Virgin Media has targeted bringing 'gigabit speeds' to close to 15 million premises by the end of 2021.[16] Between the time of data collection for this year's report (September 2020) and the time of writing, Virgin Media has enabled further areas with gigabit capable services.[17]
- Some providers, like Hyperoptic and Community Fibre, focus on connecting premises in urban areas. Hyperoptic is pursuing a target of rolling out its full fibre network to 2 million premises (both residential and business) by 2021 and 5 million by 2024.[18] Community Fibre aims to roll out full fibre broadband to 1 million London premises by 2023.[19]

[13] Virgin Media, Virgin Media brings gigabit broadband to its entire Northern Ireland network, 5 November 2020

[14] KCOM is the incumbent in and around the city of Kingston upon Hull. They committed to a full fibre deployment a number of years ago and availability is approaching 100%. KCOM are planning to extend their full fibre footprint beyond their traditional area of operation.

[15] BT Group, Financial results: Results for the full year to 30 June 2020, 31 July 2020

[16] Virgin Media, Virgin Media to bring next-generation gigabit internet to millions of homes across the UK, 25 July 2019

[17] Virgin Media, Virgin Media brings gigabit broadband to its entire Northern Ireland network, 5 November 2020

[18] Hyperoptic, Gigabit broadband designed for new build homes

[19] Community Fibre, Community Fibre to invest up to £400 million in accelerated expansion of full fibre broadband to one million households and businesses across London, 29 July 2020

- CityFibre plans to pass 'up to 8 million premises' (both residential and business) across 62 towns and cities.[20] It frames its ambitions in light of the UK Government's target for gigabit-capable coverage (which is now for a minimum of 85% of UK premises by 2025, with an ambition to get as close to 100% as possible).
- Providers like Gigaclear, B4RN and a number of others focus on connecting more rural areas. There are a range of approaches taken by these providers. Some work closely with local communities to determine areas with demand, and may include the local community undertaking some of the work. Others plan their own commercial builds in areas they assess as less well served by providers such as Openreach. Some may also bid for public funding to support rollout. A provider may follow one of these approaches, or a combination of them.

Deploying these new networks requires significant investment and engineering resources. The cost and timeframes for deployment can be reduced if a provider can roll out its network by using Openreach's ducts and poles. Openreach has c.460,000km of duct and c. 4,000,000 poles. Regulation to allow this access has been in place since 2010, but changes to our regulation in 2019 were designed to allow easier access to Openreach's physical infrastructure (PIA).[21] As at the end of September 2020, 95 providers had registered with Openreach as customers of PIA, and approximately two-thirds have already built network using PIA or had placed orders to do so. Providers had ordered c.17,000km of duct and c.90,000 poles to deploy networks. Our Wholesale Fixed Telecoms Market Review is considering the rules we should put in place to support investment in networks, including around access to physical infrastructure, and we will publish our final statement by end of March 2021.

Also, the UK Government is working with industry and other stakeholders to ensure that the process for installing full fibre in new-build and multi-dwelling units is simplified, including reducing the administrative burden required for accessing wayleaves.

While rollout of new networks has progressed since our last report, as set out above, there were constraints during Covid-19 on the capacity of network builders to carry out this engineering, and on the potential for engineers to enter buildings and homes to complete the fibre build. This is likely to have impacted the rate of fibre build in the period in which the most stringent lockdown measures were in place.

UK customers can increasingly choose ultrafast connections

59% / 17.2m UK residential premises can now choose an ultrafast connection – an increase of 6% / 1.8m since 2019.

The increased coverage of ultrafast broadband has been driven by the roll-out of full fibre and gigabit capable networks as set out in the previous section, as well as Openreach's deployment of G.fast. Openreach has now paused its G.fast deployments as it focuses on full fibre build.[22]

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[20] CityFibre, CityFibre reveals 36 more towns and cities to benefit from full fibre as rollout accelerates, 6 March 2020

[21] Ofcom, Review of the wholesale local access market, 7 October 2010
Ofcom, Promoting competition and investment in fibre networks – review of the physical infrastructure and business connectivity markets, Volume 1, 28 June 2019

[22] ISP Review, Openreach Confirm G.fast Broadband Rollout Paused Until 2021 UPDATE, 24 June 2020

Most homes in the UK have access to at least a superfast broadband connection

Rollout of superfast networks has been underway for many years, so coverage was already high (95%) in 2019. This year's report shows that superfast broadband is now available to 96% / 27.8m of UK premises, an increase of 450,000 over the year.

Figure 5: Residential superfast coverage

	Superfast	Urban	Rural
England	96%	98%	84%
Northern Ireland	89%	99%	66%
Scotland	94%	98%	72%
Wales	94%	98%	78%
UK	96%	98%	81%

Source: Ofcom analysis of provider data.

Investment in superfast broadband networks will continue in the future. This is likely to be predominantly due to publicly funded rollout under a number of schemes (described below). However, investment in the coming years is likely to be in gigabit capable networks. While superfast broadband is generally sufficient for lots of today's user needs, as demand for higher speed and better networks increases, gigabit capable networks will become increasingly important.

Decent broadband over a fixed connection is available to almost all homes and businesses

Taking into account all fixed line connections, 98% of UK homes and businesses have access to at least decent broadband, the same percentage as in 2019. Around 583,000 premises do not have access to decent broadband via a fixed connection.

Figure 6: Premises unable to receive decent broadband from a fixed line

	Total	Rural	Urban
England	1% (387,000)	7% (240,000)	1% (146,000)
Northern Ireland	6% (49,000)	19% (43,000)	1% (6,000)
Scotland	3% (95,000)	17% (85,000)	<1% (10,000)
Wales	3% (52,000)	13% (45,000)	1% (8,000)
UK	2% (583,000)	10% (413,000)	1% (170,000)

Source: Ofcom analysis of operator data.

Broadband delivered wirelessly to fixed locations can meet the needs of some people, including those in areas without access to decent broadband over wired connections

Fixed Wireless Access on mobile networks

Of the four MNOs in the UK, only O2 does not currently offer FWA services. For areas with poor indoor coverage, EE offers an external antenna for its FWA services.

Based on the MNOs' claimed coverage, we estimate that 95% of UK premises have access to an MNO FWA service. EE claims an average download speed of 31Mbit/s for customers on its 4G FWA service and 150Mbit/s on its 5G FWA service. [23, 24] Vodafone claims to have made its FWA product available at all properties where a mobile signal is available.[25] However, as we explain above, the end users' experience of the service could be affected by where they place the router, their indoor mobile coverage and the capacity available in the wireless access network and in the backhaul.[26]

Based on the data provided by the MNOs, currently 92% of FWA customers have access to a 4G FWA device compared to 8% who have access to a 5G FWA router.[27]

Fixed wireless access from WISPs

For this year's report, we have taken a new approach to collecting WISP coverage data, asking operators to provide their own estimate of coverage, factoring in network capacity constraints, interference and other external factors.[28] Based on providers' estimates, around 1.4m homes and businesses have coverage from a WISP network.

There are many more WISPs who have not given us their coverage data, so coverage from these providers could be higher. We intend to continue to collate and analyse data from these providers and monitor changes to the sector.[29]

[23] EE, 4GEE Home Router 2, [accessed 23 November 2020]
[24] EE, Pay Monthly Mobile Broadband Devices, [accessed 23 November 2020]
[25] Although we do not have data on what performance can be delivered on their network.
[26] Backhaul here refers to the bandwidth available between the cell site and the mobile network core.
[27] Consumers with a 5G FWA device but who cannot receive a 5G signal would be served by a 4G network where there is coverage.
[28] Ofcom, Technical Guidance for WISPs, 28 September 2020
[29] If WISPs would like to provide information as per the technical guidance, they can get in touch via the mailbox connectednationsreport@ofcom.org.uk.

Figure 7: Coverage of MNO and WISP FWA networks

	MNO FWA	WISP FWA
England	95%	3%
Northern Ireland	83%	3%
Scotland	94%	1%
Wales	91%	33%
UK	95%	5%

Source: Ofcom analysis of provider data.

FWA and the impact on the availability of decent broadband

If the networks are managed well, both MNOs and WISPs can deliver a decent broadband service and are an alternative network technology for consumers who cannot receive a decent broadband connection from their fixed network.

Based on the coverage estimates provided by FWA providers, we estimate that 393,000 premises that do not have access to a decent broadband service from a fixed network could have access via an FWA network. This provides an additional 1.3% of decent broadband service coverage to the UK. This breaks down into 51,000 premises that have access from a WISP network, and 342,000 premises that have access from an MNO FWA service. Some premises that can get decent broadband on a WISP network may also be covered by an MNO FWA service. Over the next year, we plan to work with FWA providers to understand how they manage the capacity of their network to ensure that a reliable service can be provided to their customers.

Figure 8: Access to a decent broadband service by different types of technology

	Has no access to decent broadband from a fixed network	Has access to decent broadband from an FWA network	Remaining premises without access to decent broadband
England	387,000	268,000	119,000
Northern Ireland	49,000	30,000	19,000
Scotland	95,000	60,000	34,000
Wales	52,000	35,000	18,000
UK	583,000	393,000	190,000

Source: Ofcom analysis of operator data.

A small – but nevertheless important – subset of UK premises still cannot access decent broadband

Our latest estimate is that 0.6% / 190,000 premises in the UK still do not have access to a decent broadband service via either a fixed or fixed wireless network. This figure has stayed consistent with our estimate of 189,000 last year.[30]

These premises may be able to have a new connection built under the broadband Universal Service Obligation (USO). We estimate that of the 190,000 premises, there are around 7,000 premises that are due to receive a decent broadband service under a publicly funded scheme within the next 12 months (these schemes are set out below). These premises are not eligible for the USO under the terms of the USO Order.[31]

The Broadband Universal Service Obligation (USO)

The broadband USO provides everybody with the right to request a broadband connection with the following technical characteristics:

- a download sync speed of at least 10 Mbit/s;
- an upload sync speed of at least 1 Mbit/s;
- a contention ratio of no more than 50:1;
- latency which is capable of allowing the end user to make and receive voice calls effectively; and
- the capability to allow data usage of at least 100GB per month.

Where an affordable service with the above characteristics is not available, or due to be available in twelve months under a publicly funded scheme, the customer is eligible for the USO if the costs of providing the connection are below £3,400 or, where the costs are above £3,400, the customer agrees to pay the excess. [32] In calculating whether the costs are below or above £3,400, the Universal Service Provider (USP) must take into account where costs could be shared by several USO eligible premises. This is known as demand aggregation and to implement this, the USP is required to assume take-up by 70% of premises.[33]

Following a process of requesting expressions of interest from providers interested in being a USP, we designated BT as the USP for the UK (excluding Hull), and KCOM for the Hull Area, requiring them to provide the USO and to report at six monthly intervals on their implementation.

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[30] While coverage of both fixed networks and FWA networks has increased, and we have gathered data from more networks, last year we included data from the largest fixed and FWA providers (specifically MNOs). In addition, the data on premises has been updated and may include new build premises for which decent broadband will be available once complete but where the network connection has not been included in data provided by operators.

[31] The Electronic Communications (Universal Service) (Broadband) Order 2018

[32] In our statement of 6 June 2019 (para 5.1), we decided that an affordable service was one that cost £45 per month, rising annually by CPI. When the USO launched, this figure was £46.10.

[33] The conditions we imposed in our statement of 6 June 2019 require the USP to use a forecast of 70%, or actual demand if it is higher.

The broadband USO launched on 20 March 2020, very soon after the UK entered lockdown due to the Covid-19 pandemic.

BT's delivery of the broadband USO

Due to the Covid-19 pandemic, we agreed to a soft launch of the USO in order to manage demand on:

- BT's call centres, which were newly trained to support the USO;
- Openreach's employees that design and cost the network; and
- Openreach's engineers that ultimately build the network.

This meant that BT did not initially promote the USO in accordance with its obligations. However, it commenced promotional activities during the summer and has been writing to all potentially eligible premises.[34] We expect these communications to be largely complete by the end of 2020.

BT is required to report on its delivery against the USO. It published its first report covering the first six months of availability in October 2020.[35]

In the first six months, BT received 9,168 requests to its helpdesk. Of these, just over half (5,131) were deemed ineligible as there was already a service that meets the USO specification available (either from BT (3,190 requests) or another provider (1,739 requests)), or publicly funded schemes would provide a service in the next 12 months (202 requests).

Of the remaining requests, 512 orders were placed. These network builds will cover over 4,000 premises.[36] Of these, 507 orders were below the cost threshold of £3400 and so the customer did not need to pay any excess costs. Five orders were placed for build above £3400 where the customer agreed to pay the excess costs. As of September 2020, 7 premises had been connected under the USO scheme.

During this initial period of implementation, several issues have received attention:

- the clarity of information being provided to customers; and
- customers receiving very high quotes.

On the first of these, BT is working to improve its communications to customers, including to provide more information on alternatives to customers and to set out the costs of building the network to the customer more clearly.[37]

On the second of these, we understand that in some cases the costs to connect premises will be very high so that many customers are likely to receive quotes above the £3,400 threshold. In our statement in May 2020, we reported that BT estimated it would only be able to connect up to

[34] BT initially targeted communications activities to areas with least restrictions on its engineering workforce.
[35] BT, BT report on progress against the Broadband USO, 30 October 2020
[36] As infrastructure can often be shared, each individual order could mean network is put in place that can serve multiple premises. The network builds resulting from the 512 orders cover 4029 premises, which include 3245 in England, 253 in Northern Ireland, 111 in Scotland and 420 in Wales.
[37] See BT's October 2020 report.

16,000 premises below the £3,400 reasonable cost threshold.[38] Those premises that are more expensive to connect may need alternative solutions.

However, we are concerned that BT may not be complying with the regulatory conditions correctly where it assesses excess costs for a given connection. This could result in some customers' quote for a connection being higher than necessary. This could in turn lead to fewer people taking advantage of the USO. As such, we have opened an investigation into BT's approach to calculating quotes for excess costs.[39]

KCOM's delivery of the broadband USO

KCOM is the USP for the Hull Area. It received 1 request in the six months to September which it deemed ineligible, as a service meeting the USO requirements was available. KCOM considers that all premises within the Hull Area have access to a service that meets the USO specification. This is mainly due to KCOM's extensive rollout of full fibre, but those premises not covered by this rollout can be served using KCOM's copper network.[40]

Private and public sector investment play a role in building faster networks

Supporting investment in faster networks across the UK is a key priority for Ofcom. While commercial and public sector investment has delivered at least superfast services to most of the UK, not every part of the UK has the same access to faster speed services. Therefore, we are continuing our work to both improve access to better broadband services in the hardest to reach locations, and support investment in new gigabit capable networks.

Governments across the UK continue to supplement commercial rollout by investing in faster speeds for the hardest to reach areas. While subsidy schemes designed to bring superfast speeds continue to operate, governments are now also considering how public funding can be used to support gigabit-capable connectivity, a renewed emphasis which we expect to continue growing over the coming year and beyond.

We expect further public funding schemes to be announced during 2021 as the UK Government sets out further details of its £5 billion UK Gigabit Programme, with at least £1.2bn available up to the end of March 2025, to provide connectivity for the hardest to reach areas.

Examples of ongoing government schemes to support faster speeds in hard to reach areas include:

- The UK Government's Gigabit Broadband Voucher Scheme, which contributes towards the installation of faster connections using gigabit-capable infrastructure, alongside the ongoing Superfast Broadband Programme which will run until 2026.
- In Wales, Phase 2 of the £52.5m Superfast Cymru which is expected to provide gigabit capable technologies to around 39,000 premises by June 2022;

[38] Ofcom, Statement: Compensating providers delivering universal services - Ofcom, 22 May 2020.
[39] Ofcom, Investigation into BT's compliance with its obligations as a broadband universal service provider
[40] KCOM explained to Ofcom that it dd not consider any premises would be eligible for the USO because all customers can access either an affordable full fibre or a copper ADSL service. See Para 2.19, Ofcom, Statement: Compensating providers delivering universal services - Ofcom, 22 May 2020.

- In Scotland, the Scottish Government has committed to ensuring every home and business in Scotland can access superfast broadband. This commitment will be delivered through the Reaching 100% (R100) programme via three key strands of activity – the £600 million R100 contracts (North, Central and South), the Scottish Broadband Voucher Scheme (SBVS) and ongoing commercial deployment.
- In Northern Ireland, Project Stratum aims to bring next generation broadband to more than 76,000 rural premises across Northern Ireland currently unable to access speeds of 30 Mbit/s or more. The contract was awarded in November 2020 with work expected to start immediately and implementation will run until March 2024.

More information about schemes run by devolved government in the individual nations reports.

We will also conclude on our wholesale regulation that helps industry continue to deliver gigabit capable networks next year. Working with the UK and devolved governments, Ofcom will continue to focus on ways to deliver decent connectivity to all.

Future developments

We expect that the pace of gigabit-capable rollout will increase, both due to more full fibre deployment and Virgin Media's upgrade and extension of its network.

On fixed wireless access, WISPs are exploring using spectrum in higher frequency bands, which will enable them to provide services with higher speeds. There has been slow take up of access to the shared spectrum bands in 3.8-4.2 GHz, following our decision last year. We have also recently announced proposals for licensing high power access to spectrum in the 57-71 GHz band to support access to wireless broadband services.[41]

To date, the deployment of gigabit capable fixed wireless networks has been limited by the availability of affordable equipment, although this is expected to change in the next 12 months. Cambium Networks, a vendor used by many WISPs, has recently released equipment for the 60GHz band, capable of delivering gigabit speeds over wireless technologies.[42] This is based on wireless meshing technology developed by Facebook Connectivity's Terragraph project.

Satellite can be an option for a fixed broadband connection, particularly for premises without an alternative fixed provider.

Geostationary (GSO) satellites orbit the earth at around 36,000km, and can be used to provide satellite broadband to premises across the UK, including the most remote premises, but the connection's performance can be limited by its high latency, and by data caps that are commonly imposed on satellite broadband connections.[43] As such, we do not consider that GSO satellites currently provide a decent broadband service. In recent years, we have reported GSO satellite customer subscriptions in the low tens of thousands.

[41] Ofcom, Consultation: Notice of Ofcom's changes to licence exemption for Wireless Telegraphy Devices and consultation on licensing equipment in 57 to 71 GHz, 7 December 2020
[42] ISPreview, Cambium Networks Launch 60GHz multi-Gigabit Wireless Tech, 16 September 2020
[43] Latency refers to the time taken for information to traverse the network. Geo-stationary satellites tend to have high latency due to the signal having to travel the long distance to and from the satellite.

In future, we will likely see Low Earth Orbit (LEO) satellite constellations beginning to offer residential and business broadband to UK consumers, at the earliest during 2021. These services will have lower latency, because the satellites are closer to earth, so they are more likely to provide decent broadband services[44]. In November 2020, the UK Government completed its acquisition of OneWeb, a constellation of LEO satellites.[45] OneWeb will recommence launching satellites in December 2020 and anticipates offering an initial service by the end of 2021.

Over £1.1bn was invested in gigabit-capable full fibre access networks in 2019

We are reporting on provider investment for the first time this year

For the first time this year, we requested network capital expenditure (CAPEX) data from more than 30 of the UK's largest fixed and mobile telecoms providers to better understand how telecoms providers are investing in network infrastructure.[46]

This information was provided for the most recent annual financial reporting periods ending on or before 31 March 2019 and 31 March 2020. As financial reporting periods differ, we have pro-rated the data to estimate network investment in the calendar year 2019. The figures shown below include any public funding provided to support the rollout of better fixed and mobile connectivity, such as UK Government funding, funding provided via the governments of the devolved nations and local authority funding.

Our analysis suggests that providers collectively invested over £5.7bn in fixed and mobile network infrastructure in 2019.[47]

Investment in fixed networks

Data collected from over 20 of the UK's largest fixed telecoms providers suggests that UK telecoms providers invested around £3.5bn in fixed network infrastructure in 2019, with an additional £0.7bn having been invested in infrastructure that is used to provide both fixed and mobile telecoms services.

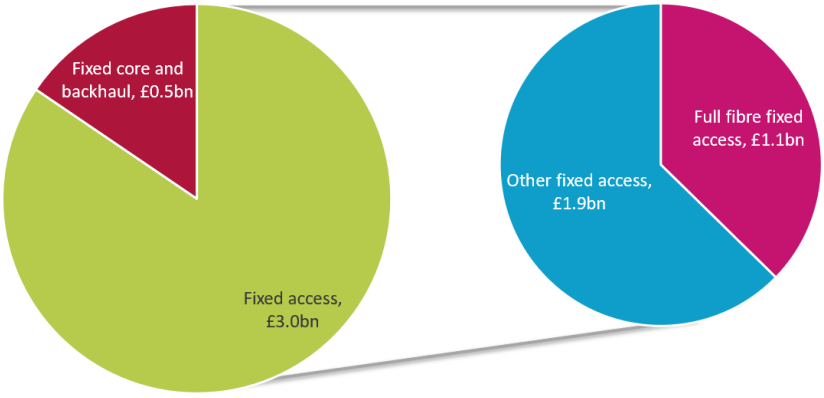
Fixed access network infrastructure accounted for most fixed network investment during the year (£3.0bn, or 84% of the total), with fixed core and backhaul networks accounting for the remaining

[44] SpaceX's Starlink LEO constellation launched a beta residential internet service in 2020. This service is currently only available in parts of the USA. We will consider the results of the beta trials when available.
[45] Department for Business, Energy & Industrial Strategy and UK Space Agency, UK government secures satellite network OneWeb, 20 November 2020
[46] Only Capital expenditure required to provide and operate network infrastructure in the UK is included: figures exclude VAT and expenditure on retail activities (e.g. retail billing or marketing systems). Figures include capital expenditure on tangible and intangible assets, including capitalised staffing and labour expenditure, and expenditure on assets in the course of construction (AICC). Figures exclude expenditure on assets that have been added to a balance sheet through adoption of the IFRS16 accounting standard, on assets held for sale and the costs of maintenance contracts purchased alongside hardware. Expenditure associated with asset transfers and leasing follows the same guidelines the Office for National Statistics provides when requesting information in its quarterly acquisitions and disposals of capital asset survey.
[47] We report on mobile investment in the mobile chapter.

£0.5bn (16% of the total). Gigabit-capable full fibre access network investment totalled £1.2bn in 2019, over a third of total fixed access network investment.

In addition, a proportion of the remaining £1.8bn may also support deployment of gigabit-capable networks where this is related to upgrades to physical infrastructure (such as fibre deployments for FTTC) that could be re-used in future.

Figure 9: Fixed telecoms network capital expenditure: 2019



Source: Ofcom / provider data

Data usage over fixed connections continues to grow

Consumers continue to use more data over their fixed connections as more people use broadband for data-heavy activities such as streaming. Average monthly data usage now stands at 429 GB per connection, up from 315 GB last year and 240 GB in 2018.[48] In addition to general web browsing and email use, a monthly usage of 429 GB could represent the download of a popular game, over 3 hours of video conferencing per working day, as well as over 3 hours per day of high definition video streaming. Average monthly download traffic has grown by around a third in the past year, whilst peak download traffic (in the period 6pm to midnight) has grown by around a quarter. The figures for this year were recorded during the Covid-19 pandemic.

More consumers are upgrading to higher speed packages

The benefits of increased coverage of broadband networks able to support higher speed services cannot be realised if consumers do not take advantage of these services when they are available. So alongside reporting on the extent of coverage of broadband networks we also examine the take-up of services over them.

[48] These figures include connections not assigned to a specific location within the UK; equivalent figures in Nations reports include only connections assigned to addresses in that Nation. The UK average given here therefore includes data for premises not included in the figures given for each individual nation in the Nations reports.

Of those properties for which we have accurate address matching, broadband provider and speed data from both 2019 and 2020, we observe that more are taking higher speed packages than last year. [49]

Overall, we estimate that for those premises that are able to take superfast broadband or a higher speed (96% of all premises in the UK), around 60% / 16.7million of them do so. This is an increase from around 57% last year.

We estimate that the take-up of services using full fibre at any speed, where fibre is available, is around 25%. [50] This is lower than the 2019 estimate, which is likely to be due to the high rate of full fibre deployment over the past year (2m additional properties) with adoption increasing at a lower rate.

The take-up of gigabit speed broadband services in the UK is currently low, which makes quantifying this with accuracy difficult, given the subset of properties for which we obtain accurate speed data. However, gigabit capable broadband services are becoming increasingly important in the UK and we will be considering how best to report on both their availability and take-up for future publications.

We have also examined the extent to which consumers have changed their broadband package over the past year:

- For those properties that last year took a sub-10Mbit/s broadband service (at least 2.2m), just under 40% of these were now, in 2020, taking a broadband package that offers decent broadband speeds (>10Mbit/s) or better.
- For those properties that in 2019 were taking a package with speeds between 10Mbit/s and 30Mbit/s (decent broadband) (at least 3.7m), this year just under 30% of these are now taking superfast (or better) broadband.
- The vast majority (>90%) of properties taking superfast services in 2019 (at least 12.4m) were still taking these services in 2020.
- Conversely, just under a fifth (18%) of properties taking ultrafast (>300Mbit/s) services in 2019 (at least 390,000) were, in 2020, taking a slower speed broadband package.

Switching broadband provider can be a catalyst to upgrading to higher speed broadband. For those properties that have remained with the same broadband provider over the past year, around 85% have remained largely in the same speed category, with 10% increasing their speed. However, for those that have changed broadband provider over the past year and signed up to a new deal, well over 20% increased their speed when doing so.

Overall, many consumers have the opportunity to take higher speed broadband packages if they choose to do so. The broadband package selected by consumers will be a matter of individual choice and will depend on a variety of factors, of which network availability is just one.

[49] See methodology Annex for details. Accurate premises-level usage data for which we were able to address match in both 2019 and 2020 is available for around 2/3 of the total premises in the UK.
[50] This take-up figure refers to the underlying technology; customers can often choose a range of speed tiers over full fibre technology.

We may also see users' needs evolving; as they come to rely more on fixed broadband connections for essential participation in digital society, they may need faster and more reliable connections to do so.

Installation times for full fibre connections

The coverage information we publish, both in this report and our associated maps and open data, shows where connections at the speeds indicated are available. For broadband services using the telephone line, such as standard broadband, the connection usually already exists to the property. However, in the case of full fibre connections, the network provider may have installed network close to the property but still needs to install the final connection to a property in order to provide service.

We asked full fibre providers the length of time it would take to make this connection. We found that there was a broad range of installation times. For those providers that provide fibre networks to new-build and campus developments, connections are built into the fabric of the properties, and hence connection times are effectively instantaneous. In general, we found that almost all operators were able to provide connections within 28 days of a customer order. In some situations, longer connection times may arise, either because of the geography (such as accessing very rural communities) or due to gaining necessary wayleave permissions.

Capacity to deliver broadband services

In some circumstances it is not possible to provide a broadband service to a new customer even though there is network coverage. This can arise because the network in the area is reaching the limits of its capacity, and therefore requests for service at the desired speed cannot be met. It may also arise if additional connections exceed the physical number of ports on equipment in the access network (such as a street cabinet or exchange equipment).

In our 2019 report, we estimated that across the UK, fixed access networks had the capacity to meet additional demand from users 99% of the time. We said we would use this as a baseline to monitor how providers met changing user needs over time, particularly as demands on providers remain to grow coverage, as well as to maintain and repair existing networks.

Similar capacity constraints were found this year, with more network providers reporting some, albeit low levels of capacity limitations. This suggests that as new entrant network providers reach maturity at scale, they too face the same challenges of network operation and management as the more established networks.

Helping customers choose the right broadband service

Ofcom has work underway to help consumers understand their broadband choices, and to see the potential benefits that faster connections may give them. Ofcom's Boost Your Broadband campaign seeks to help customers understand the broadband choices available to them, and to understand the additional benefits of a faster connection.[51]

[51] Boost Your Broadband

We have also worked to help consumers know when their contract period is coming to an end. Since February 2020, providers have been required to issue End of Contact Notifications, which tell people when their contract is coming to an end, what they will pay when it does, the best deals their provider can offer them, and that they have the choice to switch providers at the end of their minimum contract period if they wish.[52] Additionally, for out of contract customers, providers are required from February 2021 to issue Annual Best Tariff Notifications to out of contract customers, telling them that they are out of contract and the best tariffs they can offer.

Full fibre and gigabit-capable connections are still relatively new to UK consumers. In August 2020, the UK Government convened a new taskforce ('GigaTAG') to drive consumer take-up of gigabit speed internet connections.[53] Ofcom is participating in this work and will continue to work with industry, governments and consumer bodies on communicating the benefits of gigabit-capable technologies as they become more widely available.

The UK's traditional telephone network is also being replaced

It is not only the UK's fixed broadband networks that are changing – traditional landline services are also undergoing a substantial transition. Network providers such as BT, Virgin Media and KCOM, that offer traditional telephony services (referred to as the Public Switched Telephone Network, or 'PSTN'), are in the process of retiring their legacy systems and replacing them with modern systems.[54] In particular, BT plans to retire its PSTN network by the end of 2025, with fixed voice services delivered to customer homes or business premises delivered over broadband connections instead. Before the PSTN switch off in 2025, all fixed voice services will need to migrate to alternative voice services over broadband.

Last year we estimated that only around 1% of voice lines were being provided over broadband, reflecting the early stages of migration. This year, analysis of provider data shows that around 8% of fixed voices lines are delivered over broadband, as the larger communications providers begin to offer these alternative voice services to their customers. We anticipate that adoption of these services will increase rapidly in the next few years and are working with providers to address any issues that might arise with this migration to ensure consumers are protected and disruption is minimised.

The introduction of new voice services and platforms brings associated opportunities and challenges. Consequently, we are looking into how the telephone numbering scheme may evolve and considering other numbering related issues – such as call routing, number portability and trusted caller line identification.[55] The migration from the legacy telephone network also brings challenges in terms of the reliability of services, and the devices that take advantage of the traditional telephone network's line powering and voiceband data transfer capabilities (like telecare alarms, and telemetry and monitoring applications within critical national infrastructure). We discuss these in more detail in the Security and Resilience chapter.

[52] Ofcom, Companies must tell customers about their best deals, 14 February 2020
[53] DCMS, Press release: Gigabit broadband rollout milestone reached, 8 August 2020
[54] In the case of BT, PSTN services are provided by Openreach in terms of access connectivity and BT for calls services. Openreach's WLR withdrawal site gives more information.
[55] Ofcom, First consultation: Promoting trust in telephone numbers, 11 April 2019

Mobile data and voice

Introduction

Mobile services are an important part of people's daily lives. The experiences of the Covid-19 pandemic over the course of this year have further emphasised the reliance society and business place on access to good mobile services, and the key role these services play in helping people communicate and stay in touch.

In this chapter, we report on the impact of the Covid-19 restrictions on the use of mobile services. We also provide an update on the availability of mobile coverage, including the continued rollout of 5G, coverage outside and inside premises, across the UK's landmass and on roads. We also address investment in, and the take up of these services, as reflected in the continuing growth of mobile traffic year on year. Finally, we also report on the availability and use of 'Internet of Things' devices and services, which have continued to increase over the past year.

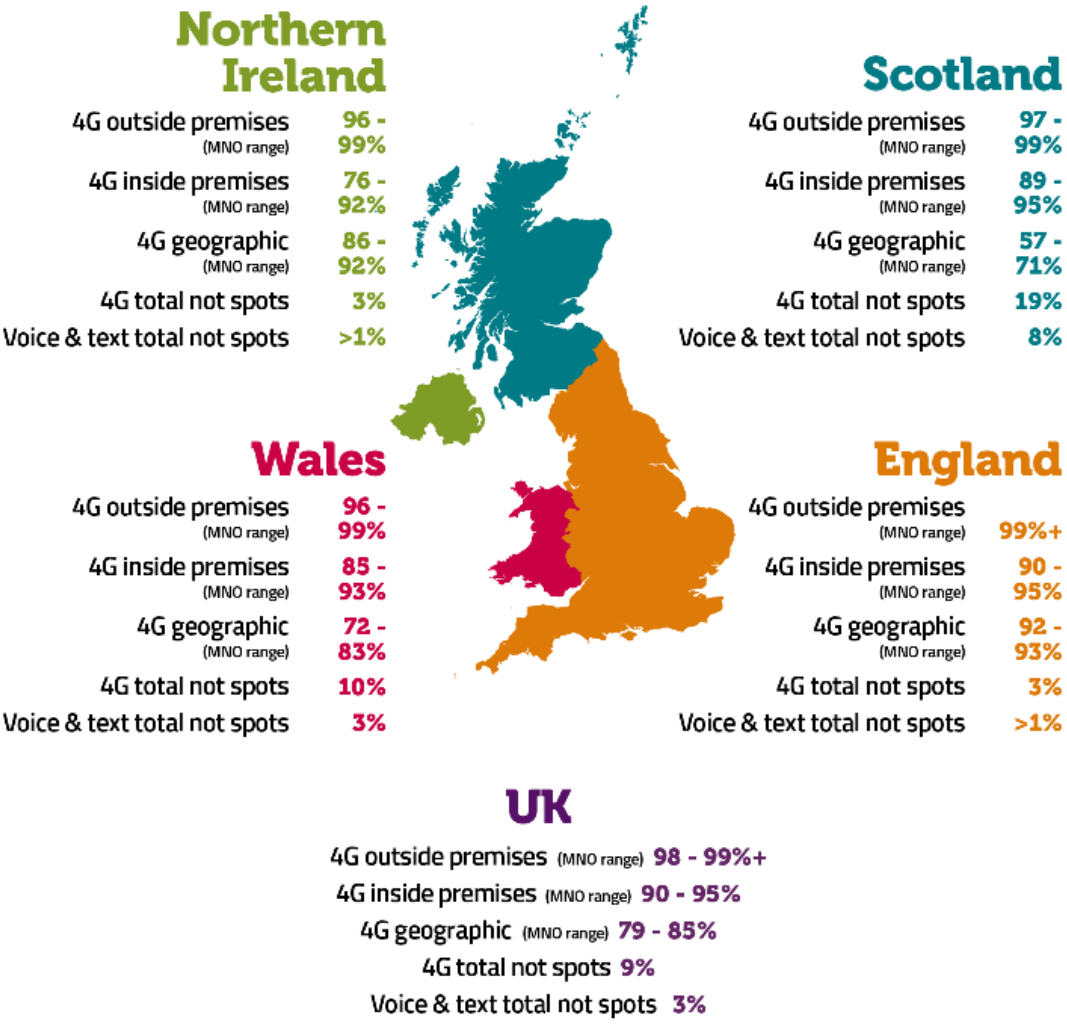
Key highlights:

- There was an increase in call volumes and average call duration in the week the national lockdown was introduced in March 2020, which networks successfully handled. As restrictions continued, mobile hotspots shifted away from the city centres to the suburbs and residential areas.
- 170,000 cumulative hours of service were lost as a result of attacks on mobile base stations - based on false conspiracy theories incorrectly linking 5G to the coronavirus and other health concerns - during this period.
- 5G deployments have continued, particularly in locations with existing high demand for mobile services. There has been around a ten-fold increase in 5G enabled base stations, with around 3,000 base stations now live for 5G services across the UK.
- 4G coverage has not significantly increased across UK premises and geographic areas, while there continues to be significant differences across the nations. MNOs have now moved into a detailed planning phase for the implementation of the Shared Rural Network (SRN) programme which will improve coverage across the UK landmass, particularly in rural areas, in the years ahead. Other public policy interventions such as the Scottish Government's 4G (SG 4G) Infill programme are also supporting increased rural coverage.[56]

[56]Scottish Government, Improving mobile coverage, 12 March 2020

- Mobile data consumption continues to rise, increasing by 42% compared with last year. 83% of the total data traffic was consumed in England with about 10% in Scotland, 4% in Wales and 3% in Northern Ireland (largely in line with UK population distribution). Reflecting this growth, the traffic carried in England in June exceeded that carried across the whole UK in February.

Summary of mobile coverage across the UK and nations[57]



[57] In providing these ranges we have rounded coverage to the nearest whole number, except where that whole number would imply 100% coverage. Fuller details on coverage levels can be found throughout this report and our accompanying interactive publication.

The UK's mobile networks successfully coped with increased traffic demands and changes in consumption patterns during Covid-19

Data usage during Covid-19

UK MNOs coped successfully with the changes in data and voice traffic volumes and distribution as many people began working from home and schools were shut during the Covid-19 spring lockdown. New peaks were reached for most of the network metrics reported by MNOs just before or during the week lockdown measures were first introduced across the UK in March 2020.[58, 59] Although these peaks generally reduced with the gradual easing of lockdown, they have remained higher than they were before (in line with the historical trend for incremental growth in data consumption).

The MNOs all experienced some form of congestion on their networks in this period, but successfully mitigated this, in part by increasing interconnect capabilities between themselves. Some operators applied further temporary upgrades to their voice and data capabilities in order to cope with increased demands during this period, for example deploying temporary base stations in and around hospitals (particularly at the Nightingale hospitals) to provide additional capacity.

Compared to periods before the spring lockdown, mobile voice traffic increased by 10-45% across the operators. [60] One operator observed an increase in average call duration from about 2.5 minutes (pre-lockdown) to 4 minutes in the week lockdown measures were introduced. These call lengths and volumes spiked in March, before gradually stabilising. Within this general trend for growth, we can also observe drops in average call duration and data traffic around 8pm for the 10-week period from 26 March 2020, coinciding with the nation coming together to applaud the efforts of the NHS during the Covid-19 crisis. Increased amounts of voice traffic were also offloaded to Wi-Fi, although with significant variations between operators. Compared with periods before lockdown, offloaded voice call volumes rose by a minimum of 16% and a maximum of 97% (we note that these increased levels still represented a relatively small part of total call volumes, ranging between 2% and 8% in this period). These dropped with the easing of lockdown but have in some cases remained up to 50% above pre-lockdown values.

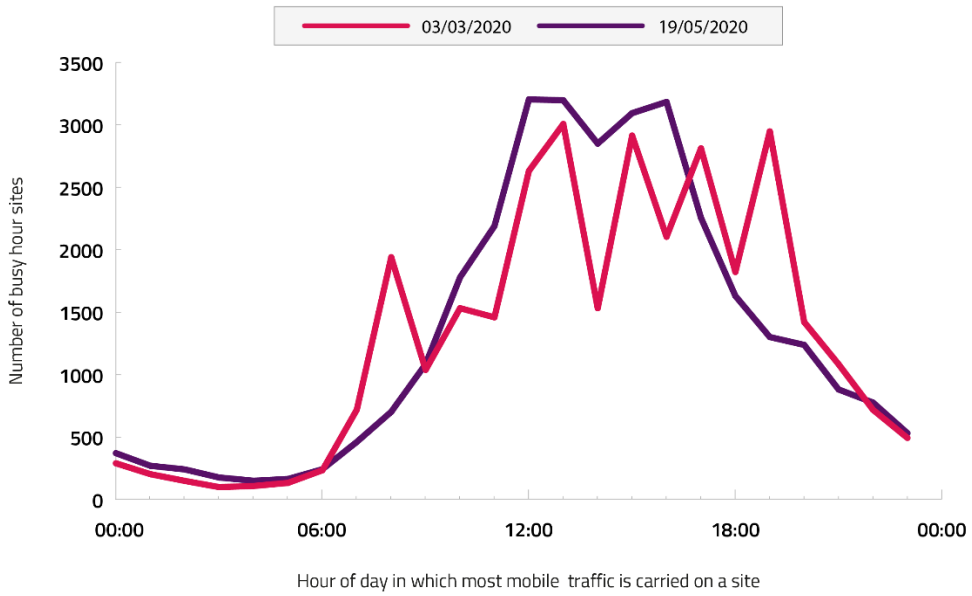
Mobile data traffic fell in the week lockdown measures were introduced across the UK. Crowd sourced data available to us suggest that the reduction in overall data traffic across the operators reflected more users being at home and offloading their data to home Wi-Fi connections. [61] Unlike Wi-Fi mobile voice call offload, which can require prior registration with MNOs, consumers only

[58] We have assessed the impact of Covid-19 on mobile networks by comparing MNO data for the second week of March 2020 (as a baseline) with those collected in the week lockdown measures were introduced in the UK and the periods after these measures were eased. We collected relevant data from MNOs between February 1- July 31, 2020. We have also clarified where we have considered data from other sources.
[59] This analysis does not include data from one UK MNO.
[60] In terms of the proportion of total minutes of originated calls.
[61] The dataset was licensed to Ofcom by network benchmarking specialist Umlaut and contains information on mobile user experience and network performance. The operating system used on iPhones (iOS) restricts the collection of network performance data by background apps, so the data in this report relate to Android devices only. These devices are predominantly smartphones, although there are a small number of tablets and other Android devices with a SIM card

need to be connected to Wi-Fi networks in order to offload their data to them, meaning significantly more data traffic offloaded to Wi-Fi than voice calls.

Consequently, the operators experienced an initial reduction of between 4% - 20% in the volume of data downloaded over their networks in the early weeks of the spring lockdown. However, these volumes recovered as lockdown restrictions eased and have generally stabilised at a level higher than before lockdown, reflecting the value people placed on mobile connectivity as they were out and about more frequently but sought new ways to connect and engage as social distancing requirements remained in place. The change in people's daily patterns also impacted the peaks in mobile traffic, with the 'busy hour' on mobile base stations more evenly distributed after the lockdown than before, when peaks were typically staggered around 8am (morning commuting), 12-1pm (lunch breaks) and 5pm (return commute), in line with historic trends.

Figure 10: Busy hour distribution for periods before and after lockdown restrictions for one operator

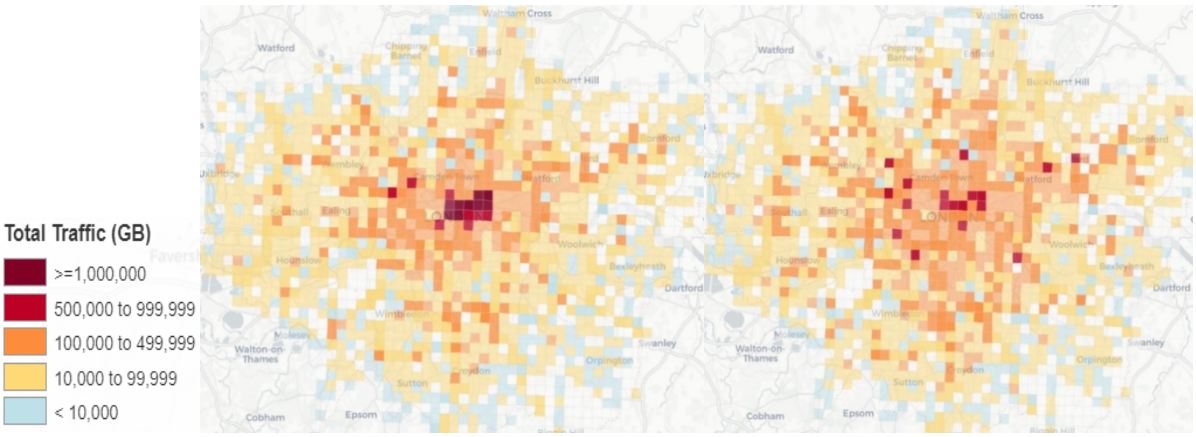


Source: Ofcom analysis of operator data

Mobile hotspots shifted from urban areas to suburban areas during lockdown

This change in people's daily lives also saw mobile traffic patterns (voice and data) shift from the city centres (urban areas) to more residential areas (suburbs) during the period, particularly as people began working from home. Figure 11 below shows the shift in all traffic from the city of London to more residential areas by comparing periods before and after the Covid-19 spring lockdown. On the left we show data from February 2020, before restrictions were introduced. On the right we show data reported to us for June 2020, when the heaviest restrictions had been lifted but the UK Government's social distancing measures, with associated changes in people's behavioural patterns, were on-going. This can be seen in the redistribution of mobile traffic from the centre of London, where traffic levels fell substantially, out across a more residential ring.

Figure 11: Variations in MNO data traffic distribution in London (February 2020 and June 2020)[62]



Similar trends were observed across other major cities.

MNO Base Stations were attacked due to false Covid-19 conspiracy theories

Over this year, a number of unsubstantiated claims have circulated, often through social media, alleging a link between new 5G services and Covid-19 (notwithstanding that 5G deployments are at a relatively early stage in the UK, and have not taken place in many of the countries impacted by the pandemic). Prior to this, there were also false claims that the Electromagnetic Field (EMF) emissions of 5G base stations posed an increased risk to people's health.[63]

MNOs reported attacks on 159 base stations associated with anti-5G or similar campaigns during this period. In several instances, the operators had restricted access to the affected base station during this period, resulting in around 170,000 cumulative hours of base station down time across all operators.

Earlier this year, Ofcom published our findings on EMF measurements we carried out around 22 locations near 5G mobile phone stations across 10 cities in the UK including Belfast, Cardiff, Edinburgh and London.[64] We found that in all cases that the measured EMF levels from 5G-enabled mobile phone base stations are small fractions of the levels identified in the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines, with the highest level recorded being approximately 1.5% of the relevant level. [65]

Our findings are also consistent with those of Public Health England (PHE) which states that overall exposure due to 5G is expected to remain low and within the guidelines (ICNIRP) and, as such, there should be no consequences for public health.[66]

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[62] This map is based on all traffic carried on all mobile networks. London has been divided up into 1km^2 tiles and traffic allocated to the tile in which the base station carrying traffic is located.
[63] Ofcom has published a statement setting out our plans to include a specific condition in Wireless Telegraphy Act licences requiring licensees to comply with the ICNIRP general public limits on EMF exposure. See
[64] Ofcom, Electromagnetic Field (EMF) measurements near 5G mobile phone base stations: Summary of results, 21 February 2020 (updated 17 April 2020)
[65] Guidelines for limiting EMF exposure that will provide protection against known adverse health effects are published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP is formally recognised by the World Health Organization (WHO).
[66]Public Health England, 5G technologies: radio waves and health, 3 October 2019

Progress with 5G continues despite the pandemic

Since the initial roll out of 5G networks last year, UK MNOs have continued to deploy 5G, largely on existing mobile infrastructure. The main focus of this activity has remained predominantly in urban areas where such deployments provide additional capacity in areas of high demand, although wider deployments have taken place. This is in line with our expectations, with current 5G deployments for consumers largely focusing on delivering mobile broadband, particularly in areas of existing high demand. The potential of 5G networks to deliver other benefits, particularly those depending on its ultra-low latency capabilities are increasingly being explored by businesses. For example, MNOs have been collaborating with various industries to monitor and maintain critical assets and accelerate the digital transformation of these industries.[67] [68] Over time we expect a range of models will contribute to meeting different types of demand from both consumers and businesses, with private networks playing an increasing role in providing mobile connectivity.

Take up remains a relatively small proportion of overall users, with about 800,000 active 5G devices across all mobile operator networks in the UK (as of early September 2020). This represents just over 1% of all active devices. As new services emerge, and more 5G handsets become available, take up is likely to increase across the UK.

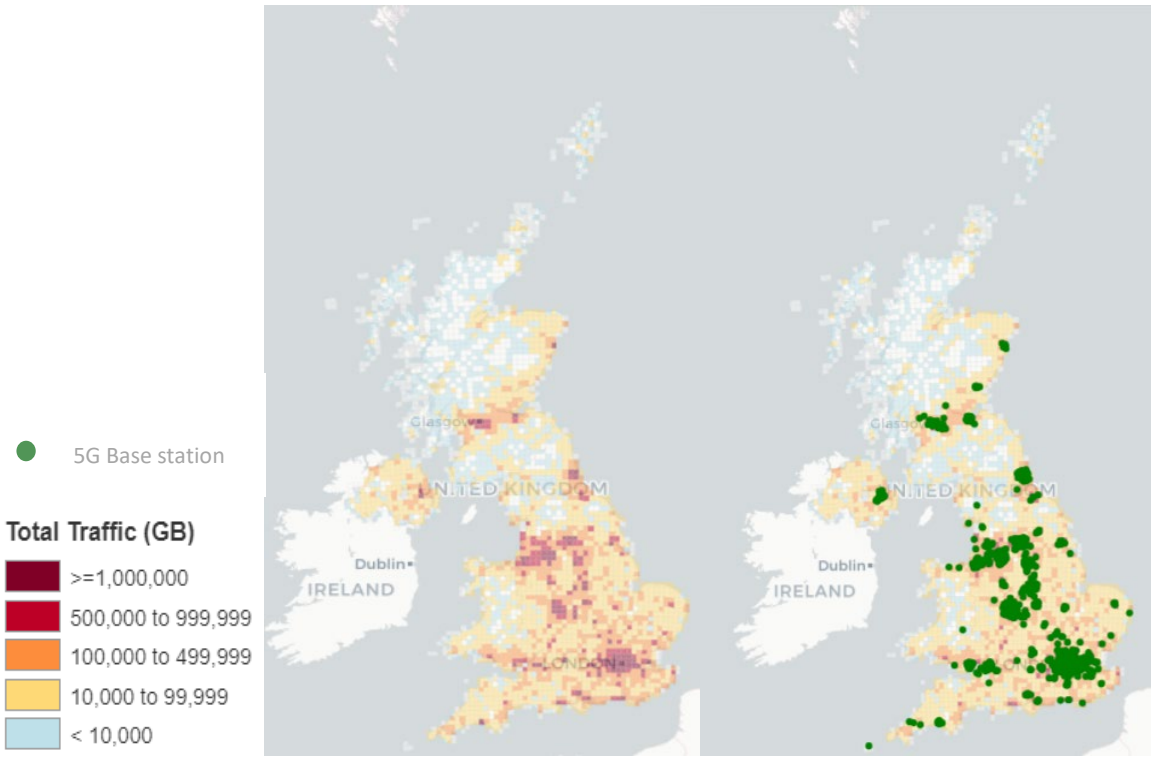
Across the UK, 5G is now carried on around 3,000 mobile base stations (around a ten-fold increase in base stations reported to us last year), with 87% of these base stations in England, 7% in Scotland and 3% in both Wales and Northern Ireland.[69] These deployments mean 5G is available on just over 8% of all urban mobile base stations, and around 1.5% of all suburban mobile base stations.[70]

We have found that the majority of current 5G deployments are in already busy areas and are providing capacity enhancements to other mobile generations i.e. 4G.

Approximately 50% of all 5G deployments have occurred within the 5,000 busiest sites (in terms of total traffic carried) across the existing UK mobile grid, emphasising that in many cases – but not exclusively – 5G is being deployed in high demand areas. In figure 12, we show how mobile traffic volume varies across the UK and is broadly followed by the pattern of 5G site deployment.

[67] Vodafone, Centrica Storage chooses Vodafone Business technology to build the gas processing plant of the future, 4 August 2020
[68] BT, Belfast Harbour and BT to build the UK and Ireland's first 5G Private Network for ports, 27 October 2020
[69] Note that for the purposes of this report, the reported tally of 5G base stations represents a tally of all individual MNO deployments, and should two MNOs have added 5G services on the same physical structure, we regard this as 2 sites.
[70] We note that the data indicating around 3,000 base stations carrying 5G is based on the most recent information available from MNOs in September 2020. More detailed analysis on the distribution across existing busy sites, and across rural and urban areas, comes from a slightly earlier, but more detailed dataset based on the situation as of June 2020.

Figure 12: illustration of base station monthly traffic volumes and base station with 5G deployed on them



As can be seen above, the early deployment of 5G on MNO networks is largely capacity-driven, although, like older cellular generations, we expect 5G will achieve wider availability over time. This could be enabled by the deployment of the 700MHz band over time (although we note that the 700 MHz band will not support as much capacity as the 3 GHz band), as well as the possibility of sharing and re-farming of spectrum currently used for 2G, 3G and 4G networks for 5G [71]. We note that 5G networks in the UK have been rolled-out in non-stand alone (NSA) mode and are therefore currently unable to provide services independently of other coverage layers, with voice services continuing to rely on Voice over LTE (VoLTE) or circuit switched fallback and 5G data services also requiring a 4G "anchor". [72]

While our findings show 5G rollout continuing, the UK Government has indicated it considers progress may be slowed by new requirements to limit fresh deployments made using High Risk Vendors. [73] [74] The UK Government has now published its diversification strategy, setting out its plan to build an open, innovative and diverse 5G supply chain, and Ofcom is engaging with this work to

[71] 700MHz, 3.6-3.8GHz spectrum auction will provide additional spectrum for the deployments of 5G
[72] In Non-Stand Alone (NSA) deployment, the radio interface is 5G, but the core network is based on 4G. In Stand Alone mode, both the radio interface and core networks are based on 5G and is completely independent of 4G networks. Operators have initially deployed 5G in NSA mode because standardization for NSA was completed first and it also allowed them to provide 5G using existing 4G core network infrastructure.
[73] High Risk Vendors are those who pose greater security and resilience risks to the UK telecoms networks, as set out in the UK Government Supply Chain Review
[74] Hansard, UK Telecommunications: Volume 678: debated on Tuesday 14 July 2020

ensure the regulatory landscape does not present any impediments to the arrival of new vendors, or the development of a new Open RAN eco-system.[75][76]

5G has started delivering benefits beyond capacity enhancements

We expect MNOs to leverage other benefits of 5G as they continue to rollout their networks and to provide connectivity solutions for both consumers and businesses. This includes private networks for businesses, which will facilitate greater control and privacy in addition to connectivity.

5G will continue to target a range of other applications (e.g. manufacturing, logistics, agriculture, automotive, energy, media & entertainment and healthcare sectors) to deliver benefits to consumers, businesses and organisations. 5G (3GPP Release 16 & 17) has features such as near instantaneous network response (a latency of only a few milliseconds) and high reliability which are key enablers for these applications (although instant response capabilities require a transition to standalone 5G deployments and to a 5G core, and moreover may require some core functionalities to be deployed at the edge to be fully realised).[77] As we noted in the fixed chapter of this document, we are also seeing some early offerings of Fixed Wireless Access based on 5G solutions.

5G and industry case study

- Businesses and enterprises across the UK are starting to explore the benefits of 5G through the deployment of non-public networks. These networks allow organisations to have total control over their operating process in addition to guaranteeing quality of services particularly through the dedication of resources. One such network in the UK is the Worcester Bosch factory.
- The network is helping Worcester Bosch drive productivity through preventive maintenance and robotics, both of which are dependent on the enhanced speed, reduced latency and high network availability of 5G. Typically, data collected from large numbers of sensors which monitor machine conditions, is sent across the 5G network and analysed in real-time, thereby reducing response time to potentially critical failures.

Earlier this year, the UK Government announced a multi-million pound investment in 5G testbeds and trials across the UK to explore potential benefits of 5G in improving the lives of people in rural areas and maximise the productivity of industries.[78] MNOs are collaborating with UK local councils, businesses and other stakeholders to deploy 5G under this initiative.[79, 80, 81] Independently, they are

[75]DCMS, Guidance: 5G Supply Chain Diversification Strategy, 30 November 2020
[76] Open RAN introduces an open standard for developing Radio Access Network technology, meaning that all suppliers could develop interoperable products and components. It enables operators to deploy equipment from multiple suppliers in the same configuration - utilising software and virtual solutions - allowing them to choose the best equipment suppliers for a particular component of the RAN to suit their particular deployment requirements or needs.
[77] The 3GPP is a global consortium of standards organisations which develop protocols for mobile telecommunications. The Releases describe evolution of mobile standards to support new features/
[78] DCMS, Press release: New £65 million package for 5G trials, 20 February 2020
[79] ISPreview, Government Hand £65m to New UK 5G Mobile Broadband Trials, 20 February 2020
[80]BT, BT Accelerates the Next Phase of UK's First Live 5G Private Network for Industry 4.0 and Smart Manufacturing 21 July 2020
[81] Vodafone UK News Centre, How Ford and Vodafone are creating the 5G 'factory of the future, 25 June 2020

also trialling 5G for the delivery of remote health, virtual reality (VR) based education and entertainment.

Availability of 2G, 3G and 4G mobile technologies and services

In this section we report on coverage both outside and inside premises, on geographic coverage and on coverage along roads.

In previous reports, we have also reported on coverage across the rail network. However, minimal improvements in 4G coverage (which we discuss in more detail below) on which it is dependent, has meant that rail coverage is currently relatively static. We continue to work with the sector and UK Government to address rail travellers' connectivity needs.

Merseyrail case study

The Liverpool City Region Combined Authority is leading on a multi-million-pound programme to introduce a new fleet of state-of-the-art trains for the Merseyrail network. As a key part of its fleet replacement project, it is introducing a dedicated Train Connectivity and Information System (TCIS) which will drive operational efficiencies, improve passenger safety and, as a by-product, provide high speed Wi-Fi connectivity for passengers. The TCIS will provide high-capacity connectivity to all trains throughout the network, including tunnels, using a 432-fibre cable to interconnect around 150 track side radio link units and on-board equipment with sets of antennas at each end of the train. The TCIS will provide high-quality, real-time CCTV, passenger information feeds, diagnostics and voice links between the trains and the control centre and allow passengers to use much of the normally spare capacity through in-carriage Wi-Fi. The solution will also allow British Transport Police (BTP) live remote CCTV access on board the train. The project is due to be completed in 2021.

Methodology

Below we report on the availability of voice services, via either 2G, 3G or 4G, and on the availability of 4G data connections.[82] The mobile coverage figures provided in this report are based on predictions which the MNOs supply to Ofcom, with Ofcom undertaking regular testing to ensure the predictions provided are suitable for national and regional reporting. We take the accuracy of the data supplied to us seriously and we continue to monitor, through drive testing, the accuracy of all operators' coverage predictions. We note that operators continue to update and improve their prediction models, and we welcome this. The data used in the report includes predictions provided to us by O2 using a newly developed coverage prediction model, which are still subject to Ofcom's validation process. In light of our own drive testing, we are continuing further discussions and work with O2.

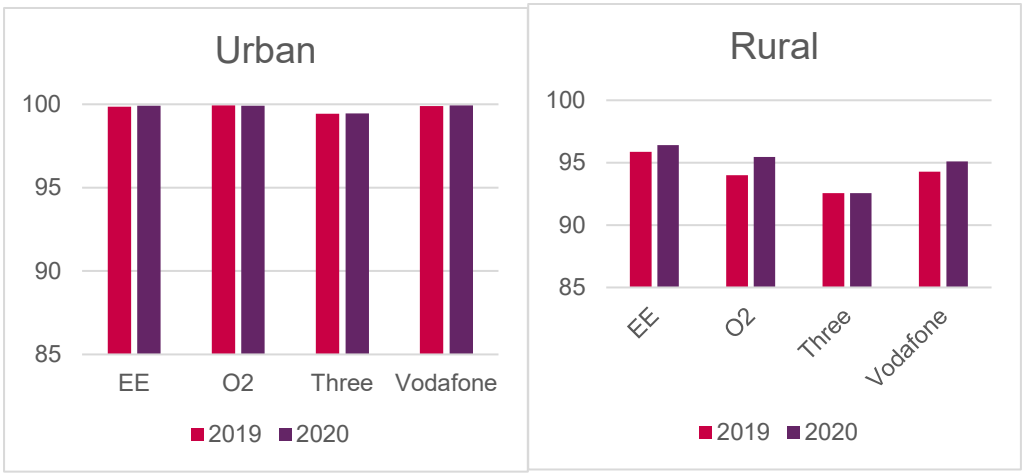
[82] Our definition of 4G coverage reflects a level of service that supports nearly all 90-second telephone calls being completed without interruption and data connections that should deliver a connection speed of at least 2 Mbit/s (fast enough to browse the internet and watch glitch-free mobile video) almost all the time.

Coverage outside premises

As with last year, over 99% of UK premises have coverage for mobile telephone calls from all operators while almost all UK premises have coverage from at least one MNO. Similarly, outdoor 4G data services from all MNOs remain available at 97.5% of UK premises and almost all UK premises have coverage from at least one MNO.

However, there are differences between coverage in urban and rural areas. Outdoor coverage for mobile telephone calls remains available at almost all urban premises, compared with 95% of rural premises. For 4G data services, coverage remains available from all operators outside 99% of premises in urban areas, compared with around 87% of rural premises. This is a small increase from last year, and our analysis indicates that this in part reflects increases in O2's predictions for rural coverage stemming largely from the new prediction tools it has adopted, and small increases across EE's and Vodafone's rural coverage footprints as well, as can be seen below in figure 13.

Figure 13: Outdoor premises coverage of 4G data services in the UK



Source: Ofcom analysis of operator data

Indoor coverage

The coverage people receive indoors will depend on a range of factors including: the thickness of walls, building materials used in construction and where in a building people are using their phone. In some premises there may be differences between our predicted indoor coverage data and the actual coverage available. Our online coverage checker provides additional information on the likelihood of there being indoor coverage in buildings at different locations, which takes into account some of the factors that can affect a mobile signal.

We estimate the availability of indoor mobile coverage for calls to have remained unchanged from last year. [83] While almost all premises have indoor coverage for calls from at least one operator, calls

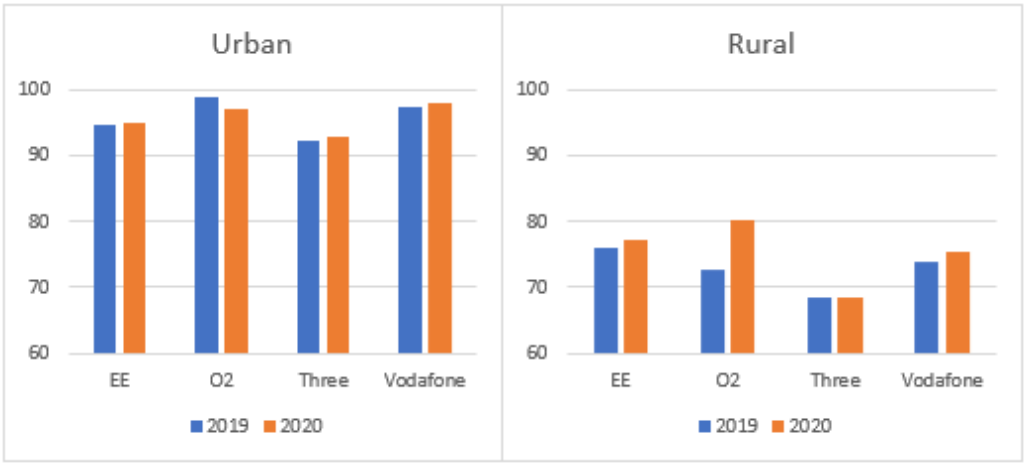
[83] We determine indoor coverage by applying an average building entry loss of 10dB across buildings. We acknowledge that this approach provides only a simplified view of what levels of indoor coverage might be, with the real experience in a building depending heavily on the types of building material and insulation in a given premises. Ofcom is engaging with mobile operators to determine if and how a more granular estimate can be developed.

from all operators are only available indoors across 93% of premises. Similarly, 99% of premises have indoor 4G coverage from at least one operator, while all operators are predicted to offer 4G data services indoors to 80% of UK premises.

Indoor voice coverage remains poor in many rural areas, and only 70% of rural premises have coverage from all operators. In comparison, indoor coverage in urban premises remains available at 97% of premises from all operators. While mobile call services are available from one or other of the providers in 99% of rural premises, there is a difference of about 16% in areas covered by individual operators.[84]

Coverage for 4G data connections are also lower in rural areas, with only 46% of rural premises predicted to have indoor 4G data coverage from all operators, compared with 86% in urban areas. However, when we look at the coverage from individual MNOs, which reflects the experience available to consumers with a service from a given operator, we can see the coverage levels are somewhat higher, with urban coverage ranging between almost 93% and almost 98%, and rural coverage ranging between 68% and 80% of premises indoors.

Figure 14: Indoor premises coverage of 4G data services in the UK



We note that on the basis of the individual MNO coverage shown in figure 14 above, 4G coverage is predicted to be available indoors from at least one operator in almost all urban premises and in 95% of rural premises.

MNOs provide a number of alternative options to improve the indoor mobile coverage experience. All the MNOs in the UK make Wi-Fi calling services (the ability to make and receive a call over a Wi-Fi network) available to consumers, and although not all mobile phones support this feature, the percentage of calls made using voice over Wi-Fi by MNOs has increased to between 2% and 18% per MNO (up from 0.2% to 12% last year).[85] Other examples of available tools include broadband-based calls on services such as Skype/WhatsApp, and femtocells. In 2018 Ofcom also introduced

[84] Reductions in indoor coverage can be the result of re-use of 3G spectrum for 4G services (when accounting for the different thresholds applied) and the in-building penetration losses that apply to signals at these frequencies.

[85] There are two types of Wi-Fi calling solutions: "cellular preferred", where the devices use Wi-Fi calling only if there is poor cellular coverage, and "Wi-Fi preferred" where all the calls are made via Wi-Fi, when Wi-Fi is available. All UK MNOs use the Cellular-preferred solution.

regulations that allow the licence exempt use of certain types of mobile repeaters, which can amplify the signal received outside a building and thus improve consumer experience indoors (devices not meeting these specifications remain unlawful). [86, 87]

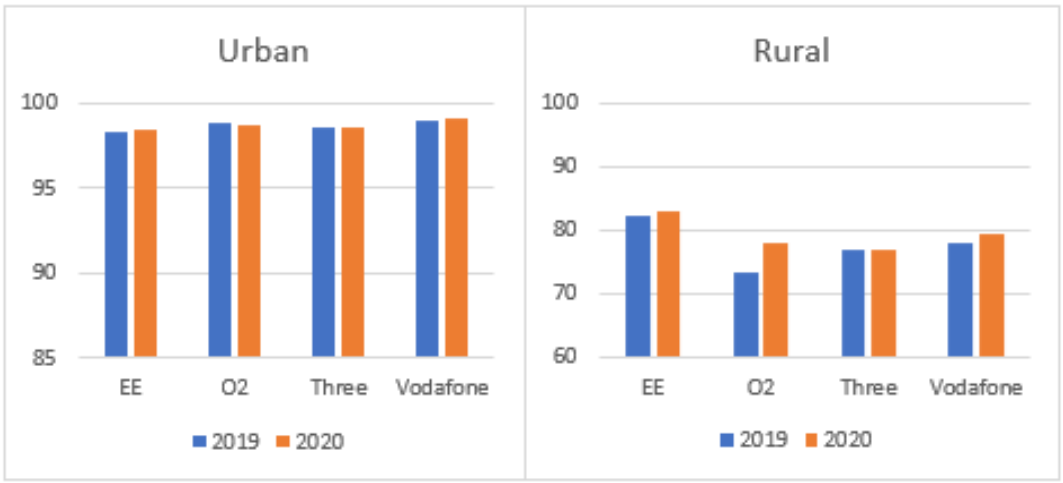
Geographic Coverage

We noted in last year's Connected Nations report that the growth in 4G geographic coverage had begun to plateau, with small increases in individual operator coverage, but no substantial changes overall. This remains the trend for this year, with differences remaining between the coverage offered by individual operators, and with good consumer experience limited by the presence of enduring 'partial not spots' (i.e. areas not covered by all operators), predominantly in rural areas. The announcement of the Shared Rural Network in March 2020 should see around £1billion of combined public and private funds invested in addressing these problems and improving rural coverage for the UK. However, there has only been limited coverage gains over the course of this year, as the SRN completes detailed planning work before shifting focus to delivery.

There are significant differences between the MNOs. BT EE increased its 4G geographic coverage by around 1% to about 85% of the UK, the most of any MNO, while the operator with the lowest coverage predictions (Three) provides coverage in around 79% of the UK's geographic landmass.

These differences are less significant in urban areas , with all operator coverage here in the 98-99% range nationally, whereas rural landmass coverage ranges from around 77% to almost 83%.

Figure 15: Outdoor area coverage of 4G data services in the UK



We note that the increase observable in rural coverage predicted by O2 may be largely attributable to the new prediction model they have adopted, as opposed to significant new network build.

As a result of these MNO footprints, 4G coverage from at least one operator remains at 91% of the UK landmass and consequently 9% of the UK landmass continues not to have good outdoor 4G coverage from any operator. The availability of 4G data services from all four MNOs is reported as having increased to 69% of the UK's geographic area, although our initial analysis indicates that the

[86] Mobile phone repeaters – what you need to know, 12 April 2018.

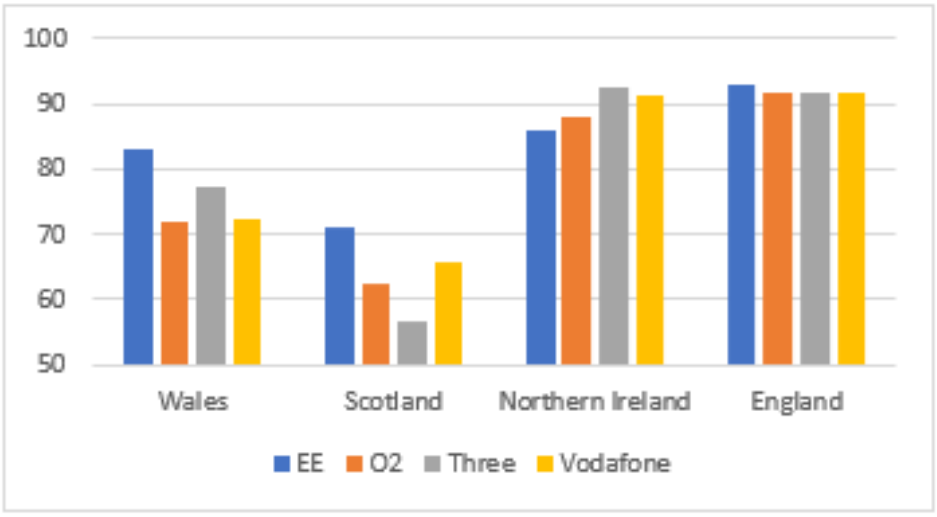
aforementioned changes in prediction tools, rather than new site deployments, may be a significant contribution to this change.

Differences across the nations

In line with the broadly static nature of coverage expansion before SRN deployment begins in earnest, there remain significant differences across the nations. 4G data coverage remains as a whole lower in Northern Ireland, Scotland and Wales than it is in England, varying considerably among mobile operators and remaining poor in many places. Today only 60% of Wales and 44% of Scotland can receive 4G data services from all MNOs. In comparison, these services are available from all MNOs in 79% of geographic areas in Northern Ireland and 84% in England.

Whilst the trend for differences in coverage between the nations is also reflected in the coverage provided by individual MNOs, the coverage levels from operators tend to be higher and reflect the actual coverage available to a consumer on a given network in each nation. We also note that some areas without coverage are very remote - for example, 20% of Scotland is considered 'wild' by Scottish National Heritage.[88]

Figure 16: Differences in 4G data geographic coverage in Wales, Scotland, Northern Ireland and England



Source: Ofcom analysis of operator data

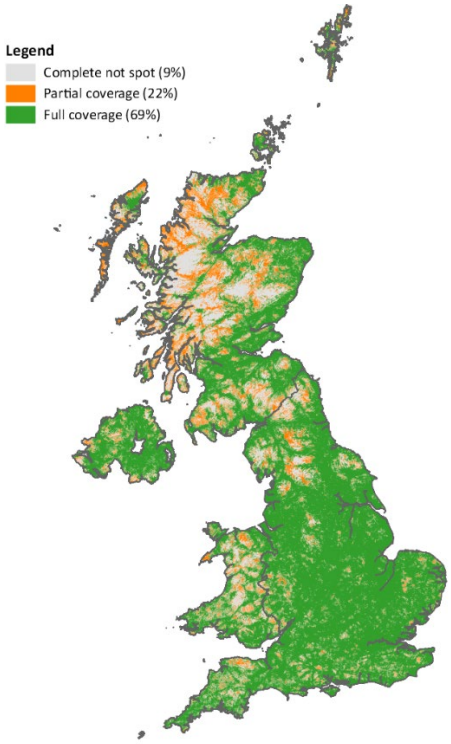
The Shared Rural Network (SRN) and other public policy interventions.

Ofcom is committed to reporting on progress made by the operators towards the legally binding commitments entered into their licences as part of the SRN. Under the agreement, each MNO is committed to reaching 88% coverage of UK landmass by 2024, and 90% of landmass within 6 years from 2020 (subject to certain conditions), with an expectation that this will see the 'at least one operator' footprint (i.e. the area where there is mobile coverage available, but not always from the same MNO) reach 95% of UK landmass by 2025.

[88] Scottish Natural Heritage (now NatureScot), Scottish Natural Heritage's Advice to Government, 16 June 2014

As noted above, MNOs have now moved into the detailed planning phase. In November, Ofcom wrote to the MNOs to confirm that in our view, the updated plans they have developed would, if delivered, meet the licence commitments.[89] As of today, only one operator (Vodafone in the villages of Longnor and Devauden in the Wye Valley) has informed us it has added 4G coverage through the programme.[90] An important focus for the SRN is the provision of new coverage in partial not spots, as part of the initial commitment for each MNO to reach 88% coverage by 2024. The potential impact of this can be seen from the current location of partial not spots in the UK today, as seen in figure 17 below.

Figure 17: full coverage, partial coverage and complete not spots in the UK



We expect to report on more significant progress as the programme moves into the delivery phase in the year ahead. We note that as well as the SRN, other public policy interventions continue to support the rollout of growth in rural mobile coverage. In particular, the Scottish Government's 4G Infill programme has begun to deliver, with more than 30 base stations in the build or pre-build stage, and one base station already live. These base stations, which will provide consumers with coverage in what were previously not spot areas, will complement the work of the SRN to improve mobile coverage in Scotland. Meanwhile, we note that other local authorities continue to plan and consider complementary interventions across the UK.

[89] DCMS, Press release: Shared Rural Network, 9 March 2020
[90] See stories on Shared Rural Network news page

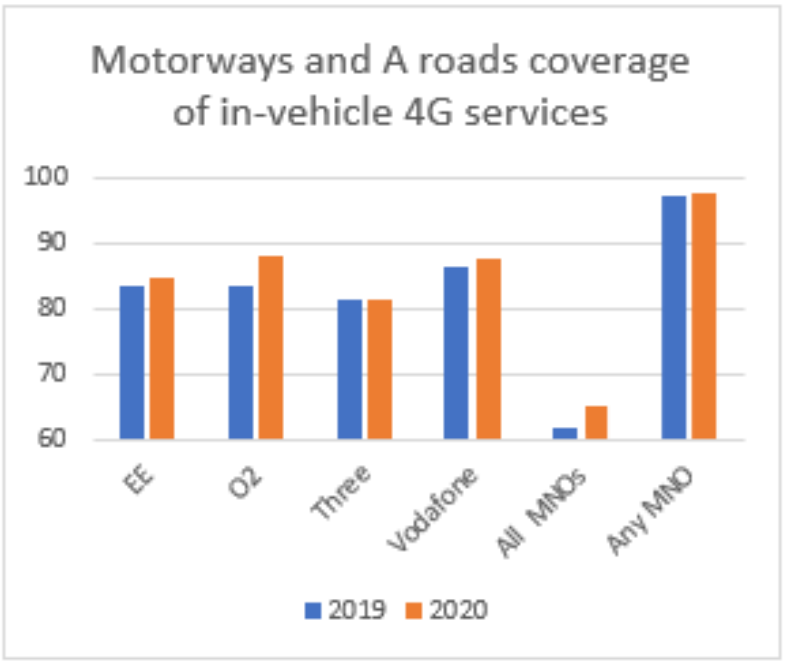
Coverage on roads

The need for connectivity to be available on all roads remains important to serve requirements such as vehicle communications, personal navigation, and infotainment. Over the past year, there has been very minimal improvement in mobile coverage from all operators on UK motorways and roads.

In-vehicle mobile voice services from all operators increased by at most 1 percentage point on UK motorways and A roads.[91] Today, mobile call services are available on 82% of UK motorways and A roads and on 69% of B roads. In 2017, Ofcom introduced regulations to enable the use of certain mobile repeaters on a licence exempt basis, which could help improve in vehicle reception to levels similar to those enjoyed outdoors.[92] Mobile voice services outside of vehicles is available on 96% of motorways and A roads and on 90% of B roads.

Within vehicles, 4G data coverage from all operators is available on 65% of motorways and A roads and 50% of B roads. Outside vehicles, 4G data services are available on 89% of motorways and A roads and 82% of B roads from all operators.

Figure 18: Motorways and A roads coverage of in-vehicle 4G services



Emergency calls

Mobile phones can use signals from other mobile networks to make emergency calls. As the mobile networks have slightly different coverage footprints, and voice calls can be carried over legacy 2G and 3G networks as well as 4G (via VoLTE), this means that 95% of the UK geographic area and almost all indoors premises are covered for mobile emergency calls. As we explain in the fixed and security and resilience chapters, traditional landline services are being retired and in future all fixed voice services will need to be delivered over broadband connections instead. Since this requires

[91] Note that we apply a 10 dB attenuation threshold to derive the availability of in vehicle coverage
[92] Ofcom, Mobile phone repeaters – what you need to know, 12 April 2018

power to the broadband router, indoor mobile coverage enabling emergency calls in a power cut may become increasingly important.

Within vehicles, mobile call coverage for emergency calls is available on 99% of motorways and A roads and 96% of B roads. Outside of vehicles, emergency mobile call services are available on almost all motorways and A roads and 99% of B roads.

Coverage for emergency mobile calls has not changed from last year.

2G/3G Switch off

Although MNOs have not publicly indicated firm timelines to switch-off their 2G or 3G networks, it is expected that factors such as operating costs and less efficient utilisation of spectrum for data services compared with newer generation technologies such as 4G and 5G may result in the eventual switch off of these networks.

Switching off these networks would impact a number of applications such as availability of mobile telephone calls, which rely either on these legacy services, or require Voice over Internet Protocol to be both available and supported by consumer devices. We note in particular that coverage for emergency voice calls, which today is primarily delivered over 2G and 3G, as well as other applications such as smart meters and e-call services, could be impacted without careful implementation.

Given that 4G is now at a level of maturity where it can outstrip the data carrying capability of 3G in most places, but that there remain a significant number of devices relying on earlier generation technology, we expect that typically 3G networks will be switched-off ahead of 2G networks.

It is important that as MNOs start to switch off these networks, adequate mitigation is in place to minimise the impact on consumers.[93]

Premises that do not have a decent fixed or 4G mobile network connection

As with last year, this report continues to examine those premises unable to get a decent fixed or 4G mobile broadband service. Premises are considered to have access to a decent fixed connection if the broadband speed is above a download speed of at least 10 Mbit/s and an upload speed of at least 1 Mbit/s and to have access to an indoor 4G mobile service if a connection speed of at least 2 Mbit/s is available.

We estimate that 98% of premises can receive both decent fixed and 4G mobile broadband services, while about 43,000 (0.1% of UK premises) are unable to access either.[94] As with last year, more premises currently have indoor 4G coverage from at least one operator than a decent fixed broadband service.

[93] Ofcom is committed to working with MNOs to minimise the impact of any 2G and 3G switch off plans on consumers.

[94] This includes premises that are unable to receive services from other providers such as Wireless Internet Providers (WISPs)

As with last year, rural areas in Scotland (particularly in the Scottish Highlands and Islands) and Wales have the highest percentage of properties that have neither decent fixed nor indoor 4G mobile services. These figures stand at 2% and 3% respectively.

Investment in mobile networks

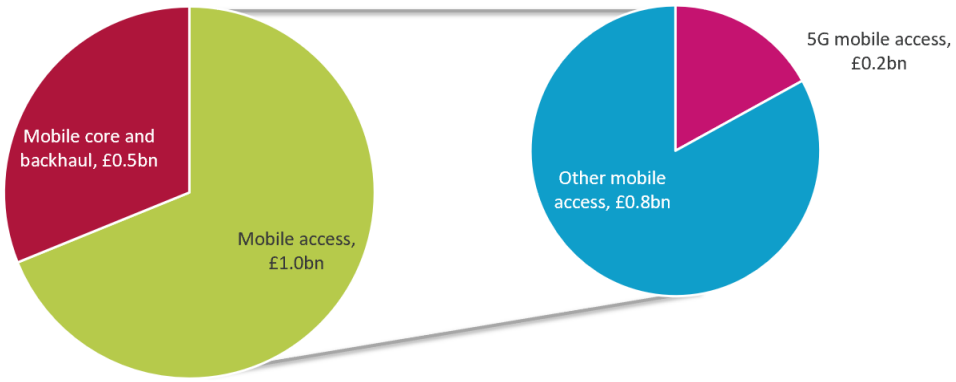
Around £1.5bn was invested in mobile network infrastructure in 2019

Ofcom data collected from providers shows that £1.5bn was invested in UK mobile network infrastructure in 2019, with an additional £0.7bn having been invested in infrastructure which is used to provide both fixed and mobile telecoms services.

Of the total mobile investment, around two thirds (£1.0bn) was investment in mobile access network infrastructure (including site acquisition, equipment and electronics), with the remaining £0.5bn spent on mobile core and backhaul networks. All four mobile network operators (MNOs) in the UK launched 5G services in 2019, when investment in 5G access networks totalled around £175m. We expect this figure will increase in 2020 as 5G rollout has gained momentum.

Further information on how these figures were compiled can be found in the fixed chapter, in footnote 45.

Figure 19: Mobile telecoms network capital expenditure: 2019



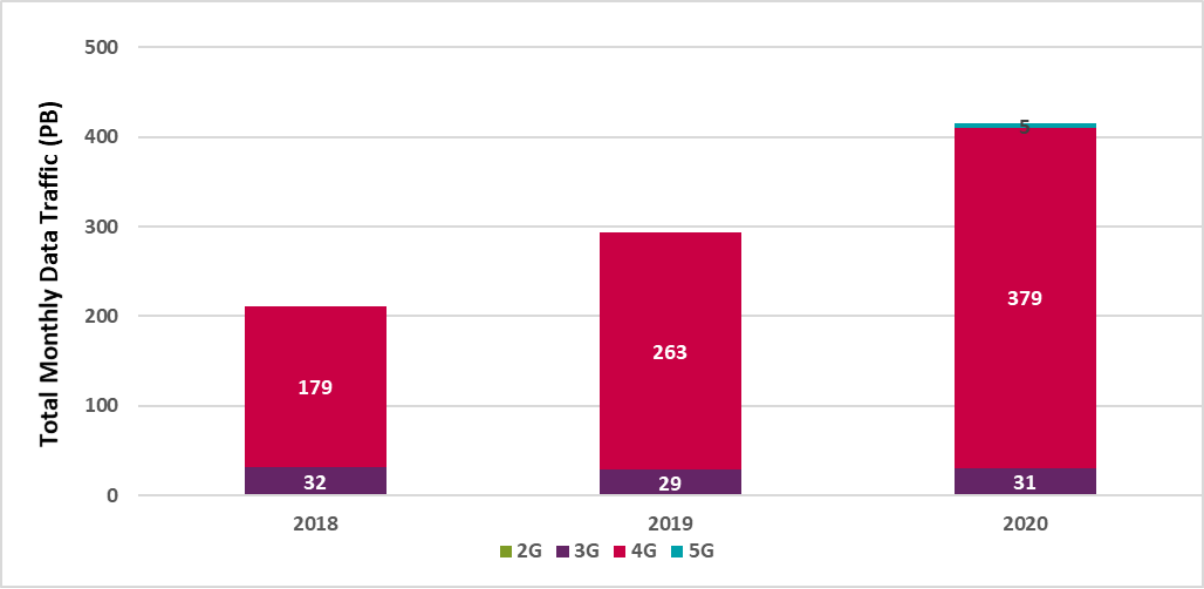
Source: Ofcom / operator data

Mobile network performance and capacity

Traffic continues to grow considerably, with 4G dominating

Mobile data traffic continues to grow significantly year-on-year. This year, our sample of monthly data consumption increased by 42% compared with last year, representing an increase of 8 percentage points in the year on year growth rate. Although operators now carry some data traffic on 5G (1% of the total mobile data traffic in 2020), 4G still carries the majority of overall data traffic. Traffic carried on 3G and 2G continues to fall in comparison with 4G, which now carries 91% of all traffic (up 1% on last year).

Figure 20: Mobile data traffic (PB) by technology (monthly consumption)[95]

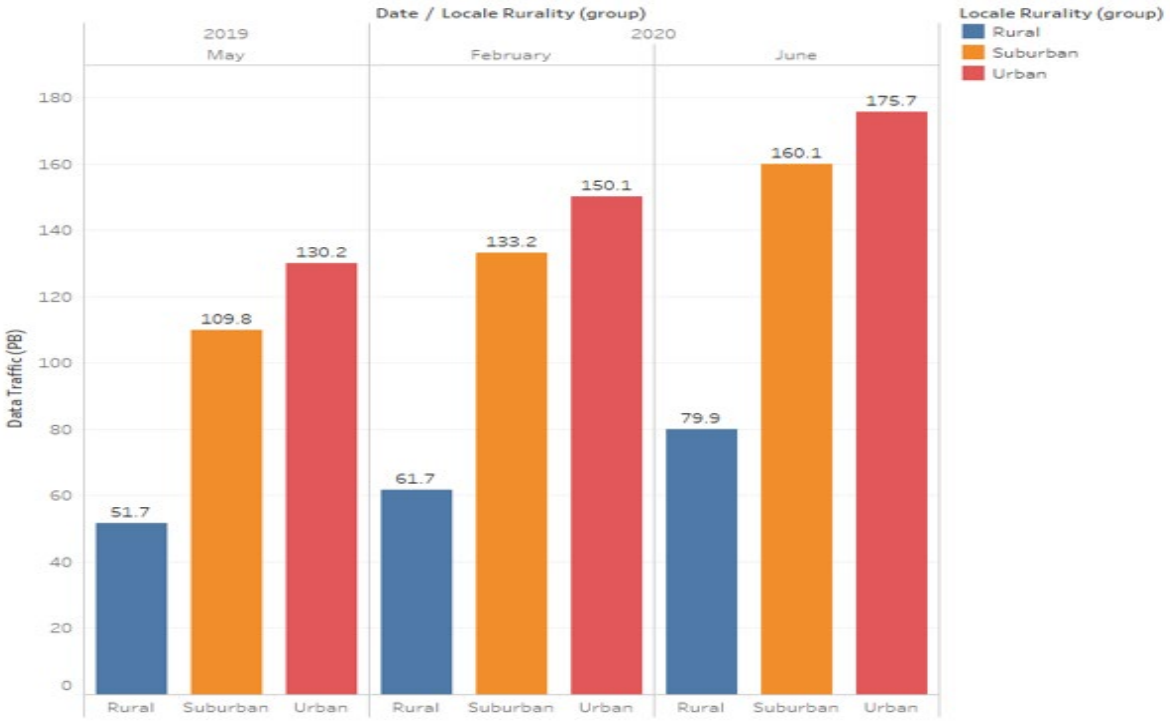


Source: Ofcom analysis of operator data

The vast majority of mobile data traffic (81%) is generated in urban and suburban areas, and data growth in these areas is continuing rapidly, up 40% compared with last year. We note that the difference to rural traffic consumption broadly reflects population distribution, rather than suggesting any fundamental differences in behaviour between customers based in urban and rural areas.

[95] This year's analysis is based on data collected for the month of June, with last year's sample collected in the month of May. Note that 1 Petabyte is equivalent to 1,000,000 Gigabytes

Figure 21: Evolution in Mobile Traffic by Rurality[96]

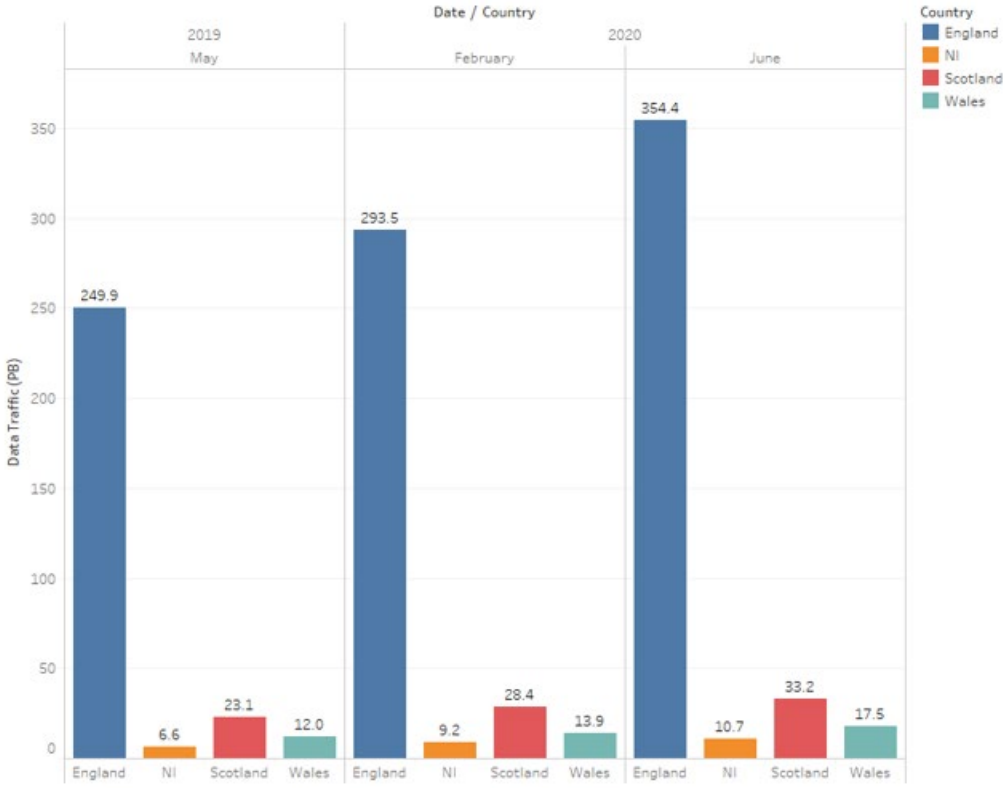


Rural mobile data consumption has also continued to grow year-on-year, increasing by 55% this year. However, this growth is from a relatively low base and represents only 19% of the total data traffic.

The essential link between population and traffic is also reflected in how traffic is distributed across the UK nations. The continuing growth in data consumption which is pushing ongoing spectrum requirements can be seen by the fact that the traffic carried in England in June of this year exceeds that which was carried across the UK as a whole in February.

[96] We note that traffic volumes were not supplied for the 3G layer of one MNO for 2020, and this may have some impact on year on year trend analysis.

Figure 22: Traffic distribution across the UK nations



We note that the preponderance of UK traffic carried by mobile base stations in different UK nations is broadly reflected in deployment trends for 5G base stations in each nation.

Internet of Things (IoT)

The Internet of Things (IoT) refers to a network of devices and sensors which provide actionable insight from data they collect and share between themselves or with humans. IoT has applications across a wide range of sectors such as healthcare, utilities, manufacturing, consumer electronics, and smart cities among others.

As with last year, we continue to provide qualitative and quantitative insights into public and private wide-area IoT networks in the UK. [97]

Low-power wide area networks (LPWANs)

- **Sigfox** is a proprietary technology that uses licence-exempt spectrum and offers good coverage with very low transmission power.
- **LoRaWAN**, developed by the non-profit LoRa Alliance, is an open source technology also using licence-exempt spectrum. It provides good coverage with very low transmission power and allows the building of an end-to-end private solution.

[97] We have found that mobile network operators generally do not differentiate between machine to machine (M2M) and IoT from a connectivity perspective and therefore we have included M2M data in our IoT analysis.

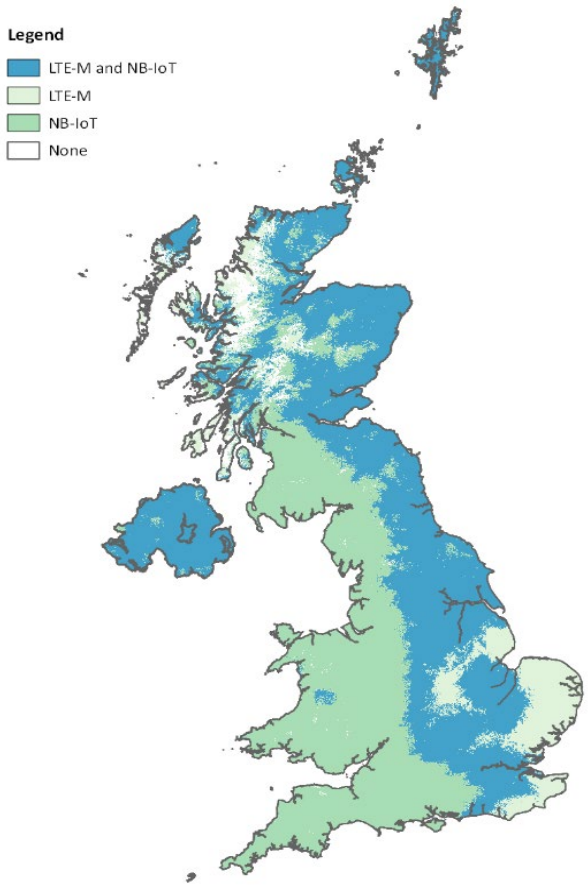
- **Narrowband IoT (NB IoT)** is a wide-area solution that supports massive deployment of IoT devices and is also optimised for a very long battery life. NB-IoT networks can be deployed in mobile bands and integrated on existing mobile base stations.
- **Long Term Evolution for Machines (LTE-M),** is a complementary technology to NB-IoT with the added capability of supporting IoT applications with higher data rates and lower latency requirements. It can also be deployed in mobile bands and integrated on existing mobile base stations.
- **NB-IoT** and **LTE-M** have been standardised by 3GPP and they are now part of the 4G standard. 3GPP is further evolving these technologies as a part of 5G. LPWAN technologies are designed for IoT applications and services that have low data rates, require long battery lives and can operate in remote and hard to reach locations

IoT Connectivity available from Mobile Network Operators

IoT connectivity is available from UK MNOs through a mix of cellular and Low Power Wide-Area-Network (LPWAN) technologies. Commercial IoT connectivity is available from all four UK MNOs through 2G, 3G, and 4G cellular technologies. Within the past year, Vodafone has increased the coverage of its NB-IoT network extending coverage to eastern parts of the UK. Whilst O2 has also deployed LTE-M at various locations across the UK, it is yet to offer commercial services using this technology. Three and EE continue to explore proof-of-concept deployments using NB-IoT, LTE-M and 5G.

This year, the number of active IoT connections on MNO networks increased by 30% to 6.3 million. However, at 810TB, the overall volume of IoT data traffic across all UK MNOs remains less than 1% of their overall data traffic. We note that this represents a snapshot of all IoT traffic, much of which is carried over Wi-Fi in indoor settings. We expect IoT data traffic to increase significantly with the availability of LTE-M and 5G both of which are capable of supporting higher bandwidth applications, such as video surveillance, compared with other IoT technologies.

Figure 23: Map of the UK showing LTE-M and NB-IoT Coverage



Source: Vodafone and O2

IoT Connectivity available from non-mobile network operators[98]

Sigfox

Within the past year, WND UK, the sole Sigfox network operator in the UK increased the number of its base stations from 1,900 to about 2,000. These improvements have focused on the provision of coverage overlays and densification of its urban footprints as well as deploying indoor solutions at locations not covered by the public network.

The network supports very low bandwidth applications with infrequent transmissions such as device telemetry, metering, asset tracking, gas and water leak detection.

LoRaWAN

In the UK, LoRaWAN connectivity is provided through public community and private deployments. The public community networks, which are open-source and free to use, allow users to connect devices to existing gateways (base station) or add new gateways to increase overall coverage. [99, 100]

[98] IoT can be delivered via other tech such as Wi-Fi, Zigbee, Bluetooth and several others. In this report, we focus only on LPWAN technologies.

[99] They are usually bound by fair use policies which restrict data rates, packet sizes, transmit time, number of gateways/devices, etc

[100] The network servers are hosted by not for profit institutions like the Digital Catapult (UK) or companies which also offer private networks.

These networks are collaborative and driven by the user community. The private networks offer managed carrier-grade services with guaranteed availability, on a paid basis.

Public LoRaWANs

Providers of public LoRaWANs allow users to connect freely (public 'open') or at minimal charges (public 'closed') thereby supporting developers, small/medium businesses and enterprises (particularly for Proof-of-Concept), government and public initiatives across the UK local authorities. Today, The Things Network (TTN), one of the leading (global) providers of public LoRaWANs has about 900 gateways in the UK (50% increase from last year) serving about 100 communities i.e. cities, counties or groups of hobbyists with deployments in close proximity.[101]

Private LoRaWANs

We are aware of several private LoRaWAN providers operating in the UK, such as Comms365, Connexion, The Things Industries (TTI), Boston Networks and Pinacl Solutions Limited[102]. We estimate that these networks have at least 350 gateways between them serving about 25,000 devices. Some of the services provided by these networks include intelligent lighting and property management, waste management solutions, flood and air quality monitoring.

[101] The Things Network

[102] Boston Networks and Pinacl Solutions Limited have now merged (and other businesses) to form North

Figure 24: Indicative map of locations in the UK where carrier-grade LoRaWAN Services are available [103]

IoT has played an important role during Covid-19

- IoT solutions have played significant roles in helping governments, businesses and the wider society meet the challenges of the Covid-19 pandemic. Several applications emerged which have helped minimise the spread of the disease such as: the NHS Covid-19 tracing app; drones for the delivery of medical supplies to remote locations; ensuring business continuity through the use of sensors for detecting desk/station occupancy, safe distancing and temperature detection; and in maintaining public safety through the use of drones for monitoring lockdown compliance.

[103] We note that LoRaWAN operates in an unlicensed spectrum band and there are several deployments which may not have been captured in the map. The locations shown represent providers who have provided us with this information. We will continue to collect data to populate this map.

Security and Networks

Key highlights:

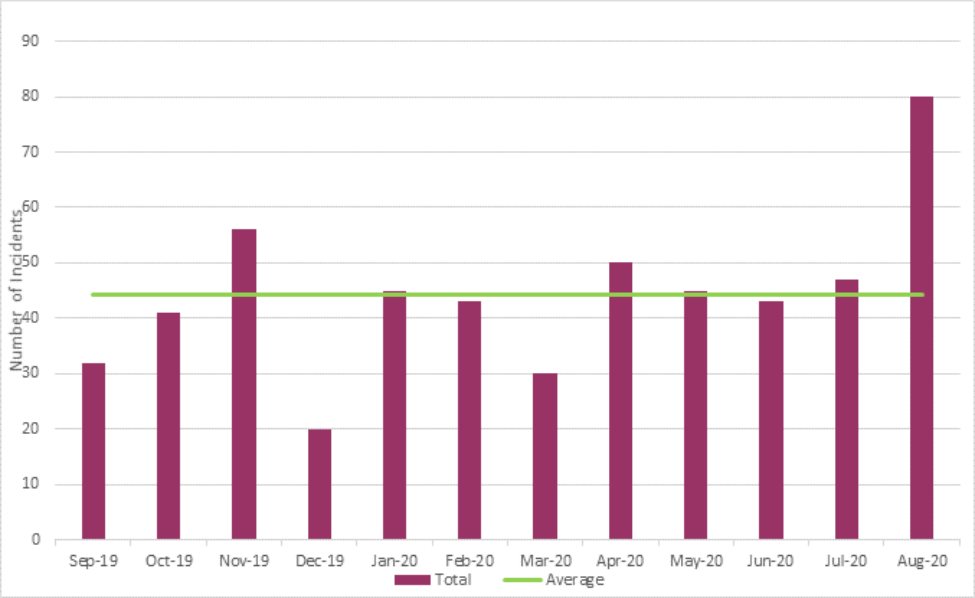
- The security incidents reported to Ofcom this year do not suggest that the Covid-19 pandemic has resulted in a noticeable increase in telecoms outages, despite the increased demands on the networks. One major incident affecting mobile phone users at the start of the first national lockdown does not appear to have reoccurred, but has led to some important lessons for the future.
- The work we started last year with telecoms providers to better understand the most common causes of major outages has identified several themes, and work to tackle these causes is ongoing.
- Ofcom has been working closely with DCMS and the National Cyber Security Centre (NCSC) in preparation for the introduction of the *Telecommunications (Security) Bill*, which will bring major changes to our existing regulatory regime.

Although slightly up on last year, the overall number of reported incidents is within the typical annual range

As in previous years, we have continued to receive reports from telecoms providers about any security incidents with a significant impact on their networks and services. We publish guidance for providers, explaining the types and sizes of incident we expect them to report to us in order to comply with their regulatory obligations.[104] We have received reports of a total of 532 relevant incidents this year. While this is a notable increase over the 410 incidents we reported in 2019, it is still within the usual year-on-year variability so does not raise any particular concerns. For example, we reported over 700 incidents in 2018. The number of incidents related to fixed networks is very similar to last year (283 in 2020 compared with 284 in 2019), which means that the increase in incidents reported to us resulted from mobile network incidents (249 in 2020 compared with 126 in 2019). As we have discussed in previous years, ensuring consistent reporting across mobile operators has been an ongoing challenge, and the increase we have reported in 2020 may to an extent be a reflection of progress in ensuring that more of the incidents occurring on mobile networks are properly reported to Ofcom.

[104] Ofcom, Ofcom guidance on security requirements in sections 105A to D of the Communications Act 2003, 18 December 2017

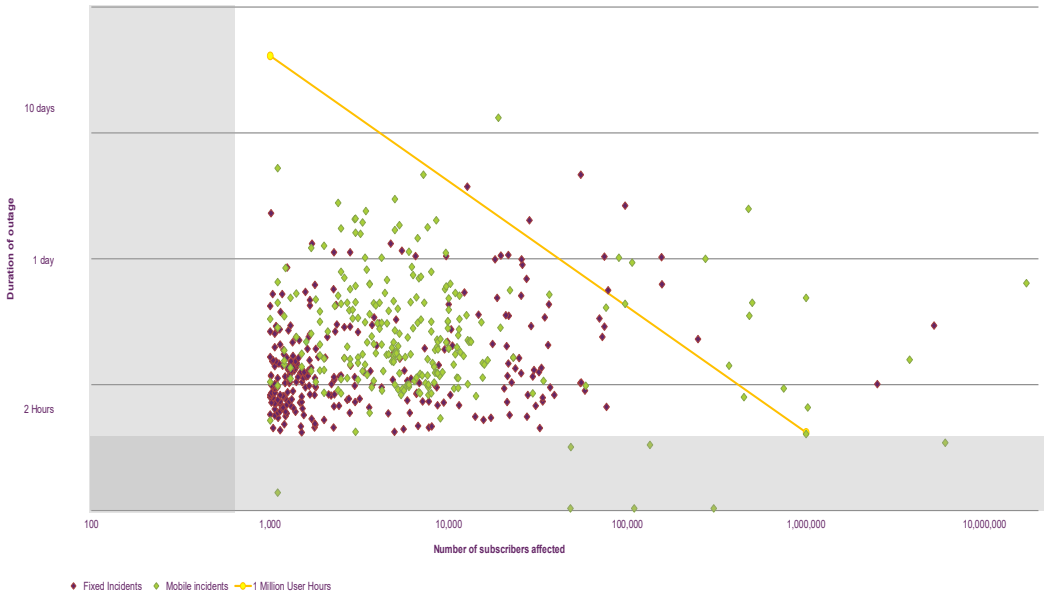
Figure 25: Monthly number of incidents reported between September 2019 and August 2020



Source: Ofcom analysis of operator reported data

The monthly breakdown of incidents in Figure 25 shows a degree of month-on-month variability which is somewhat higher than we have seen in recent years. As is usually the case, there are no obvious seasonal patterns. The average rate of incidents during the period of the Covid-19 pandemic is greater than it was for the period immediately before it. However, given the variability we see every year, the trend is not strong enough to suggest that the Covid-19 pandemic might have been the cause.

Figure 26: The impact of incidents reported between September 2019 and August 2020

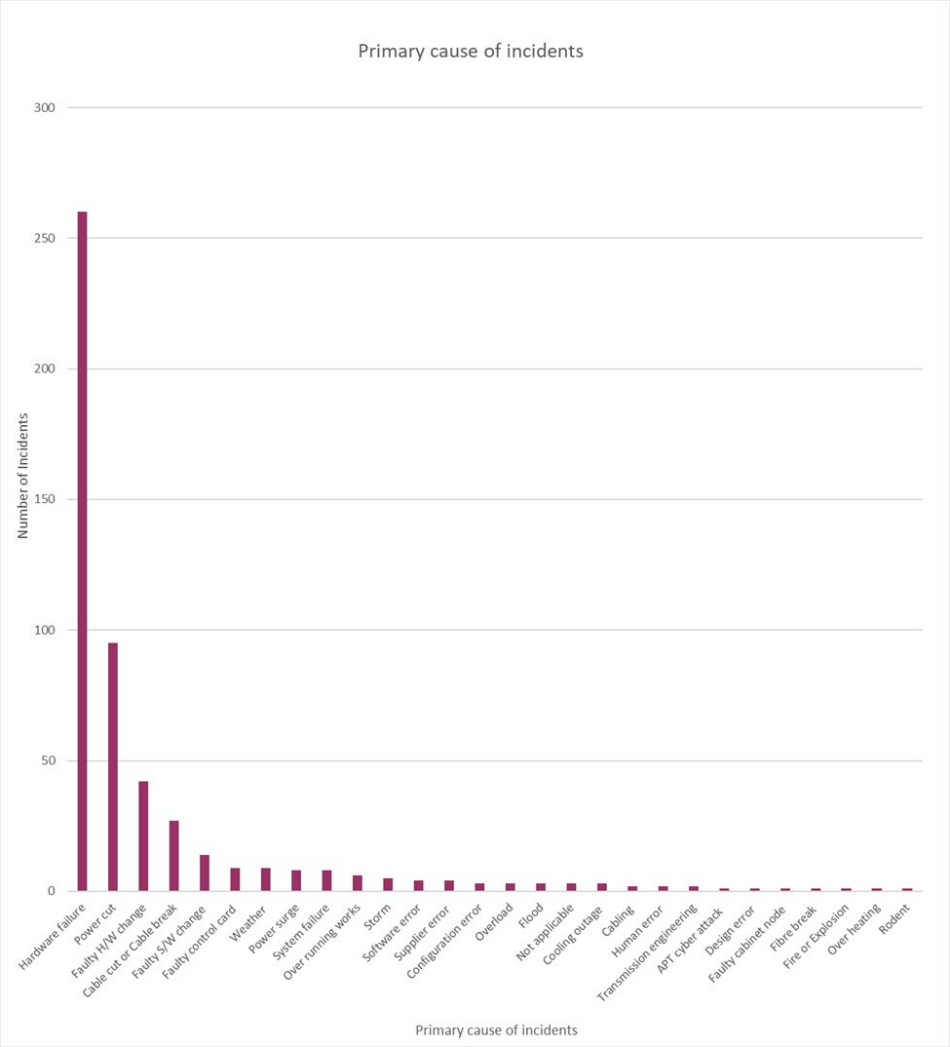


Source: Ofcom analysis of operator reported data

During this reporting period, we have changed the root cause categories we use to classify the primary cause of each incident based on the information in the providers' reports. This year we have assigned each incident to one of 28 possible root cause categories, whereas in previous years we have used only 12. This more granular approach allows us to better understand the common factors behind incidents. It also better aligns with the categories used by the European Network and Information Security Agency (ENISA) in its annual report on EU-wide trends.[105]

The most common causes of hardware failures and power cuts continue to dominate, as they have in previous years. One example of a new category - faulty hardware change - contains incidents which would have previously been most likely to appear in the broader hardware failures category. As such, the new categories now provide more insight into incidents caused by changes to hardware that a provider has made but have gone wrong, by separating them from the random in-life hardware failures that made up most of the original category.

Figure 27: Primary cause of incidents reported to Ofcom, September 2019 and August 2020



[105] ENISA, Telecoms Services Security Incidents 2019 Annual Analysis Report, 23 July 2020

Source: Ofcom analysis of operator reported data [106]

The geographic distribution of incidents is broadly in line with population density, with the heat map of incidents across the UK showing a similar pattern to previous years. There is no obvious evidence of a disproportionate number of incidents in rural areas.

Figure 28: Heat map showing the distribution of reported incidents throughout the UK

Source: Ofcom analysis of operator reported data

Networks have generally coped well with the increased demand placed on them during the Covid-19 pandemic, with limited evidence of additional outages

Our use of telecoms services has changed substantially due to the Covid-19 pandemic, and this has placed a considerable strain on many aspects of the networks. However, from the reports submitted to us, this has only caused one notable service outage. This incident affected customers on O2's mobile network in March 2020, just before the first national lockdown was announced and as many people started working from home. We have been working with the mobile network operators affected by the incident in order to fully understand the technical reasons for the incident and ensure the lessons learnt are incorporated into industry best practice. The following is a summary of the incident and the follow-up actions:

- there was a significant increase in mobile voice traffic in the run up to the first set of UK Government restrictions, with growth in both call volume and duration;

[106] H/W – Hardware, S/W – Software, APT – Advanced Persistent Threat

- this created a temporary congestion condition within the IP-based infrastructure used to interconnect traffic between a subset of mobile operators;
- this congestion was resolved by increasing the capacity of this infrastructure progressively over the following days;
- based on the technical findings, we are working with a number of operators to evaluate technical standards detailing how interconnect in IP networks should operate in such situations. We are considering both the applicability of existing standards and whether there is a need for an update or addition; and
- we are also considering the promotion of operational profiles for IP network interconnect and improved resilience to overload conditions.

Our work to better understand the common causes of network incidents has highlighted several resilience themes

To progress the UK Government's objective of an increased focus on the resilience of networks and services previously identified in the Supply Chain Review, we introduced in January 2020 an enhanced approach to information collection and analysis of service-affecting incidents. [107] We have worked with the telecom operator members of the Electronic Communications Resilience and Response Group (EC-RRG), who have provided the incident data. [108]

The purpose of this new approach is to increase the level of detail being supplied to us by operators in their incident reports. This additional detail enables us to undertake analysis of the root causes of incidents, and identify and understand any correlation between them, in greater depth than we have been able to in the past. This in turn adds significant value to the information and learnings that can be subsequently shared with operators.

The event correlation analysis conducted to date has produced a number of leading 'themes'. We will be working with respective communications providers to examine the root causes of these in further detail:

- **Change Management and Testing** - As communications providers have engaged in a number of network upgrade or transformation activities during 2020, we have seen multiple service affecting events caused by poor practice in change management and testing. In some examples, these events have not only caused extensive loss of service hours but have also been repeated within a change programme as it has progressed. Other examples have introduced single points of failure in the ability for consumers to access emergency services through implementation of a change followed by lack of adequate testing.
- **Backhaul Transport** - An analysis of incidents affecting backhaul transport in mobile networks appears to indicate a number of events where disruption at a single site caused the loss of service availability at a large number of additional sites. This indicates a dependency which in some cases impacts a significant volume of end users.

[107] DCMS, Notice: Telecoms Supply Chain Review, 8 November 2018
[108] Cabinet Office, Guidance: Telecoms resilience, 20 February 2013 (updated 5 December 2019)

- **Access & Aggregation** - An analysis of incidents within local access and aggregation networks that have occurred on a regular and sometimes frequent basis has indicated patterns within specific local areas that have been creating a cumulative impact on some consumers.
- **Interconnect** - the migration from the traditional PSTN towards IP networks and the progressive development of the alternative network service provider environment has increased the number of incidents affecting interconnect services.
- **Grey State** - Although not representing a large number of events, an increasing number of incidents have been recorded where resilience to equipment failure, being provided through the configuration of redundant nodes, has been unable to detect a trigger state such as the loss of a circuit and has therefore resulted in a single point of failure.

We have agreed with a number of operators that the analysis from our work on incidents can be anonymised, and a synthesis of causes and mitigation actions can be shared with other relevant operators.

Our analysis of reported incidents is supporting a number of other activities to improve resilience within the sector

We have helped to establish an operator Resilience Working Group within the EC-RRG through which the information and shared learnings from the enhanced approach described above can be used on a regular basis to provide updates for the EC-RRG Resilience Best Practice Guidance document. [109] [110]

Additionally, we are supporting the Resilience Working Group in the development of a Resilience Assessment Framework, that can employ the updated Resilience Best Practice Guidance to assist us and the communications provider community in the evaluation of future service affecting incidents.

Our work is also now extending beyond the large operators. This is important because the impending closure of the legacy Public Switched Telephone Network and evolution to all IP networks, together with the promotion of full fibre access networks, has created a vibrant eco-system of alternative network infrastructure and service providers.

We have already started to engage with these providers to advise them of their incident reporting obligations, and we will look to adapt and extend the work we are doing with the EC-RRG to ensure that the resilience capabilities of these networks also protect the availability of the services they provide to their customers.

Finally, the National Infrastructure Council (NIC) published in May 2020 its report and recommendations on the resilience of specific sectors that support critical national infrastructure. [111] We will be working with the UK Government where we can assist in its response to the NIC recommendations.

[109] Cabinet Office, Guidance: Telecoms resilience, 20 February 2013 (updated 5 December 2019)
[110] Cabinet Office, EC-RRG resilience guidelines for providers of critical national-telecommunications infrastructure
[111] National Infrastructure Commission, Resilience, 28 May 2020

There are important questions about how sufficient reliability will be delivered in the future

The telecoms sector is facing an unprecedented rate of change over the next five years or so. Some key underlying network technologies are being replaced; the range of services provided will evolve; and our reliance on these services in all aspects of our lives is rapidly increasing. It is vital that the new networks built during this period offer sufficient reliability to meet citizen and consumer needs.

A particularly important network technology change is the replacement of copper with fibre in the fixed access network. Fibre has made up the core of all networks for decades and has been gradually extending out towards customer houses and offices. Some customers already benefit from full fibre connections, but many more still rely on copper for at least part of their connection to the network.

As set out in the fixed broadband and voice section, there is another change to the technology that delivers basic phone calls over the fixed network. It is expected that by 2025, the PSTN will be switched off. Customers will still be able to make fixed line phone calls and for many, the experience and even the telephone that is used may not change. However, the technology will have changed, with these calls being carried over the broadband network. While this will bring many benefits, it will change some of the technical aspects of the service which determine its current levels of reliability.

One potentially negative impact of this change is on the ability of the future phone service to operate in the event of a power cut in a customer's home. Today, the traditional PSTN, when delivered over a copper connection, can use that copper to also deliver sufficient electricity to the home to power a basic wired handset. Most importantly, this means that if there is a power cut in the home, a customer can still use this handset to make an emergency call. This will no longer be the case after the PSTN and copper lines have been replaced. While contacting the emergency services may still be the single most "life or death" use of telecoms services, there are also other uses of the telecoms network that could be considered critical.

With so many more people and businesses relying on telecoms for such a range of different things of differing importance, it makes determining the optimum reliability of a given telecoms service very complex. This is particularly true when we consider that additional reliability often leads to additional cost, so these considerations involve a degree of trade-off with ensuring services are affordable.

Answering these questions requires careful consideration of the current and likely future uses of telecoms services. It also needs some coordination between all the networks that are being built now and in the coming years to ensure that the sector as a whole best delivers what the UK needs. This coordination is difficult for Ofcom or individual companies to achieve under the existing regulatory regime. It may instead require a government policy intervention, and consideration of whether the current regulatory regime can deliver any required changes in resilience and the associated investment.

Despite these challenges, there is much work underway. For example, as BT plans to replace the PSTN, it is consulting not only with its own retail division, but also with the many other telecom operators that rely on its network to sell services, to ensure the wide range of end customer needs are best met in the future. Also, as set out above, Ofcom is currently working closely with the EC-

RRG's industry members on a major update to its best practice guidance for members on building reliable networks. We are also drawing on the lessons we have learnt about the most common causes of network outages discussed earlier in this section.

New legislation next year will improve telecoms security and increase our role in monitoring and enforcement

Following on from the UK Government's Supply Chain Review, during the last year DCMS has developed new legislation to improve the security of the telecoms sector. [112] The *Telecommunications (Security) Bill* (the Bill) was introduced to Parliament in November. [113] It is expected to have implications not just for security, but also for the resilience of telecoms networks to certain types of service disruption.

The Bill changes the current telecoms security and resilience legislation in three main ways: [114]

- it imposes new, strengthened security duties on public telecoms providers, to be supported by detailed requirements in secondary legislation, and technical Codes of Practice giving guidance on the measures to be taken. The Bill also gives Ofcom powers to monitor and enforce industry compliance with these duties and specific security requirements, and to impose financial penalties in the event that we find a breach;
- it introduces new powers for the Secretary of State to set rules limiting the use of products and services provided by **High Risk Vendors (HRV)** where necessary in the interests of national security. [115] Although not involved in its enforcement, Ofcom may be asked to monitor public telecoms providers' HRV usage; and
- it implements some of the changes to the framework underpinning the existing legislation which were introduced in the **European Electronic Communications Code (EECC)**. These changes are relatively minor, and relate mainly to additional definitions to certain terms. [116]

[112] DCMS, Notice: Telecoms Supply Chain Review, 8 November 2018 (Last updated 22 July 2019)
[113] DCMS, Guidance: Telecommunications (Security) Bill: overarching documents, 28 November 2020
[114] Section 105A-D of the Communications Act 2003. More information can be found in Ofcom's guidance.
[115] High risk vendors are those that pose a higher security risk to the UK telecoms networks. For further details, please see: NSC, NCSC advice on the use of equipment from high risk vendors in UK telecoms networks, 28 January 2020 (reviewed 14 July 2020)
[116] DCMS, Government response to the public consultation on implementing the European Electronics Communications Code, 22 July 2020