Ofcom
making communications work
for everyone

Connected Nations 2018

UK report

18 December 2018

Overview

People now rely on being connected through calls and online services more than ever, whether at home or on the move. So, it's important that they have access to reliable, good quality broadband and mobile connections, to help them keep in touch with friends and family, shop and pay bills online, or stream the latest must-see TV series.

This annual report tracks progress in fixed and mobile services in the UK and summarises the role Ofcom plays in helping to further improve them.

Key findings

Over the past year:

- Superfast broadband coverage has increased to 94% of homes and businesses, up from 91% last year. This refers to the availability of fixed broadband services with a download speed of at least 30 Mbit/s.
- Almost 1.8 million homes and businesses (6%) now have access to full-fibre connections (compared to 840,000 last year). These connections can deliver much higher download speeds, of up to 1 Gbit/s.
- 91% of the UK's landmass has access to good 4G mobile coverage from at least one operator, while 66% has coverage from all four mobile network operators. Within this, individual operator coverage varies, with the highest being 84% and the lowest 74%.

Despite this progress, there are still large parts of the UK that are poorly served by communications services.

- Around 2% of UK premises cannot access a decent fixed broadband service that delivers a download speed of at least 10 Mbit/s and upload speed of at least 1 Mbit/s. However, this has improved from 4% last year.
- While 94% of UK homes and businesses are in areas where superfast, or better, broadband is available, only 45% of homes are subscribing to these services.
- 9% of UK landmass has no good 4G coverage from any operator. This has improved from 21% a year ago but rural areas are still badly affected.
- 23% of homes and businesses do not have good indoor 4G coverage from all operators.
- We also estimate that there are 39,000 homes and businesses that cannot access a decent fixed broadband service or get good 4G coverage.

This report highlights the work Ofcom is doing, alongside UK and devolved governments and communications companies, to improve the availability of fixed and mobile services across the UK.

People's expectations of communications services continue to grow. In this year's Communications Market Report we found that 88% of adult internet users spend an average of 24 hours online each week, almost double the time spent in 2007.[1] People are now able to do more online - on average people now use 240 GB a month on a fixed connection (a growth of 26% compared to last year) which is approximately the equivalent of people downloading 160 films. People now spend an average of two and a half hours a week online when they are not in home or work – this has quadrupled since 2007 and can be linked to improvements in mobile data services, encouraging people to get online more often.

We expect these trends to continue as companies invest in new technologies such as 5G and full-fibre. This will support innovative new services across manufacturing, logistics, agriculture and healthcare. Ofcom shares the UK Government's ambition for the UK to be a world leader in these technologies. We are working with the UK and devolved governments and companies to promote the innovation and investment needed to meet the UK's demand for coverage and capacity.

Alongside this report, we also publish reports on each of the UK's nations and an interactive dashboard, allowing people to see data at the level and locations they are most interested in.[2] We are also making it even easier for people to access our data on fixed broadband and mobile coverage availability. We have released two Application Programming Interfaces (APIs), a way of sharing data between different systems. These will allow others to use our data creatively to develop services, such as apps and widgets to benefit consumers and businesses.

We have also launched the *Boost your broadband* campaign to help people identify the fixed broadband services available to them and get better value from their broadband deal. Despite superfast broadband being available to more than nine in ten UK premises and momentum building behind full-fibre broadband, our data shows people are often not on the fastest service in their area. So, we are encouraging people to check what broadband they need, what's available in their area and to speak to their provider or shop around to make sure they are on the best deal for them.

International comparisons of fixed coverage are published in our Broadband Scorecard.[3]

Fixed broadband and voice services

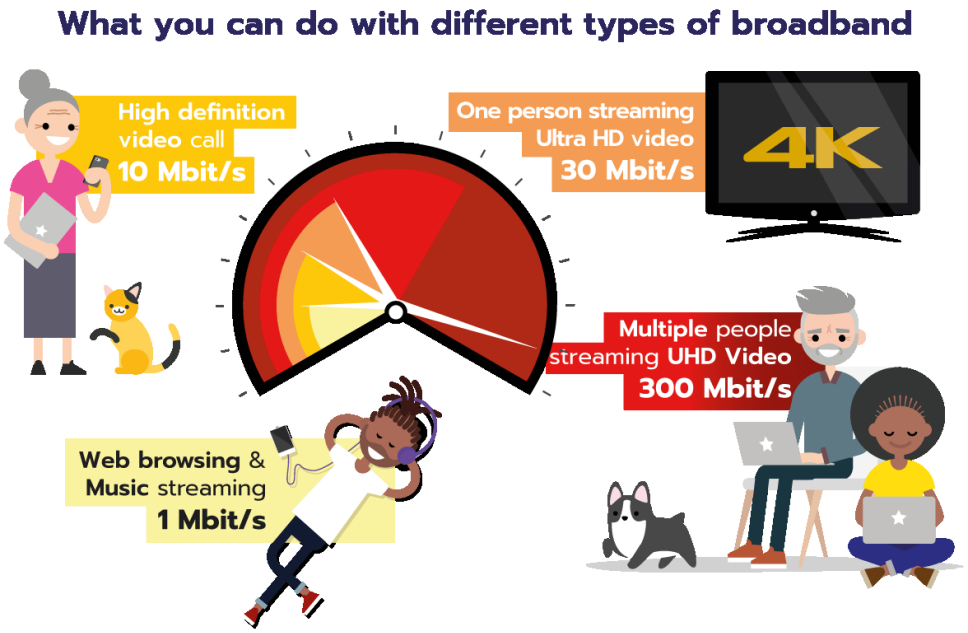
We are supporting investment in ultrafast, more reliable fibre networks, which will be critical to the UK economy in the future. There is already growing momentum behind full-fibre broadband and this section highlights the progress being made to improve its availability across the UK. In July the UK Government set out its ambition in the Future Telecoms Infrastructure Review (FTIR) for 15 million premises to be connected to full-fibre services by 2025 and nationwide coverage by 2033.[4]

Although broadband availability continues to improve, too many people still can't get the connection they need. In March this year, the UK Government made Ofcom responsible for implementing the

[1] https://www.ofcom.org.uk/research-and-data/multi-sector-research/cmr/cmr-2018
[2] https://www.ofcom.org.uk/research-and-data/multi-sector-research/infrastructure-research/connected-nations-2018/interactive-report
[3] https://www.ofcom.org.uk/research-and-data/telecoms-research/broadband-research/eu-broadband-scorecard
[4] https://www.gov.uk/government/publications/future-telecoms-infrastructure-review

broadband Universal Service Obligation. This will give people and businesses the right to request a broadband connection capable of delivering a download speed of at least 10 Mbit/s and upload speed of at least 1 Mbit/s, which we describe as 'decent' broadband.

In this report, we also focus on the availability of services for superfast (30 Mbit/s and above), ultrafast (300 Mbit/s and above), and full fibre broadband, which can offer speeds of 1 Gbit/s.



Broadband coverage continues to improve, with superfast broadband now at 94%

This year has seen continued investment in faster broadband, with 94% of premises now able to access superfast broadband with a download speed of at least 30 Mbit/s. This is up from 91% in 2017. Coverage for small businesses is now at 90%. In April we reported that the UK Government had met its target of 95% coverage for superfast broadband, with this target based on a download speed of at least 24 Mbit/s.[5] Coverage of ultrafast broadband, with download speeds of at least 300 Mbit/s, has also increased from 36% of premises in 2017 to 50% this year.

Superfast broadband coverage has increased across all the UK nations:

- In Scotland, superfast coverage is at 92% of premises (up from 87% in 2017). At the end of 2017, the Scottish Government announced its plans to deliver superfast broadband to every home and business by 2021, under its R100 programme.[6]
- In Wales, superfast coverage is at 93% of premises (up from 89% in 2017). Just over £13m of Welsh Government and EU funding has now been committed to extend the rollout to most of the remaining premises.[7]

[5] https://www.ofcom.org.uk/research-and-data/multi-sector-research/infrastructure-research/connected-nations-update-spring-2018
[6] https://www.gov.scot/Publications/2017/12/2810/1
[7] https://www.ispreview.co.uk/index.php/2018/10/welsh-government-award-13m-fibre-broadband-contract-to-bt.html

- Northern Ireland has seen a similar improvement, with superfast broadband coverage at 89% (up from 85% in 2017).
- There has been a more moderate improvement in England, where superfast broadband coverage is now at 94% of premises (up from 92% in 2017).

Full-fibre coverage has now reached 6% of premises

Increasing investment in full-fibre broadband resulted in coverage doubling to 1.8 million (6%) homes and offices in the UK, up from 3% last year. Northern Ireland has the highest full-fibre coverage, at 12% (up from 1% in 2017), compared to 7% in Wales, 6% in England and 4% in Scotland.

The rollout of full-fibre at scale requires significant planning and investment and we have seen several major announcements this year, in particular:

- Openreach plans to cover 10 million homes by 2025;
- CityFibre and Vodafone have plans to cover five million homes by 2025;
- TalkTalk has a new company (FibreNation) to roll out full-fibre to three million homes;
- Virgin Media plans to reach four million premises by the end of 2019/20 as part of its Project Lightning network expansion; and
- Hyperoptic plans to extend its full-fibre network to 50 towns and cities.

But 2% of premises still cannot access decent broadband

Across the UK, 2% of premises (677,000) cannot currently access a decent broadband connection. We recently published a consultation on which providers will deliver the Broadband Universal Service Obligation.[8] We expect people to be able to request these connections from 2020.

Lack of access to a decent broadband service[9] is more common in rural areas: 12% of rural premises cannot get access to such a connection, compared to 1% of urban premises.

In the nations, Northern Ireland has the highest proportion of total premises unable to access a such a service, at 5% of premises (down from 7% in 2017). Meanwhile, 4% of premises in Scotland (down from 6% in 2017) and 3% of those in Wales (down from 5% in 2017) cannot access decent broadband. In England the proportion is 2%, down from 3% last year.

We are currently looking at how 'fixed wireless access' might provide an alternative for decent broadband access in these remote areas. Fixed wireless access networks use a wireless link for the final connection to a home or business, avoiding the installation of a cable to the building.

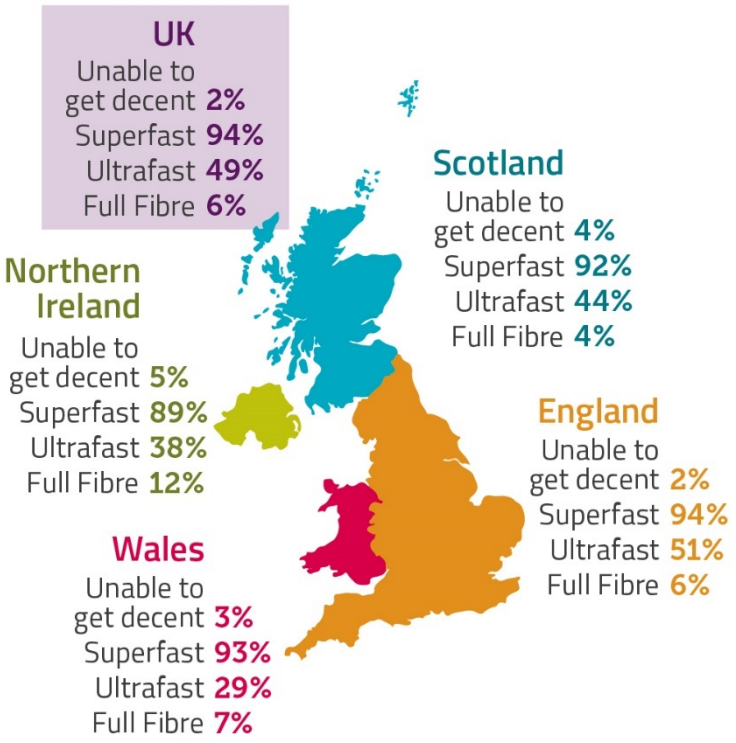
Where a faster service is available, many people are not taking it up

People do not always sign up to faster broadband packages where they are available. Although 94% of premises have access to superfast broadband, only 45% of premises have signed up to them. Similarly, although 98% of premises have access to a decent broadband service, only 65% of premises have an active broadband service that delivers a download speed higher than 10 Mbit/s.

[8] https://www.ofcom.org.uk/consultations-and-statements/category-1/delivering-broadband-universal-service
[9] Defined in our work on the Broadband USO as a service with at least 10Mbit/s downstream and 1 Mbit/s upstream speeds.

Ofcom wants to ensure everyone is aware of the best broadband services available for them and can get the best deal. The *Boost your broadband campaign* will highlight the better value people can get from their broadband service if they engage with their provider or switch to make sure they are on the best possible deal.

At the end of 2017, the UK ranked first among the EU5 on household availability of fibre broadband networks and second for ADSL broadband networks. However, it ranked last for the availability of 'full-fibre' FTTP networks.[10]



Mobile voice and data services

People increasingly expect to be able to go online wherever they are so improving mobile coverage is a priority for Ofcom.

Mobile coverage across the UK is gradually improving but too many parts of the country still struggle to get a good mobile connection. We define an area as having good call coverage if nearly all voice calls complete without interruption and there is a good data connection with speeds of at least 2 Mbit/s.

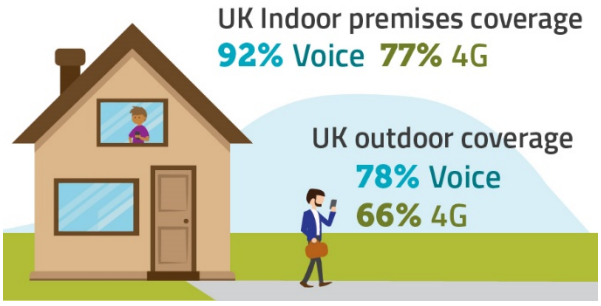
Good reception is easier to achieve outdoors than inside because mobile signals are weakened by obstacles such as walls and the glass used in cars and trains. Because of this, we report separately on outdoor (by UK landmass) and indoor (by premises) coverage. We also report on in-car and out-of-car coverage on roads.

[10]Details on our international comparisons can be found in the Broadband Scorecard https://www.ofcom.org.uk/research-and-data/telecoms-research/broadband-research/eu-broadband-scorecard

Outdoor coverage

Outdoors, voice coverage is available from all four operators to 78% of the UK's landmass, up from 69% a year ago. Vodafone and O2 have the highest voice call coverage now covering 90% of the UK's landmass, and Three and EE have the lowest voice call coverage with 85%.

Good 4G services - which provide a connection speed of at least 2 Mbit/s- are available from all four mobile operators to 66% of the UK landmass, an improvement from 49% last year. However, there are significant differences between the operators. EE has the highest good 4G coverage, at 84%, 10 percentage points more than O2, the operator with the lowest coverage. 9% of the landmass does not have good outdoor 4G coverage from any operator, from 21% in 2017, as operator roll-outs near completion.



Indoor mobile coverage

Indoor voice call coverage from all four operators is available to 92% of UK premises. The operators with the highest coverage are O2 and Vodafone, who provide coverage to 99% of premises, 3 percentage points more than EE and Three, which have the lowest coverage.

77% of premises have good indoor 4G coverage from all four operators. The operator with the highest coverage, O2, provides 95% good 4G indoor coverage, 7 percentage points more than EE and Three who have the lowest indoor coverage. Good indoor coverage is available to 41% of rural premises, compared to 24% in 2017.

Coverage is lower in rural areas

The areas with limited or no mobile coverage tend to be sparsely populated rural areas where the commercial incentives to provide coverage are lower. We investigate this in more detail in the Economic Geography report published alongside this report.[11]

Coverage can vary a lot between operators. Ofcom's online coverage checker and app enables people to identify which operators provide a good connection in the locations that matter most to them.[12] People can then choose the operator that best meets their needs.

There are a small number of premises that do not have a decent fixed or good 4G mobile network connection

For the first time this report looks at the number of premises unable to get a decent fixed *or* good 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 good mobile coverage if indoor 4G mobile coverage is available. We estimate that 97% of premises can receive both decent fixed and good mobile broadband services,

[11] https://www.ofcom.org.uk/research-and-data/multi-sector-research/availability-of-communication-services/economic-geography-2018
[12] http://www.ofcom.org.uk/checker

while 39,000 (0.1% of UK premises) are unable to access either. More premises currently have good indoor 4G coverage from at least one operator than a decent fixed broadband service.

Premises in the Scottish Highlands and Islands and rural areas of Wales are most likely to have neither a decent fixed or good mobile service available. 3% of rural premises in Scotland and 2% of rural premises in Wales are unable to receive either a decent fixed or good mobile service.

Our work to improve fixed and mobile coverage, through the broadband USO and mobile coverage obligations should reduce the number of premises that are unable to receive either a decent fixed or good mobile service. However, there may be some premises that will require an alternative technology solution.

Operators have started the journey to 5G

While mobile companies continue to extend their coverage of 4G networks, attention is also turning to 5G networks. We are playing our part in making 5G available in the UK by focusing on widespread good quality coverage across the UK, in buildings, cars and trains. We will continue to release spectrum for 5G and will continue to support the UK Government's ambitions in this area. In the FTIR, the UK Government set a target for the majority of people to have 5G coverage by 2027.

Ofcom has a comprehensive programme of work to improve mobile coverage, enable 5G and support other innovative services

Since last year's report, Ofcom has been working on several initiatives:

- **Making more spectrum bands available for mobile to improve capacity and coverage:**
    - Earlier this year we auctioned 190 MHz of spectrum, increasing the total amount of mobile spectrum available to operators by 29%. This included 40 MHz of spectrum at 2.3 GHz, that is already been used by many mobile devices today, and 150 MHz of spectrum at 3.4 GHz that may be used for 5G services. Both bands will be important for equipping operators to meet the increasing demand for mobile data.
    - We are making more spectrum available for mobile, including for 5G services, at 700 MHz and 3.6-3.8 GHz. In addition, we recently changed the regulatory regime at 57-66 GHz as well as making new spectrum available at 66-71 GHz, to free a total of 14 GHz of spectrum in the 57-71 GHz band to be used available for 5G and a range of fixed and mobile applications – without the need for a licence.
    - We are proposing to introduce shared spectrum access in bands where mobile technology is either available or currently under development, including in the 3.8-4.2 GHz band where 5G technology is expected to be developed.[13] Spectrum sharing could enable new users to access spectrum for new business models and services, including 5G applications and high capacity solutions to improve rural coverage.
- **Coverage obligations:** in March 2018, we consulted on our initial proposals to introduce new obligations on companies wishing to access the airwaves in the 700 MHz spectrum, including

[13] https://www.ofcom.org.uk/consultations-and-statements/category-1/enabling-opportunities-for-innovation

options to impose enhanced coverage.[14] We have today published a consultation on our proposals for the auction of 700 MHz and 3.6-3.8 GHz spectrum, which includes our proposal to include two coverage obligations in the auction.[15]

- **Legalising repeaters to boost signals:** in April 2018 Ofcom introduced new rules that allow people to use certain types of mobile phone repeater, without the need for a licence, to help boost mobile signal at home.
- **Addressing barriers and reducing costs:** we are supporting improvements to make it easier and cheaper to deploy mobile masts and transmitters. Changes to the Electronic Communications Code help companies to install and maintain equipment without the need for a specific street works licence. Ofcom has also supported changes to UK planning laws through UK Government initiatives.
- **Making information on coverage more useful and accurate:**
    - As noted in our October Update, we have restated mobile coverage predictions following the identification of errors in EE's 3G and Vodafone's 4G data.
    - We are launching two APIs on fixed broadband and mobile coverage, to enable third party websites and apps (content providers, price comparison websites, etc.) to use this information.
    - Ofcom has also helped to create an industry working group to provide better information on mobile coverage.

Network security and resilience

As people and businesses become more reliant on fixed and mobile networks, and as the threat of cybersecurity risks increase, companies must manage security risks and safeguard the availability of their services. We are working closely with the UK Government and its agencies to improve security and resilience, for example by contributing to the Supply Chain Review being led by DCMS.[16]

Incidents reported

In previous Connected Nations reports, we have reported on the significant incidents that we have been informed about by landline and mobile phone companies. This year, we have found:

- Most incidents relate to small-scale and short-duration interruptions in landline services. The threshold for reporting such incidents are relatively low level to enable us to closely monitor them, because many affect the public's access to the 999 emergency services.
- Many of the incidents that have the greatest impact are the result of major national mobile network failures, such as that suffered by O2 on 6 December. We are working with the UK Government and industry to identify how such network failures can be mitigated.
- The majority of incidents were caused by the failure of hardware components, the loss of power supply or by software bugs.

[14] https://www.ofcom.org.uk/consultations-and-statements/category-2/700-mhz-coverage-obligations
[15] https://www.ofcom.org.uk/consultations-and-statements/category-1/award-700mhz-3.6-3.8ghz-spectrum
[16] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754741/20181108_Telecoms_Supply_Chain_Review_Terms_of_Reference.pdf

Increasing our role in cyber security

We have also updated our guidance on the security requirements for phone and broadband companies. This means that managing cyber security risks effectively is an essential part of compliance and these firms must report any security breaches and network failures to us.

In May this year, new regulations for cyber security came into force. Ofcom was appointed regulator for the digital infrastructure subsector and assumed new responsibilities. These include keeping a list of the new companies we will be regulating, who are known as “Operators of Essential Services” (OES), and publishing guidance for these companies on what they need to do. These companies are those providing critical elements of internet infrastructure. They must prevent and minimise the impact of incidents affecting the security of their network and information systems.

Network resilience and availability

We are working with companies to better understand network resilience now and in the future. In particular, we have asked what plans they have to improve their resilience where there is a failure in the ‘mains’ electricity supply. Traditionally, PSTN voice networks have had a high level of power resilience and generally have both battery and generator back-up sufficient for a number of days. Those facilities also power access networks and conventional “corded” telephones connected to them. Modern networks do not necessarily offer the same levels of protection so it is important that stakeholders and people are properly informed about the levels of resilience available.

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Fixed broadband and voice

Introduction

The increasing availability of content-rich websites, online streaming services such as Netflix and "cloud" based applications means people and businesses increasingly expect reliable, resilient and stable broadband connections. A key priority for Ofcom is to encourage investment in fibre, which provides greater speed and reliability than copper-based telecoms networks.[17] The UK and devolved governments are also supporting the move to full-fibre.

In July, the UK Government set a goal to deliver full-fibre to 15m premises by 2025 and to all premises in the UK by 2033.[18] Both established and alternative providers are rolling out full-fibre networks across the country. In addition, and much earlier, the UK Government's Universal Service Obligation (USO) will allow people and businesses the legal right to request a decent broadband connection, delivering download speeds of at least 10 Mbit/s and upload speeds of 1 Mbit/s by 2020.[19]

For this report, we have expanded the number of companies contributing data to our analysis, incorporating coverage information from fixed wireless access providers and a number of smaller full-fibre network providers.

We also highlight some of the developments in the preparation for migrating voice services to be delivered over fibre broadband connections.

Key highlights:

- Superfast broadband coverage has increased to 94%. This relates to the availability of fixed broadband with a download speed of at least 30 Mbit/s.
- Almost 1.8 million premises now have access to a full-fibre connection, which are capable of delivering much higher download and upload speeds.
- Around 677,000 UK premises are still unable to access a fixed broadband service that delivers a decent broadband connection, that is one that delivers a download speed of at least 10 Mbit/s and an upload speed of at least 1 Mbit/s.

[17] https://www.ofcom.org.uk/about-ofcom/latest/media/media-releases/2018/investment-full-fibre-broadband
[18] https://www.gov.uk/government/news/forging-a-full-fibre-broadband-and-5g-future-for-all
[19] https://www.ofcom.org.uk/__data/assets/pdf_file/0013/115042/implementing-broadband-uso.pdf

Fixed broadband coverage has increased across the UK

There has been continued investment in fixed networks resulting in improvements in the availability of superfast, ultrafast and full-fibre broadband. Consequently, the number of premises that do not receive decent broadband (a download speed of at least 10 Mbit/s and an upload speed of at least 1 Mbit/s) has also declined.

Access to a superfast broadband service continues to increase

In our spring update of the Connected Nations, we reported that the UK Government met its target of 95% coverage of broadband with a download speed of at least 24 Mbit/s.[20] Having met the target, the Government's Broadband Delivery UK (BDUK) programme has continued to fund superfast roll out beyond this.

Ofcom defines superfast broadband as a service which delivers a minimum download speed of at least 30 Mbit/s. The Scottish Government and Welsh Government also use this definition in their schemes to extend broadband coverage. Under the R100 programme, the Scottish Government has plans to deliver superfast broadband to every home and business by 2021. The Welsh Government completed the initial phase of its Superfast Cymru project earlier this year.

Over the past year the coverage of superfast broadband across the UK increased from 91% to 94%, with Scotland seeing the largest increase of 5 percentage points (pp) from 87% to 92%. In Wales it has increased from 89% to 93% and in Northern Ireland from 86% to 89%. England saw a moderate 2pp increase to 94%.

While superfast availability has increased for people, only 90% of small businesses are able to access superfast speeds.[21] This may be due in part to lower availability in business parks, due to the costs involved in rolling out technology to areas that have fewer occupants than residential areas.[22]

There is also a significant difference between the availability of superfast broadband in urban and rural areas, with 97% of premises in urban areas having access to superfast broadband compared to 74% of premises in rural areas. However, rural superfast coverage has improved from 66% of premises in 2017.

We expect superfast broadband coverage to continue to increase, as BDUK funding continues beyond the 95% target. In its 2018 budget, the UK Government allocated £200m to pilot innovative approaches to deploying fibre in rural areas. As well as the Scottish Government's ongoing R100 programme, the Welsh Government has recently announced a further £13m to connect 16,000 premises in North Wales, South West Wales and the Valleys, with the majority served by full-fibre connections.[23] In Northern Ireland, £150m has been earmarked for Project Stratum, to reduce the number of premises unable to access superfast broadband.

[20] https://www.ofcom.org.uk/research-and-data/multi-sector-research/infrastructure-research/connected-nations-update-spring-2018

[21] We define a small business as a Small or Medium Enterprise (SME) with at least one employee.

[22] Data for the Connected Nations is gathered from providers offering services over residential broadband technologies and therefore does not include coverage from dedicated business connections, such as leased lines.

[23] https://gov.wales/newsroom/science-and-technology/2018/59926094/?lang=en

Ultrafast broadband deployment continues to increase

Ultrafast services are defined as being able to deliver broadband speeds that are greater than or equal to 300 Mbit/s. This definition includes G.fast[24], cable networks and full-fibre technologies. G.fast services operate from a point near the end user, meaning that premises that are very close to the cabinet are capable of receiving very high speeds.

Over the last year the coverage of ultrafast broadband has increased from 36% to 50%. Virgin Media has continued to upgrade its network, increasing its fastest residential broadband service to 300 Mbit/s for the majority of its network. We also expect ultrafast coverage to increase as a result of growth in full-fibre networks.

Full-fibre investment and roll out continues to increase

In a 'Full-fibre' or Fibre-to-the-Premises network, fibre optic cables are connected all the way from the local exchange to the home or small business, and can reliably deliver speeds of 1 Gbit/s or more.[25] This contrasts with technologies that are a combination of fibre and copper, like Fibre to the Cabinet, where the quality and distance of the copper to the premises can impact on both the reliability and speed of the service.

Almost 1.8 million premises now have access to a full-fibre connection. This is an increase of 1m premises compared to last year.

This year we have also collected data from 12 additional full-fibre providers. These providers contributed additional coverage to around 100,000 (0.3%) premises. A full list of the providers who contributed coverage data can be found in Annex A.

Ofcom supports the UK Government's ambitions to extend the availability of full-fibre networks. To encourage investment in building full-fibre networks and to provide investors and companies with long term regulatory certainty, Ofcom has proposed several changes in our regulatory and policy approach.[26] They include:

- Allowing competing companies to use Openreach's ducts and poles for both people and businesses. Currently, duct and pole access is restricted to networks focusing primarily on the residential market, but we are proposing that the restriction now be removed to allow it to also be used for business customers.
- A flexible approach to regulation by deregulating in areas where there are competing fibre providers.
- Increasing the periods between major reviews of the telecoms market from 3 to 5 years.

We are also supporting work of the UK and devolved governments to overcome barriers to network deployment.

In the Future Telecoms Infrastructure Review (FTIR), the UK Government published a target for full-fibre availability for 15 million

[24] G.Fast is a Digital Subscriber Line (DSL) technology that reuses the existing copper connection to a cabinet, and makes use of a greater amount of frequencies to deliver faster services than current fibre to the cabinet services that use VDSL technology.

[25] We define full fibre coverage as where the network has been rolled out to a "lead-in" that will serve the consumer end premise and where the customer would expect to pay a standard installation charge for that connection.

[26] https://www.ofcom.org.uk/__data/assets/pdf_file/0025/116539/investment-full-fibre-broadband.pdf

premises by 2025, and coverage across the UK including rural areas by 2033.[27] To support this goal the UK Government is allocating funding and has created a Barrier Busting Task Force.

The UK Government is also supporting alternative and established providers to deploy full-fibre across 13 areas in the UK under the Local Full Fibre Network Program (LFFNP).[28] This focuses on extending fibre networks to a public sector 'anchor tenant', providing a full-fibre 'hub' which surrounding homes and businesses can also be connected to.

Investment in full-fibre networks continues to grow and we expect deployment to continue to increase over the coming years as established and alternative providers announce plans:

- Openreach's Fibre First program aims to roll-out full-fibre broadband to 3 million UK homes and small businesses by the end of 2020, with a target of covering 10 million homes by 2025.[29]
- CityFibre and Vodafone have announced plans to roll out full-fibre to 5 million homes and businesses by 2025.[30]
- TalkTalk has launched a new company (FibreNation) to roll out full-fibre to 3 million homes and businesses in medium sized towns across the UK.[31]
- Virgin Media plans to reach 4 million premises by the end of 2019/20 as part of its Project Lightning network expansion.
- Hyperoptic plans to reach 500,000 premises by the end of 2019, 2 million by 2022 and 5 million by 2025. In August 2018 it announced plans to extend its full-fibre network to 50 towns and cities.[32]
- KCOM plans to have 100% full-fibre availability across its network by March 2019.[33]

The number of premises unable to access decent broadband has fallen

While superfast coverage continues to improve, there remain premises that do not have access to decent broadband. In March 2018, the UK Government introduced legislation for a Broadband Universal Service Obligation, which will give eligible homes and businesses the right to request a broadband connection that delivers a decent broadband service of at least 10 Mbit/s download speed and 1 Mbit/s upload speed. Ofcom is responsible for implementing the USO.

The number of UK premises that were unable to access a decent fixed-line broadband service fell from 1.1 million (4%) last year to 677,000 (2%).

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27 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727889/Future_Telecoms_Infrastructure_Review.pdf

28 https://www.gov.uk/guidance/local-full-fibre-networks-programme

29 http://news.openreach.co.uk/pressreleases/openreach-launches-fibre-first-programme-to-make-fibre-to-the-premises-broadband-available-to-three-million-uk-homes-and-businesses-by-the-end-dot-dot-dot-2399074

30 https://www.cityfibre.com/news/vodafone-cityfibre-bring-gigabit-speed-fibre-uk/

31 https://www.talktalkgroup.com/articles/talktalkgroup/TalkTalk-launches-new-company-FibreNation-

32 https://www.computerweekly.com/news/252446282/Hyperoptic-raises-250m-funding-to-roll-out-full-fibre-broadband

33 https://www.kcomhome.com/discover/categories/kcom-news/hull-reaches-broadband-milestone-as-kcom-announces-growth-in-fibre-customers/

This difference is more acute in rural areas with 496,000 (12%) of premises not able to receive decent broadband compared to 181,000 (1%) premises in urban areas.

Coverage of decent broadband also varies across the nations in both rural and urban areas. The following table highlights the differences between the nations and the urban/rural divide. Premises with no access to a decent broadband connection would be considered eligible for the UK Government's USO.

Figure 1: Premises unable to receive decent broadband from a fixed line

Nations	All	Rural	Urban
England	2% (484,000)	11% (322,000)	1% (162,000)
Northern Ireland	5% (40,000)	17% (38,000)	0.5% (3,000)
Scotland	4% (105,000)	21% (94,000)	0.5% (11,000)
Wales	3% (48,000)	13% (42,000)	1% (6,000)

Source: Ofcom analysis of operator data

All of the nations have seen a decrease of at least 1 percentage point in premises that cannot get decent broadband.

We are investigating to what extent the availability of Fixed Wireless Access (FWA) services from Mobile Network Operators and other providers might contribute to coverage of broadband services and hence provide a viable alternative for decent broadband services. We discuss this later in this chapter.

Ofcom is currently in the process of designating the providers who would be responsible for delivering the Broadband USO. In June 2018 we published a consultation, inviting expressions of interest in being designated as a Universal Service Provider. Having received eight expressions of interest to this document, in our consultation published in December 2018, we proposed that BT and KCOM should be designated as the Universal Service Providers and that we expect people to be able to request these connections from 2020. By this point we expect the number of premises that could be eligible for the USO should have fallen further.

Fixed Wireless Access as a means of delivering broadband

Fixed Wireless Access (FWA) networks provide an alternative solution to traditional fixed broadband services. These networks use a wireless link for the final connection to a home or business, avoiding the installation of a line into the building. The capacity in the wireless access network is shared between multiple users. The service needs to be managed appropriately to ensure there is sufficient capacity to meet user needs, especially in areas with capacity constraints.

FWA networks can be deployed in different frequency bands, including licence exempt or light licensed spectrum such as the 5 GHz band, and licensed mobile band or new bands like mmWave. Some FWA networks use

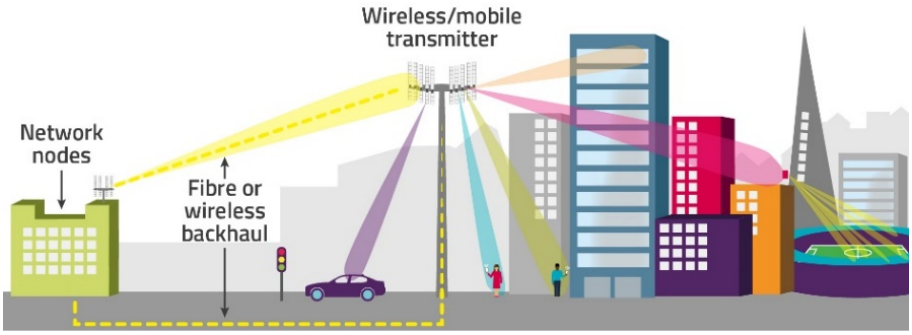


Figure 2: Schematic of Fixed Wireless Access network

current mobile technologies such as the 4G Relish or EE home broadband router services or, in future, will rely on new 5G mobile technology. In response to our consultation on the broadband USO, BT has claimed that it will be able to cover around 450,000 premises that might otherwise need the USO using their EE home broadband service. We are doing more work to validate the likely coverage from the EE network.

This section initially focuses on the FWA services provided by licence exempt or light licensed systems and then considers the FWA service delivered by mobile networks.

Fixed Wireless Access on shared spectrum

The majority of these services are delivered over FWA networks that communicate via a wireless link between a provider's mast site and an external antenna fixed to a customer's premises. The speeds and services delivered will depend on a number of factors including, but not limited to: the number of premises being served from the same transmitter, the location of the premises, line-of-sight issues, consumer equipment and available network capacity.

Ofcom's work with FWA network providers

Ofcom is working with companies to understand how FWA networks operate and the levels of service people receive.

Over the last year we contacted over 100 FWA providers to gauge their level of interest in providing us with details of their network and service.[34] To date, 12 of these FWA providers have submitted data to Ofcom.

We have applied a modelling method to this data in order to predict the number of unique premises which could receive an FWA service via existing infrastructure. The modelling method provides an estimate only and does not account for network capacity constraints, interference or other external factors.[35]

We estimate that over 900k premises are able to receive a decent broadband service from an alternate FWA provider on licence exempt or light licensed spectrum.

The results of our modelling show that 903,500 unique homes and businesses in the UK have a medium or high chance of being able to receive a decent broadband service from an alternate FWA provider. Of these, 41,500 currently have no other means of accessing a decent fixed broadband service. This provides an additional 0.15% of decent broadband service coverage to the UK, meaning that, if coverage from other fixed providers is included, 634,500 premises do not currently have access to a decent broadband service.

Figure 3 shows the total number of premises covered by one or more FWA networks. It also shows the number of premises which are unable to access a decent broadband service but can be covered by an alternate FWA network. This is labelled FWA USO in the table below.

Figure 3: Number of premises which can receive decent broadband from FWA providers by nation

Nation	FWA coverage	FWA USO
UK	903,500	41,500
England	829,500	32,500
Northern Ireland	21,000	5,000
Scotland	21,500	3,000
Wales	32,000	1,500

Source: Ofcom analysis of operator data

[34] The full list of FWA providers who were contacted can be found in Annex A.
[35] More detail on the methodology used to determine FWA network coverage can be found in Annex A.

We intend to continue collating and analysing data on FWA networks given the increasingly important role that FWA plays in delivering a broadband service to people, especially in harder-to-reach areas.

Fixed Wireless Access via mobile technologies

This year we have also seen mobile technologies such as 4G networks begin to be used in greater volumes to deliver home broadband services to people.

In February this year, BT/EE released its 4G home broadband router, delivering fixed wireless access on primarily their existing 1800 MHz spectrum. Unlike mobile data packages in the past that tended to have very low data caps, the EE 4G home broadband router service is accompanied with broadband packages with comparable pricing and data caps to fixed broadband packages. These services, however, share the limited available capacity on 4G networks with existing mobile users on the site. EE manage these capacity constraints by limiting the number of FWA connections on the network until upgrades are made to meet the demand.

Fixed wireless services using 4G technology is also currently available from Relish (owned by Three). These services are currently deployed in London, Swindon and Reading and primarily deployed on their 3.5 and 3.6 GHz bands using 20 MHz wideband channels. While this service is not currently available nationwide, Relish has indicated that over 830,000 premises currently fall within its FWA coverage footprint. Although Relish does not guarantee any minimum speed, all packages include unlimited data usage and average speeds on their LTE-enabled hubs are of 20 Mbit/s. Over 20,000 premises are currently active on its network, which includes over 2,000 business customers.

On 20 November, Three released a study that examines the opportunity for 5G-based FWA services to become an effective substitute for current and future fixed network broadband.[36] Three also announced its intention to launch such a service in 2019, which it expects will deliver speeds of 80-100 Mbit/s.

The synergies of providing both fixed broadband and mobile services from the same network infrastructure may help coverage to be expanded further into rural areas. We will continue to engage with mobile operators to better understand the signal levels and capacity required for different mobile technologies to deliver a decent broadband service indoors.

Take-up of fixed services

Although the terms ‘coverage’ and ‘take up’ are often interchangeable in the context of broadband speeds, they have very different meanings.

Coverage is used to refer to the maximum broadband speed available at a property, e.g. if the building can receive a decent broadband service (10 Mbit/s) and a superfast (30 Mbit/s) broadband service from BT, and an ultrafast broadband service (300 Mbit/s) from Virgin Media, the coverage at the premise would be 300 Mbit/s as it is the maximum speed available at the premise.

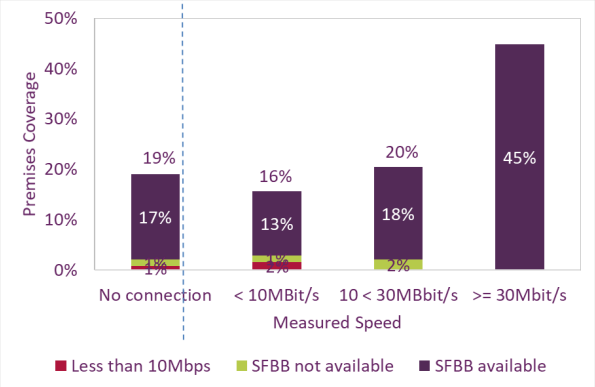
Take-up is defined based on the package the customer subscribes to and the measured speed that is delivered on that line, e.g. if the consumer receives a broadband service at the premises above, they have the option of

[36] http://www.threemediacentre.co.uk/news/2018/5g-wireless-home-broadband-predicted-to-double-internet-speeds-for-uk-households.aspx

selecting either a decent broadband or superfast service from BT or ultrafast service from Virgin Media.

Figure 4 shows that, although 94% of premises have access to superfast broadband, only 45% of premises have signed up to them. However, this has increased from 38% last year. Similarly, although 98% of premises have access to a decent broadband service, only 65% of premises have an active broadband service that delivers a download speed higher than 10 Mbit/s.

Figure 4: Some consumers could sign up to faster services



Source: Ofcom analysis of operator data

People should be given the choice to sign up to a fast broadband service but may not choose to do so for different reasons, for example where the slower service is sufficient for their needs or because the faster service is too expensive. However, people should have access to information that helps them to make the most suitable choice for their situation. Therefore, we have launched a campaign to help people to identify the fixed broadband services that are available to them in their area and advice on how to get the service most suitable for their needs.[37]

Data use on fixed networks continues to increase

Data use on fixed networks has increased to an average of 240GB, from 190GB in 2017. The median value of data use on fixed lines has increased by almost 50% to 124GB from 84GB last year. This suggests that users with faster connections are using a lot more data.

Satellite

Some areas are challenging to reach for both fixed and mobile networks, so satellite broadband is an alternative. However, current satellite broadband services have high latency.[38] This is due to the time it takes for the broadband signal to travel to the earth from a geostationary orbit.

There are approximately 18,000 fixed satellite broadband customers in the UK. We plan to work with satellite broadband providers to understand the broadband services that are delivered to these customers.

There are plans to launch new satellites in the next few years, which could introduce improvements in the characteristics of satellite broadband services, with Low Earth Orbit (LEO) satellites that orbit closer to the surface of the Earth. This will reduce the latency experienced by satellite broadband users. LEO satellite based services will be provided by constellations of hundreds or thousands of satellites, which could provide greater capacity and lower latency for satellite broadband services.

[37] https://www.boostyourbroadband.com/

[38] Latency is the round trip delay in the transmission of data. In particular, this can affect the performance of live applications, such as live video streaming, gaming and video calling/conferencing.

Future of voice

As companies move away from deploying copper-based to fibre broadband technologies, the traditional telephone network will also have to change. Traditionally most landline services are delivered to people over the Public Switched Telephone Network (PSTN), using copper. With a reduction of technical knowledge on such copper dependent systems and the unavailability of spare parts, companies are already preparing to move to an all IP world where telephone services will be delivered over the broadband connection, often referred to as Voice over IP (VoIP).

Earlier this year, Openreach consulted on plans to withdraw its wholesale PSTN voice service and to move to offering access network inputs that will only support VoIP based services by 2025.[39] Virgin Media is also planning to migrate voice services to VoIP. Sky and TalkTalk already carry voice calls as IP traffic in their core network.

We are now gathering information about the technology used by companies to provide voice services so that we can track the migration to VoIP in the coming years. This data shows that the migration of voice services onto the broadband connection has yet to begin in any volume. The majority of services are still being supported by the traditional PSTN network, with a large minority (around a fifth) of services being supported by a modern IP-based network that imitates the characteristics of the traditional PSTN (known as 'emulation'). We will continue to monitor this in future Connected Nations reports.

Some services that rely on the analogue characteristics of the current PSTN may be affected by the migration to IP, for example some types of fire alarms and telecare services. As a part of their plan for migration, BT are offering a test facility for providers of such services to test the impact of this transition.[40] Ofcom is also engaging with the UK and devolved governments and other regulators to help raise awareness about the migration and potential impact for services they or their stakeholders use.

We have published guidance for companies on protecting access to emergency calls during a power cut at the customer's premises

Traditional voice calls are delivered to premises via copper connections and as these lines are powered from the local telephone exchange, people with corded phones can still make emergency calls in the event of a power cut at the premises. However, calls in such circumstances made over broadband using VoIP based technology will not function, as the broadband equipment at the premises requires mains power to work. As a result, calls will only be possible if additional protection measures are in place.

To support preparations for delivering voice services on fibre broadband connections, in October we published guidance for companies setting out our expectations on the measures they should have in place to ensure customers making calls over broadband are able to make

[39] https://news.openreach.co.uk/pressreleases/openreach-to-consult-communication-provider-customers-on-switch-to-digital-phone-services-by-2025-2507133
[40] https://www.btplc.com/DigitalServicesLab/index.htm

emergency calls in a power cut at their premises.[41]

There are a number of other regulatory and operational implications of the change to VoIP that Ofcom will address during 2019 and beyond

The work in this area has focused to date on consumer migration and service compatibility issues. In the near term, we will add other topics including**:**

- End-to-end connectivity and Interconnection – moving our interconnect regulation away from PSTN.
- Number portability – ensuring a fit for purpose porting system to facilitate the large-scale movement of numbers to and between the new technology platforms.
- Calling Line Identification (CLI) and Identity management – considering the introduction of some form of authentication check to address the problems of "CLI spoofing" and nuisance calls.

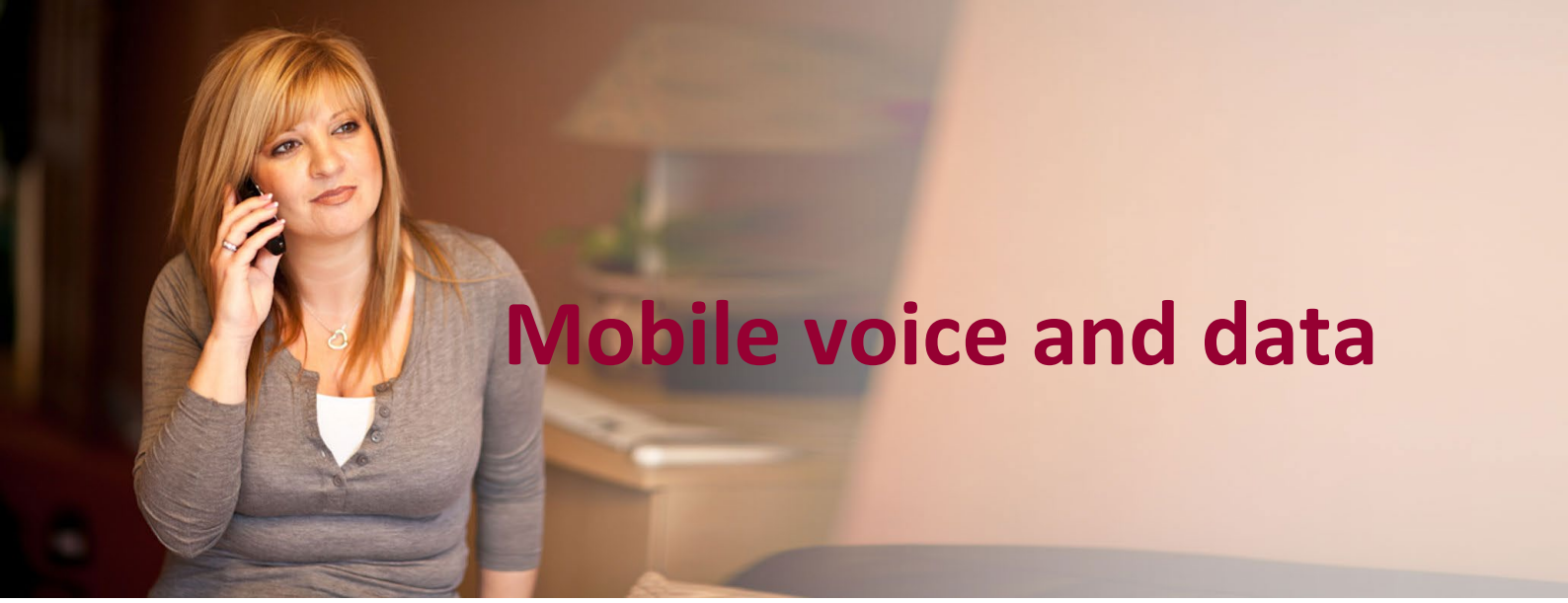
We are also exploring how blockchain and distributed ledger technology could improve the management of UK landline numbers

In October, Ofcom was awarded funds from the Department of Business, Energy and Industrial Strategy to explore how blockchain[42] or distributed ledger technology could improve how UK landline telephone numbers are managed.[43] We are responsible for the issuing of blocks of numbers to companies, who then manage the numbers and port them between different network providers. As voice services move to VoIP, a new system will be needed to support increased company agility. Blockchain has the potential to deliver a cost effective long-term system. It will also help to improve the customer and business experience when moving a number between providers and support more effective management of nuisance calls and fraud. We plan to use the fund to trial a blockchain solution to number porting and management by April 2020, working collaboratively with companies and other parties.

[41] https://www.ofcom.org.uk/consultations-and-statements/category-2/access-emergency-organisations-power-cut

[42] Blockchain allows for the transfer of digital assets between two parties, that creates a trusted record of transactions and ownership.

[43] https://www.ofcom.org.uk/about-ofcom/latest/features-and-news/blockchain-technology-uk-telephone-numbers



Mobile voice and data

Introduction

Mobile services are an increasingly important part of people's lives and how business is conducted.

People increasingly expect to be able to access a decent mobile connection wherever they are. At the same time the devices we use to access mobile services have changed, with the greater take-up and use of smartphones, tablets and Internet of Things (IoT) devices. These often require stronger signals than older, simpler phones.

The UK Government's Future Telecoms Infrastructure Review (FTIR) sets out important and ambitious targets for making mobile coverage more widely available.[44] Ofcom continues to support this ambition and its focus on providing widespread good quality coverage across all parts of the UK.

Key highlights:

- With the ongoing active roll out, good 4G coverage is now available from all four operators to 66% of the UK landmass, up from 48% last year. The operator with the highest coverage provides 84% coverage.
- There remains 9% of the UK landmass that does not have good outdoor 4G coverage from any operator. This is mainly in rural areas.
- We also estimate that 41,000 premises are unable to access a decent fixed broadband service or have good 4G coverage indoors.

44 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/732496/Future_Telecoms_Infrastructure_Review.pdf

Coverage is provided using a combination of different mobile technologies

Several types of technology are used to deliver mobile services to people. Most modern mobile handsets support 2G, 3G, and 4G, whereas 5G devices will become available in 2019.

2G: this was the first digital mobile technology, launched in the UK in 1992. It is used to deliver: voice, text services and very low-speed data services.

3G: this is a later generation of digital mobile technology, launched in 2003. It can be used to deliver: voice, text and lower speed data services.

4G: this is the latest generation of mobile technology, launched in 2012. It can provide download speeds of over 10 Mbit/s, and is used to deliver: voice, text and higher speed data services.

5G: will be the fifth generation of mobile technology. It is expected to deliver faster, lower latency mobile broadband, and to enable more revolutionary uses in sectors such as manufacturing, transport and healthcare.

Our approach to reporting on mobile coverage

The levels of mobile coverage included in this report relate to where a sufficiently strong mobile signal is available to deliver a good experience to smartphone users.[45] [46] This is where:

- Nearly all 90-second telephone calls are very likely to complete without interruption;
- Nearly all 4G connections will deliver a connection speed of at least 2 Mbit/s. This is fast enough to browse the internet and watch glitch-free mobile video.

How you measure coverage is important, but so is *where* you measure it. To reflect the places in which people are likely to use their mobile, we look at coverage in three main ways:

a) *Outdoor:* The percentage of geographic area where someone can use their phone while outdoors. This measurement is useful for assessing the likelihood of successfully using a phone while out and about.
b) *Indoor:* The percentage of premises in which someone can use their phone. This measurement is useful for assessing the likelihood of successfully using a phone while at home or at work. This is estimated using the average reduction buildings cause to mobile signal levels. In next year's report we intend to provide more details on how signals are reduced by

[45] We have used crowdsourced data from consumer handsets and drive testing to identify the signal levels needed to meet these targets at least 95% of the time.
[46] We also report on the availability of lower speed earlier generation 3G data services. These are reported in combination with lower speed 4G data services (based on a lower target signal threshold) where they are likely to provide a connection speed of at least 200 kbit/s for nearly all connections. These connections are likely to be sufficient to support lower speed data services such as basic web-browsing as opposed to higher resolution video.

different types of building and the materials used in their construction.

c) *Roads:* The percentage of roads on which someone can use their phone while inside a vehicle. This measurement is useful for assessing the likelihood of successfully receiving coverage whilst on the road.

Finally, we report on whether coverage is available from all four operators. This reflects the level of choice of provider available to people. It is often much lower than the coverage available from a single operator.

Ensuring the accuracy of the mobile coverage data

The mobile coverage figures provided in this report rely on the accuracy of coverage prediction data supplied by the mobile operators.

In our last Connected Nations report update published in October 2018, we noted that Ofcom's drive testing measurements had identified a potential overprediction in EE's 2100 MHz 3G signal level data. More recent drive testing by EE has found a similar level of overprediction. Given this, EE has resubmitted signal level predictions for their 2100 MHz 3G services to generate the mobile coverage data for this report. This resubmitted data reduces EE's reported 3G coverage.

Separately, we identified a potential underprediction of the signal levels for Vodafone's 4G services. This has been confirmed by Vodafone and corrected for this report. This correction factor increases Vodafone's reported 4G coverage.[47]

We provide re-stated historic mobile coverage levels taking into account these adjustments in the interactive dashboard.

We take the accuracy of the data supplied to us seriously given its importance to policy making and the information provided to people on coverage. In light of these corrections we decided to formally investigate these matters further.[48] [49] We have been reviewing the evidence and plan to publish an update in the new year.

In addition, we will continue to monitor, through drive testing, the accuracy of all of the operators' coverage predictions.

Mobile coverage continues to improve but remains limited in many rural areas

The ongoing roll out of 4G services combined with two coverage obligations being met at the end of 2017 have helped improve coverage.

The two coverage obligations delivered at the end of 2017 included:

1. All operators providing voice call coverage to 90% of the UK's landmass;[50]
2. O2 providing 2 Mbit/s indoor 4G data connections to 98% of people.

In early 2018 we concluded that both these obligations had been successfully met by mobile operators.[51] Despite this coverage remains poor in many rural areas. For example, in urban areas voice call services are now available from all operators to 97% of

[47] A correction factor of 6dB has been applied.
[48] https://www.ofcom.org.uk/about-ofcom/latest/bulletins/competition-bulletins/open-cases/cw_01232
[49] https://www.ofcom.org.uk/about-ofcom/latest/bulletins/competition-bulletins/open-cases/cw_01231
[50] These were based on a lower voice call signal level than that used to report on voice call coverage in this report.
[51] https://www.ofcom.org.uk/spectrum/information/cellular-coverage

premises and good 4G data services of a least 2 Mbit/s to 83% of premises. In contrast, only 41% of premises can access good quality data services in rural areas.

Hence, additional steps will be needed to improve coverage in rural areas, such as coverage obligations in the award of the 700 MHz spectrum band and the use of technical innovation offered by 5G.

The factors affecting the availability of coverage in rural areas is explored in our Economic Geography report. This includes a detailed analysis of the factors that influence the decisions made by mobile operators in providing mobile coverage in different areas. Regression techniques are used to examine how much of the regional variation in 3G and 4G coverage can be explained by differences in the demand and cost factors.[52]

We find that population density and composition, topography, distance to mobile backhaul and whether the locality is urban or rural will affect the availability of mobile coverage. Compared to urban areas, rural areas will typically have a lower population density and more uneven terrain. This would mean that demand for mobile services is likely to be lower and costs are likely to be higher when deploying mobile infrastructure to rural locations.

Our analysis showed that these demand and cost factors were able to account for a sizable proportion of the differences in mobile coverage across regions and nations of the UK.

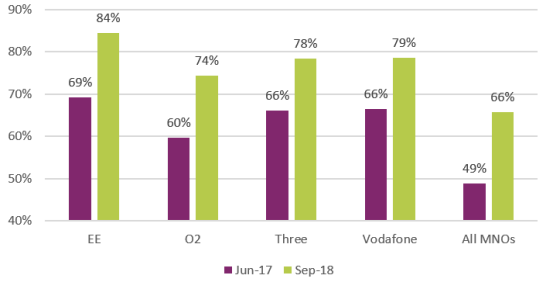
Outdoor geographic coverage

Overall outdoor mobile coverage has improved, but the improvements vary considerably between operators and a quarter of the UK does not have coverage from all operators.

Seventy-eight per cent of the UK's geographic area is now covered by all four operators for telephone calls, up from 69% in June 2017.[53] Geographic area not covered by any operator for telephone calls has fallen from 9% last year to 5% this year.

Outdoor access to good data services through 4G has also significantly increased from 49% to 66% over the same period.[54] The area without good 4G data service from any operator has significantly reduced from 20% last year to 9% this year. The significant difference between operators can be seen in Figure 5.

Figure 5 - Outdoor area coverage of 4G mobile services in the UK



Source: Ofcom analysis of operator data (restated)

[52] https://www.ofcom.org.uk/research-and-data/multi-sector-research/availability-of-communication-services/economic-geography-2018

[53] These figures include voice calls over 4G LTE services.

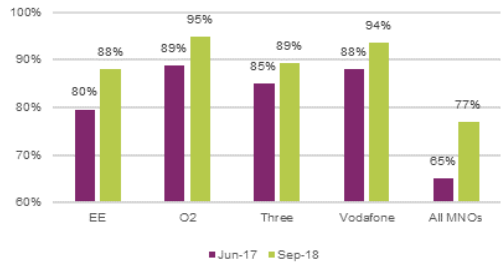
[54] Outdoor access to lower speed data services through 3G and 4G (where nearly all connections have access to a connection speed of at least 200 kbit/s) has similarly increased. 83% of the UK's geographic area now has a lower speed mobile data service from all four operators, up from 70% in June 2017. 96% of the UK geographic area has a lower speed mobile data service from at least one operator, up from 89% in 2017.

Indoor premise coverage

More than nine in ten UK homes and businesses have indoor voice coverage from all networks. Some 92% of UK premises have indoor telephone call coverage from all four mobile networks, up from 90% in June 2017.[55] We welcome the improvement, but indoor coverage is very important for people so much more must be done to increase it.

Three quarters of UK homes and businesses have good indoor 4G coverage from all operators. Seventy-seven per cent of UK premises are now covered by a good 4G signal from all operators, up from 65% in June 2017.[56] The difference between operators is significant, with O2 premises coverage 7 percentage points higher than the worst operator.

Figure 6 - Indoor premises coverage of 4G mobile services in the UK



Source: Ofcom analysis of operator data (restated)

Emergency calls

Mobile phones can use signal from other networks to make emergency calls. As the mobile networks have slightly different coverage footprints this enables 95% of the UK geographic area, and inside almost all premises, to be covered for mobile emergency calls.

There are 39,000 premises that do not have coverage from either decent fixed or good 4G mobile

Premises are considered to have access to a decent fixed connection if the broadband service has a download speed of at least 10 Mbit/s and an upload speed of at least 1 Mbit/s and to have good mobile coverage if indoor 4G mobile coverage is available. Using this approach, we estimate that 97% of premises can receive both decent fixed and good mobile services[57], while 39,000 (0.1% of UK premises) are unable to access either. More premises currently have good indoor 4G coverage than a decent fixed broadband service.

Premises in the Scottish Highlands and Islands and rural areas of Wales are most likely to have neither a decent fixed or good mobile service available. 3% of rural premises in Scotland and 2% of rural premises in Wales are unable to receive either a decent fixed or good mobile service.

Roads coverage

The need for connectivity to be available to all roads is continuing to increase, with requirements including vehicle communications, navigation, infotainment, and safety aids.

Over a third of all Motorways and A-roads do not have good in-car 4G coverage from all operators. Some 64% of Motorway and A roads have good 4G coverage from all four

[55] We determine indoor coverage by applying an average building entry loss of 10dB across all buildings.
[56] Indoor access to lower speed data services through 3G and 4G (where nearly all connections have access to a connection speed of at least 200 kbit/s) from all operators has similarly increased, 98% of UK premises now have a lower speed mobile data service from all operators, up from 94% in June 2017. Almost all premises have coverage from at least one operator.
[57] This consists of 3% of premises that can receive decent fixed, good mobile and FWA services and 94% that can receive decent fixed and good mobile.

operators, whilst 33% only have good coverage from some operators. Three percent of Motorways and A roads do not have good in-car 4G coverage from any operator.

Outside the vehicle, 88% of Motorways and A roads have good 4G data coverage from all operators, but one percent of Motorways and A roads do not have coverage from any operator. For emergency calls, where calls can be made on any network, coverage increases to 99%.

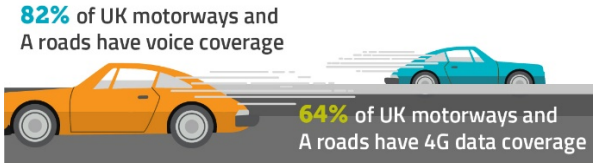
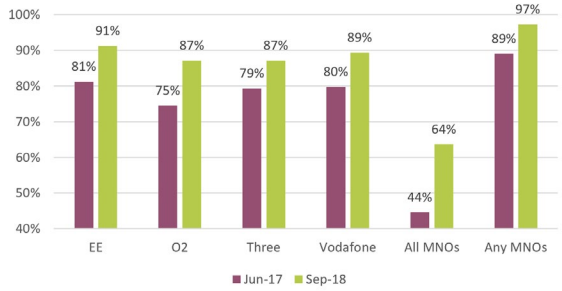


Figure 7 – Motorways and A road coverage of in-car 4G mobile services

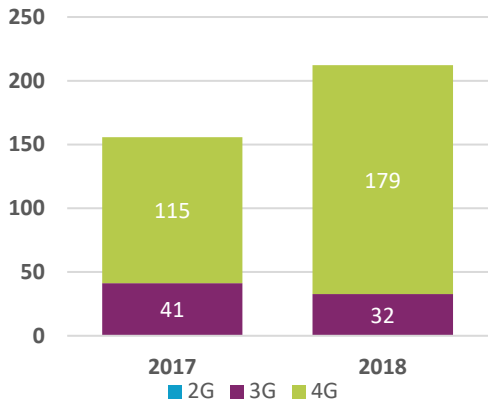


Source: Ofcom analysis of operator data

Performance and capacity

Increasing demand for mobile data, combined with improvements in good 4G coverage and take-up of 4G devices has driven a large increase in 4G data use. 4G carries 85% of data traffic but only carries 7% of voice traffic[58], with 3G and 2G carrying 81% and 12% of voice traffic respectively.

Figure 8 - Mobile data traffic (GB, Millions)



Source: Ofcom analysis of operator data, June 2017, May 2018

Differences across the Nations

While the ongoing roll-out of 4G services has led to improvements, mobile coverage is still worse in Northern Ireland, Scotland and Wales than it is in England.

Coverage varies considerably among mobile operators and remains poor in many places, with only 57% and 38% of geographic area covered by good 4G services from all operators in Wales and Scotland respectively compared with 79% in Northern Ireland and 82% in England. This is unsatisfactory and more needs to be done to improve coverage in all the nations. Figure 9 shows the parts of the UK that have outdoor 4G coverage from all operators, the parts that have coverage from some operators and the parts that have no coverage at all.

[58] In terms of the proportion of total minutes of originated calls.

Figure 9 - Complete and partial 4G not-spots

Source: Ofcom analysis of operator data

Further details about the coverage in each nation are available in our nations reports.[59]

Internet of Things

The Internet of Things (IoT) is a network of "things" connected to the internet. IoT will affect our every-day lives, businesses and industries; it provides opportunities for improving standards of living, enabling cost savings and providing new avenues for revenue generation.

IoT faces a number of challenges; one of which is connectivity. Today, mobile operators support IoT and machine-to-machine (M2M) services via their 2G, 3G, and 4G mobile networks.

As the IoT market develops, a number of IoT use cases have emerged for which existing traditional cellular networks are not the best option (e.g. smart meters in the basement of buildings). Low Power Wide Area (LPWA) networks can provide alternative connectivity for IoT applications requiring low cost, ubiquitous coverage and a long battery life.

Low Power Wide Area (LPWA) Technologies

The last Connected Nations Report introduced LPWA networks and discussed in detail LPWA technologies, some of which are listed below for reference.[60]

LoRa (LoRaWAN)
LoRa is a wide area network technology, developed by the non-profit LoRa Alliance and operates in the 868 MHz band in Europe which is exempt from licensing. This facilitates easier entry for new providers without requiring any prior authorisation.

Sigfox
Sigfox is an LPWA technology developed by a French-based company of the same name. Sigfox transmits data using "Ultra Narrow Band" (UNB) radio technology enabling good coverage with very low transmission power. Sigfox, like LoRa, operates in the unlicensed ISM band 868 MHz.

NB-IoT
NB-IoT (NB for "Narrow Band" – giving a lower data rate but greater penetration) is a 3GPP[61] standardised technology optimised for cheaper wireless modules and very long battery life. NB-IoT can be used within the LTE bands as well as in other licensed radio spectrum outside the normal LTE bands.

[59] https://www.ofcom.org.uk/research-and-data/multi-sector-research/infrastructure-research/connected-nations-2018/nations
[60] https://www.ofcom.org.uk/__data/assets/pdf_file/0016/108511/connected-nations-2017.pdf
[61] 3GPP is the global standardisation body for mobile technologies.

LTE-M

LTE M is another 3GPP standardised technology. Like NB-IoT, LTE-M is suitable for low-bandwidth cellular communications for devices with long battery life. The main difference between NB-IoT and LTE-M is that LTE-M supports higher data rates (up to 1 Mbit/s), while also having better latency. It also supports mobility and potentially voice services.

There are currently no deployments of LTE-M or NB-IoT in the UK, and the four UK mobile operators currently have no live deployments of LPWA networks.[62] However, trials have taken place and Vodafone plans to launch NB-IoT in the UK in 2019.[63]

In November WNDUK, Sigfox network operator for the UK, announced that 1,000 base station are covering over three quarters of the UK's population.[64]

Initiatives to improve mobile communications

Mobile coverage is improving, but so are consumers' expectations. We continue to work with the UK and devolved governments and companies to improve mobile communications in the UK and set out below our key initiatives to improve services across the UK.

Making more spectrum available for coverage

As set out in our Strategic Review of Digital Communications, the award of the mobile airwaves in the 700 MHz band provides an important opportunity to improve coverage.

To ensure mobile operators provide good quality coverage to more of the UK, we are consulting on including two coverage obligations in the award of 700 MHz and 3.6 GHz spectrum. Our proposed obligations would require the licence holders to improve geographic coverage for at least 90% of the UK's landmass (including improving coverage in each of the nations), as well as delivering outdoor coverage to an additional 140,000 premises and deploying a minimum of 500 new sites.[65]

We have made more spectrum available for capacity and performance with both 4G and 5G

This year we auctioned and released 40MHz of 2.3 GHz spectrum, ideal for providing extra speed and capacity to 4G mobile services. This spectrum is supported by many mobile devices today and has already been put into service to improve performance across large areas.

We also auctioned and released 150 MHz of spectrum at 3.4 GHz that may be used for 5G services in the future.

In addition, we recently changed the regulatory regime at 57-66 GHz as well as making new spectrum available at 66-71 GHz, to make a total of 14 GHz available for a range of fixed and mobile applications, including 5G, on a licence exempt basis.

Innovative spectrum uses

[62] Refer to https://www.gsma.com/iot/mobile-iot-commercial-launches/ for the most up-to-date information
[63] https://www.vodafone.com/business/news-and-insights/press-release/vodafone-to-double-size-of-nb-iot-network-to-expand-enterprise-possibilities
[64] https://www.sigfox.com/en/news/wnduk-sigfox-network-operator-uk-announces-1000-base-station-installs-covering-more-50-million
[65] https://www.ofcom.org.uk/consultations-and-statements/category-1/award-700mhz-3.6-3.8ghz-spectrum

To enable opportunities for innovation, we are proposing to enable new users shared access to spectrum bands supporting mobile technology in locations not used by other licensed users.[66] This includes the 3.8-4.2 GHz band which is covered by 5G technology standards. This could enable new users to access spectrum for new business models and services, including 5G applications and high capacity wireless solutions that may address rural broadband coverage.

Improving coverage in buildings and in vehicles

This year we introduced new regulations that allow people to use some types of mobile phone repeaters without the need for a licence.[67] These repeaters can be an effective low-cost solution to help to boost mobile signal indoors and in vehicles.

Improving coverage in rural areas by addressing barriers and reducing costs

We continue to work with the UK and devolved governments and companies to improve rural coverage in other ways. We have also supported changes to the Electronic Communications Code and to planning laws, to make it easier and cheaper to deploy mobile infrastructure.

We have provided advice to the UK Government following technical analysis of a variety of options to improve mobile coverage.[68] The advice focused on public subsidy, rural wholesale access (commonly known as rural roaming), infrastructure sharing and planning reform.

An example of public funding is the Scottish Government's *Scottish 4G Infill* Programme, which aims to extend 4G coverage to areas not covered by commercial roll out. Up to £25m of public funding, including funding from the European Union, will be invested to deliver 4G mobile infrastructure to serve selected mobile 'not-spots' throughout Scotland.[69] [70]

Potential impact of innovation and 5G

We fully support the UK Government's aspiration to be a world leader in the next generation of mobile technology, 5G, with deployment to the majority of the country by 2027.

The improved performance, speed, latency and capacity from 5G will support innovative new mobile communications services in various sectors of the economy.

To date, some small-scale trials are operating across the UK ahead of commercial launches expected in 2019. Our release of 5G spectrum, trial licensing, and flexible shared spectrum models are supporting innovation.

Improving rail coverage

Providing good connectivity to train passengers has a huge value to productivity and consumer convenience. However, this can be challenging due to modern train construction, cuttings, tunnels, and the very rural locations of some train routes.

Ofcom has recently published advice to the UK Government on current and future demand for data services from passengers on

[66] https://www.ofcom.org.uk/consultations-and-statements/category-1/enabling-opportunities-for-innovation
[67] https://www.ofcom.org.uk/consultations-and-statements/category-2/mobile-phone-repeaters
[68] https://www.ofcom.org.uk/phones-telecoms-and-internet/coverage/advice-government-improving-mobile-coverage
[69] https://news.gov.scot/news/improving-mobile-coverage-2
[70] https://www.gov.scot/publications/scottish-4g-infill-programme-consultation-request-information/

mainline railways; the spectrum bands that have the potential to meet these requirements and could be used for track-to-train connectivity; and how, in principle, Ofcom might authorise the use of spectrum for rail connectivity.[71]

We continue to work with industry and UK Government as they further develop plans to improve passenger connectivity on rail routes. Wi-Fi systems in train carriages are increasingly being made available. They are linked to roof top antennae that connect to mobile operator networks for internet and other service access. Whilst these are providing some improvements, they rely on a good outdoor mobile signal connection to the train, which is often not available in many tunnels, deep cuttings and rural areas. The UK Government and Network Rail are looking at options to improve this, including the use of dedicated trackside infrastructure providing additional connections using other radio spectrum.[72]

Underground trains are particularly difficult to serve, but Transport for London plans to offer mobile connectivity from all operators in London. TfL plans to launch the first phase of 4G services on the London Underground in 2019.[73]

Better coverage information

We have examined the coverage claims by all mobile operators and have identified errors in EE's 3G and Vodafone's 4G data. Corrections to these have been applied and the effected coverage metrics are restated in this report.

We are also enabling access to our coverage database by launching an API. This will make coverage information available to third party websites and apps (content providers, price comparison websites, etc.).

Alongside these improvements in the communication of accurate coverage, Ofcom has helped create an industry working group to provide more consistent information on mobile coverage.

Making mobile coverage data more widely available

This report is accompanied by an interactive dashboard to provide readers with the ability to explore the data in greater depth and allow them to create customised views.[74] Additionally, Ofcom makes data available at an aggregate level for anyone to access use and share.[75]

The data that supports this report has also been used to update our coverage checker app for smartphones and tablets, which helps people check the availability of fixed broadband and mobile services in their area.[76]

We are making an API available for the first time, allowing users and organisations access to Ofcom coverage data on a premise by premise basis, which they can use in services such as apps and widgets. This will make it easier for third party websites to integrate the mobile coverage information available on our coverage checker.

[71] https://www.ofcom.org.uk/__data/assets/pdf_file/0024/123657/Rail-connectivity-advice-DCMS.pdf
[72] https://www.gov.uk/government/news/trans-pennine-railway-5g-trial
[73] http://content.tfl.gov.uk/fc-20181213-item07-tfl-business-plan-approval.pdf
[74] https://www.ofcom.org.uk/research-and-data/multi-sector-research/infrastructure-research/connected-nations-2018/interactive-report
[75] https://www.ofcom.org.uk/research-and-data/multi-sector-research/infrastructure-research/connected-nations-2018/data-downloads
[76] http://www.ofcom.org.uk/checker

Security and Resilience

Introduction

The security and resilience of fixed and mobile networks and services is increasingly important. This section summarises the major security and resilience issues that were reported to us over the past year along with some key themes from our work.

Our role in security and resilience

Providers of public communications networks and services are subject to certain security requirements.[77] These include an obligation to appropriately manage security risks, to prevent or minimise impacts of security incidents on customers, and to report certain breaches of security or network failures to us. It falls to Ofcom to enforce these obligations. In doing so, we work closely with the UK Government and its agencies, who have a particular interest in the security and resilience of critical national infrastructure.

This year, the Network and Information Systems Regulations 2018 ("NIS Regulations") came into force extending security obligations similar to those mentioned above to a wide range of additional companies in several different infrastructure sectors across the UK economy. The Regulations give Ofcom an enforcement role in relation to companies providing essential "Digital Infrastructure" services. These are companies which provide certain important internet functions.

We recently published our initial guidance setting out our expectations of the companies we will regulate under the NIS Regulations.[78]

Key highlights:

- The majority of reported security incidents continue to relate to small scale and short duration interruptions in voice services. This is a result of our lower reporting thresholds for outages that affect consumer access to 999 services;
- The majority of incidents are caused by the failure of hardware components, the loss of power supply or by software bugs, often linked to a lack of failure or resilience in the access network;
- However, incidents that have the greatest impact are the result of major, national mobile network failures and we are working to address how their likelihood and impact can be mitigated.

[77] In accordance with Article 13a of the Framework Directive, sections 105A-D of the Communications Act 2003 place requirements on providers and Ofcom regarding the security and resilience of communications networks and services.

[78] https://www.ofcom.org.uk/phones-telecoms-and-internet/information-for-industry/guidance-network-information-systems-regulations

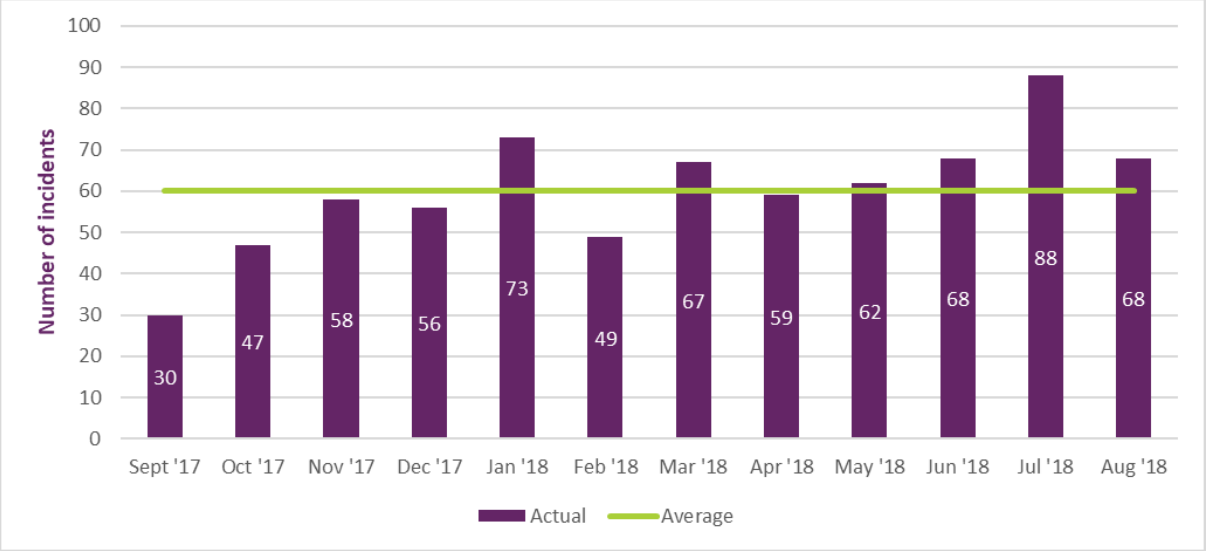
Resilience of fixed and mobile networks

Most reported incidents relate to voice services, often affecting consumer access to the 999 emergency services

In the past year, 726 security incidents meeting our thresholds were reported to us by fixed and mobile providers under the requirements in s105B. This is a small increase in the number of incidents reported over the previous year. At the time of writing, we had not yet received any reports from companies under the NIS Regulations.

Figure 10 summarises the number of incidents reported each month between September 2017 and August 2018. The monthly variation could be the result of seasonal factors, although we note there is little, if any, correlation with the variations seen in last year's report. We continue to monitor for trends over time.

Figure 10: Number of incidents reported between September 2017 and August 2018



Source: Ofcom analysis of operator data

Framework for incident reporting

Under s105B, companies are required to report breaches of security or reductions in availability that have a significant impact on their network or service. Our guidance provides quantitative criteria, or thresholds, against which a provider can gauge the impact of an incident and determine if it should be reported. The most critical is the 'emergency services access' threshold which applies to incidents that affect voice access to the emergency services for 1000 customers, for one hour.

We measure the impact of an incident in 'customer-hours' of lost service. This is the product of an incident's duration and the number of people affected. While customer-hours is not the only metric by which incidents may be measured, it provides a useful basis for comparison.

We note that reported mobile incidents tend to have larger customer-hour figures than fixed incidents. One reason for this is the ability of mobile customers to roam to other networks to make emergency calls. Mobile networks are often designed with overlapping signals from multiple transmitters – so the loss of a single transmitter does not always result in a loss of service. This means that the smaller mobile incidents are often not reportable against our thresholds. At the other end of the impact scale, most of the

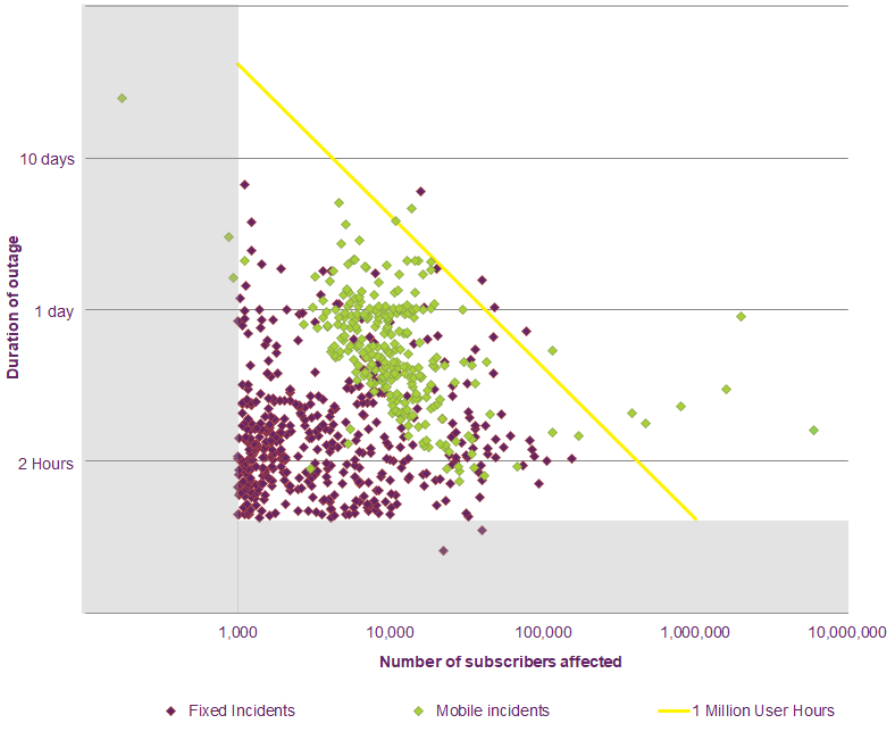
largest incidents are from mobile networks. We think that, to some extent, this is due to overly pessimistic estimates of the number of customers affected in some mobile operator reports. As discussed above, we are working with the mobile operators in order to improve the consistency of reporting. However, as recent events have shown, some protracted and widespread mobile network incidents can have the most disruptive impact and, as noted below, we intend to work with industry to find ways to mitigate such risks.[79]

Drawing comparisons between fixed and mobile incidents continues to be challenging due to the differences between the networks. Due to the inherent mobility of mobile customers, mapping between the affected infrastructure and the impact in terms of geographic area, the number of customers, and the service affected, is an estimate, rather than a precise calculation (as is the case for fixed networks).

We are concerned that there remain significant differences between the mobile operators in deciding which incidents should be reported and how their impacts should be calculated. There has been improvement from some mobile operators, but not from others and we are increasing our engagement with the mobile operators to further address this issue.

Figure 11 shows the customer-hours impact of the 726 incidents that were reported to us, split between fixed and mobile networks.

Figure 11: The impact of incidents reported to Ofcom, between September 2017 and August 2018

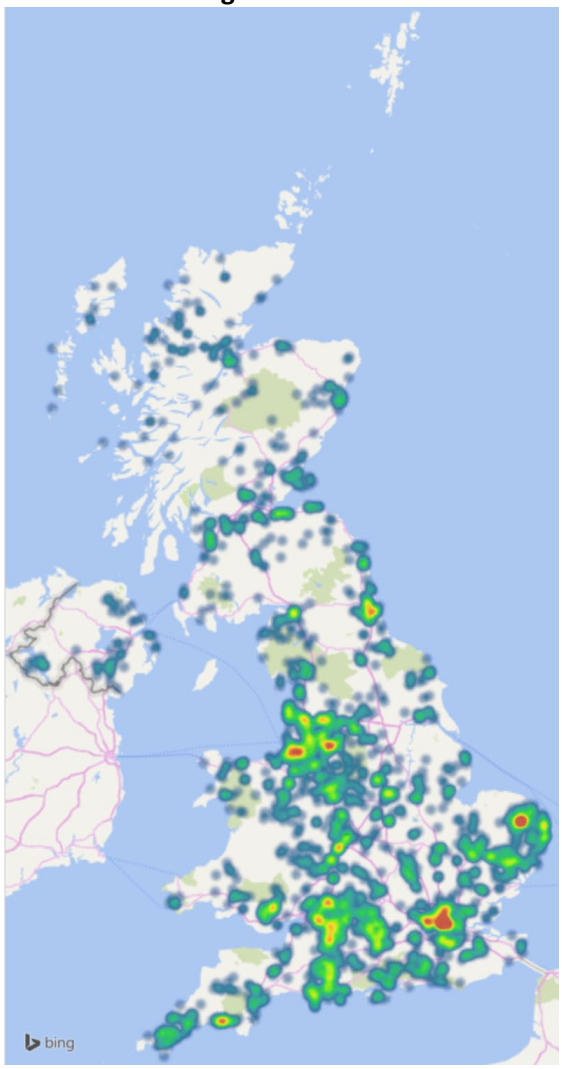


Source: Ofcom analysis of operator data

[79] https://www.bbc.co.uk/news/business-46464730

Figure 12 shows how the reported incidents are geographically distributed across the UK and reveals that there is a correlation between incident frequency and population density. Where population densities are higher, a higher concentration of network equipment, or assets, is required to provide services.

Figure 12: Heat map showing the distribution of incidents throughout the UK



Source: Ofcom analysis of operator data

Main causes of network outages

Establishing the root causes of incidents is central to understanding risks to the security and resilience of networks and services. There are four broad categories of root cause used in reporting at a European level. Of these, system failure is overwhelmingly the main root cause of significant network incidents; 90% of reported incidents fall into this category. This includes hardware and software failures, and the failure of systems, processes and procedures. Human error, natural phenomena (which includes severe weather) which were responsible for 3% and 6% of the reported incidents, respectively. There were 2 incidents which were caused due to 'malicious actions'.

Figure 13 shows that incidents were reported against a wide range of primary causes. 'Hardware failure' is the most common primary cause, followed by 'power cut', 'cable break' and 'software bug'. Together these causes account for over 86% of the incidents that are reported to us.

We are also working closely with the UK Government and its agencies to address other key aspects of security and resilience, for example by contributing to the recently announced Supply Chain Review being led by DCMS. This will address how to ensure that the systems and services that communications providers rely on to build and operate their networks are secure in both design and delivery. In the light of both the recent high profile network incidents apparently attributable to supply chain issues and the concerns expressed about individual supplier design and operational practices, this is a key priority.[80]

This work will also address the vulnerability of networks to the failure of other key assets or elements, such as those that led to the recent

[80] https://www.theguardian.com/technology/2018/dec/07/huawei-pledges-2bn-in-effort-to-allay-uk-security-concerns

data service failure on the O2 network on 6 December 2018.[81]

O2 outage – 6 December 2018

Starting early on the morning of 6 December, O2 suffered a major network failure which resulted in a loss of data services for the vast majority of its customers. The failure affected all of O2's networks (2G, 3G and 4G) and both its direct customers and those of MVNOs like Tesco, Sky and TalkTalk Mobile, giffgaff and Lycamobile, which all rely on O2's networks.

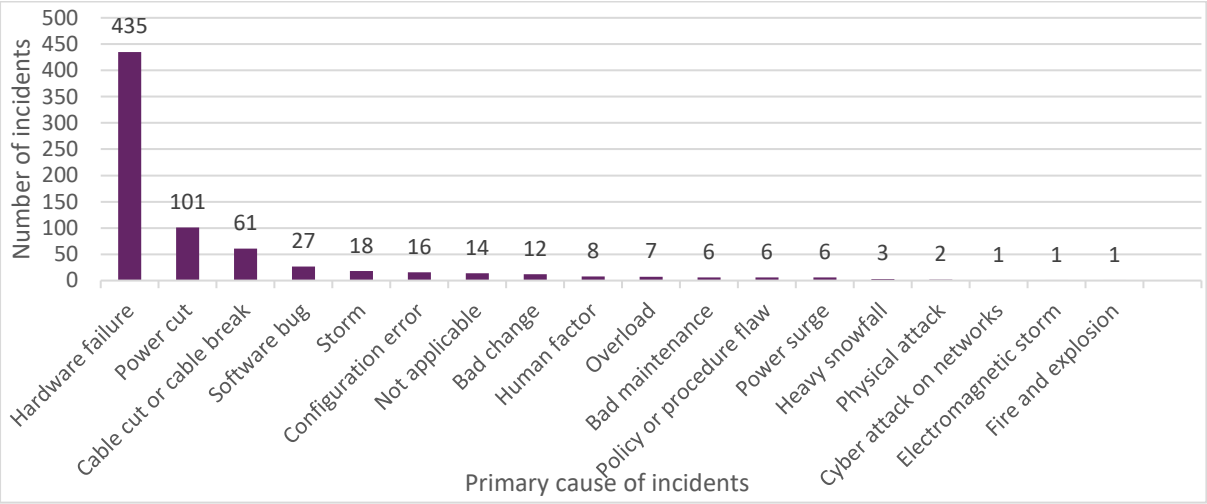
It took until 10pm on the 6th to fully restore service on the 3G network and 3am the following day for 4G. Some customers also experienced problems with voice and SMS services during the restoration process.

O2 explained the root cause of the failure was an expired digital certificate in the software used by one of its core network elements.

Given the very high impact this had on consumers and businesses, we will work with operators, vendors and the UK Government to determine what could be done to mitigate some of the associated risks. While this specific case was related to the O2 physical network, we believe there are a number of key areas across all networks where Ofcom can play an important role to mitigate the likelihood of large-scale outages and to reduce their impact when they do occur. In particular we will:

- Identify those network elements key to network availability and propose systematic preventive hardware, software and process checks to improve network availability and resiliency;
- Propose a code of best practice to reduce the time required to reconnect subscribers following a large-scale network outage; and
- Examine whether it is feasible for networks providing services on a significant wholesale basis, for instance to large MVNOs, to offer greater levels of redundancy and resilience in the control plane.

Figure 13: Primary cause of incidents reported to Ofcom, September 2017 to August 2018



Source: Ofcom analysis of operator data

[81] https://www.theregister.co.uk/2018/12/06/ericsson_o2_telefonica_uk_outage/

Resilience of networks to localised power and transmission issues

We are also working with providers to better understand the current and future level of network resilience.

During 2019 and beyond, we intend to collect information from providers about their approach to network design, with particular emphasis in the short term on the type of "single point of failure" in "backhaul" or other network transmission links referred to above. It is accepted that, for fundamental economic reasons, some network links will not have built in redundancy or alternative routing, particularly in access networks for nodes serving perhaps only a few hundred customers. We would like to establish what best practice is in making such design decisions and what network topology and technology choices are available to provide greater resilience and a better consumer experience.

In addition, we asked what plans they have to improve their resilience where there is a failure in the "mains" electricity supply. Traditionally, PSTN voice networks have had a high level of power resilience with core network elements generally having both battery and generator back-up sufficient for a number of days, with those facilities also powering access networks and conventional "corded" telephones connected to them.

Today's core networks follow this multi-day resilience across both fixed and mobile networks, However, more modern fibre-rich and radio access-based networks do not necessarily offer the levels of protection that the PSTN afforded people. This is partially due to the fact that mobile networks usually serve most locations from several transmitters – this overlapping coverage provides a certain amount of resilience inherently.

We think it is important that stakeholders and people are properly informed about the levels of resilience available. For this year's report we have asked a number of initial questions in order to better understand the power protection arrangements that companies have in place. We intend to build on this with more quantitative data in the future and consider how we can use this to provide information for people about the level of service they can expect from different technologies during extended power interruptions. We will also continue to work closely with the UK Government in order to assess and mitigate the impact of major power outages.

Summary of power resilience arrangements for networks

The specific arrangements in place to deal with mains power interruptions vary between companies, but some elements are similar.

For core network nodes, fixed exchanges, and some remote mobile sites, back-up arrangements are expected to able to support normal operation for 2-7 days, with continuous operation beyond this possible with regular refuelling of generators.

Mobile "hub" sites, through which other base stations are connected to the network, tend to have 4-8 hours of battery protection with longer term back-up provided by either on-site or temporary generators. Other mobile sites typically have little or no on-site protection, with a figure of 10 minutes typical duration given by one mobile operator. Most street cabinets and other powered nodes within the fixed access network have battery back-up lasting between 2 and 24 hours.

The pre-provisioned back-up power at a site is often intended to provide continuity until a

temporary generator can be deployed to the site as a longer-term solution. Some companies have tens or hundreds of their own generators distributed around the UK for this purpose, while others rely on contracts with third party suppliers. All companies have arrangements in place for refuelling their fixed and temporary generators. In principle this should mean that there is no restriction on how long back up power could be maintained, although these arrangements could be challenged by particularly long or widespread power cuts.

Many of the companies do not offer any back-up power facilities for the equipment they provide to customers. However, several that offer a voice service delivered over a full-fibre connection noted that they do provide a battery back-up unit that operates for 1 hour in the event of a local power outage. Some provide back-up only to vulnerable customers, or can recommend a solution for customers requesting it.

The impact on customers

Some companies rightly pointed out that power cuts of extended duration are rare events. The most extreme form of this – a complete nationwide loss of electricity, which plans suggest might last 5 days – is included in the UK Government's National Risk Register.[82]

When power cuts do occur, however, the experience for the mobile customer is difficult to predict, not least because it will depend on exactly where in the UK they happen to be at the time. It is possible, if they remain within coverage of a major site, or are in certain rural areas, that their service would continue to operate as normal indefinitely, provided they are able to charge their mobile device when required. However, in other areas, service, including the ability to call the emergency services, could fail immediately.

For the new generation of fixed broadband and voice networks, it is clear that the levels of power resilience do not match those offered by the traditional fixed voice network. As with mobile, fixed providers' national networks are generally well protected. However, customers affected by a local power outage are likely to lose the ability to make emergency and other voice calls, if not immediately then within a few hours.

Resilience of networks to external factors

As noted earlier, power outages of one form or another are one of the most common causes of network and service unavailability. With the current changes in network technologies, noted elsewhere, it is an obvious focus for investigation to ensure consumer expectations continue to be met.

However, there are a number of other factors that can fundamentally impact resilience and the consumer experience. Some of these, such as reliance on single network links to provide service to particular groups of customers or to unique network assets, are the result of design and operational practice decisions based on risk assessments and cost benefit analysis. Others, such as susceptibility to natural events such as flooding and "space weather" phenomena such as Coronal Mass Ejections, can be mitigated through adopting appropriate design principles but cannot be eliminated entirely.

82 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/644968/UK_National_Risk_Register_2017.pdf

With regard to natural events, the flooding that occurred in many parts of the UK in 2015 and 2016 exposed some previously poorly understood vulnerabilities in a number of telecoms networks including some serving critical national infrastructure.[83] In the wake of these events, the UK Government undertook the National Flood Resilience Review which looked at the potential impact of river and tidal flooding across several infrastructure sectors, including fixed and mobile telecommunications.[84] While this work identified a number of short term mitigations that providers have implemented, with significant new network investment now being made, we think it is important that information on best practice in network design choices is more widely available.

The issues associated with the impact of so called "space weather" are becoming better understood.[85] The direct impact of "solar storms" on some forms of radio communications is perhaps obvious. However, there are other less obvious effects such as network timing problems caused by degradation of satellite- based GPS services that may have a greater impact overall. Industry is working to understand these issues and recently completed a sector-wide exercise to test and improve response arrangements to a major event. Again, we think it is appropriate to ensure that best practice is clearly defined.

Focus on cyber security

Cyber-attacks are among the highest profile threats facing our sector today. Cyber security is a top tier national security priority for the UK Government and there have been major cyberattacks on several companies in various UK sectors. The National Cyber Security Centre (NCSC) reports that it has dealt with over 1,000 cyber incidents since its launch in October 2016.

The incidents reported to us are rarely attributed to cyber-attack, because causing a service outage has not often been the objective of such attacks. However, a sophisticated and successful cyber attacker has the potential to cause huge disruption if that is the objective. Given the critical role the services provided by our sector plays in the economic and social life of the UK, it is essential to ensure they are properly protected against cyber threats.

At the end of 2017 we updated our guidance on the security requirements for communications providers to clarify that managing these sorts of cyber security risks is an essential part of compliance. As mentioned above, in May this year the NIS Regulations came into force, with Ofcom appointed as the regulator for the "digital infrastructure subsector". While the Regulations require that the companies in scope take appropriate steps to manage all security threats, there is a strong focus on cyber security in many parts of this new legislation.

The companies regulated by Ofcom under the NIS Regulations are collectively known as Operators of Essential Services (OES) and have often not been subject to our regulation before. They divide into several groups:

- companies which register and administer internet domain names;
- companies which operate parts of the Domain Name System – essentially the internet phone book; and

[83] For an example see - https://www.raeng.org.uk/publications/reports/living-without-electricity
[84] https://www.gov.uk/government/publications/national-flood-resilience-review
[85] For example: https://www.raeng.org.uk/publications/reports/space-weather-full-report

- companies which operate Internet Exchange Points at which internet traffic is interconnected.

As a result of these developments, we are increasing our oversight of the levels of cyber security achieved by the companies we regulate, both communications and digital infrastructure providers. We are working with these companies to ensure they take measures to manage the security risks to their networks and services and prevent and minimise the impact of incidents.

To do this effectively, we are working closely with the NCSC in their role as the UK technical authority on cyber security, and with DCMS.

Glossary

2G Second generation of mobile telephony systems. Uses digital transmission to deliver: voice, text services and very low-speed data services.

3G Third generation of mobile systems. It can be used to deliver: voice, text and lower speed data services. It supports multi-media applications such as video, audio and internet access, alongside conventional voice services.

4G Fourth generation of mobile systems. It can provide download speeds of over 10 Mbit/s, and is used to deliver: voice, text and higher speed data services.

5G will be the fifth generation of mobile technology. It is expected to deliver faster, lower latency mobile broadband, and to enable more revolutionary uses in sectors such as manufacturing, transport and healthcare.

Access network An electronic communications network which connects end-users to a service provider; running from the end-user's premises to a local access node and supporting the provision of access-based services. It is sometimes referred to as the 'local loop' or the 'last mile'.

ADSL Asymmetric Digital Subscriber Line. A digital technology that allows the use of a standard telephone line to provide high-speed data communications. Allows higher speeds in one direction ('downstream' towards the customer) than the other.

Backhaul The part of the communications network which connects the local exchange to the ISP's core network

Base station This is the active equipment installed at a mobile transmitter site. The equipment installed determines the types of access technology that are used at that site.

Decent Broadband A data service that provides download speeds of at least 10 Mbit/s and upload speeds of at least 1 Mbit/s.

Broadband A data service or connection generally defined as being 'always on' and providing a bandwidth greater than narrowband connections.

Broadband USO Broadband Universal Service Obligation. This will give consumers and businesses the right to request a broadband connection capable of delivering a download sync speed of 10Mbit/s and an upload sync speed of 1Mbit/s.

Core network The central part of any network aggregating traffic from multiple backhaul and access networks.

DOCSIS Data Over Cable Service Interface Specification. It is a standard for the high speed transmission of data over cable networks.

DSL Digital Subscriber Line. A family of technologies generally referred to as DSL, or xDSL, capable of transforming ordinary phone lines (also known as 'twisted copper pairs') into high-speed digital lines, capable of supporting advanced services such as fast internet access and video on demand. ADSL and VDSL (very high speed digital subscriber line) are variants of xDSL).

FTTC Fibre to the Cabinet. Access network consisting of optical fibre extending from the access node to the street cabinet. The street cabinet is usually located only a few hundred metres from the subscribers' premises. The remaining segment of the access network from the cabinet to the customer is usually a copper pair.

FTTP Fibre to the Premises. A form of fibre optic communication delivery in which the optical signal reaches the end user's home or office. Also known as full fibre broadband.

FTIR Future Telecoms Infrastructure Review. This document sets out the government's ambition for digital connectivity published in July 2018.

Full fibre coverage Where the network has been rolled out to a "lead-in" that will serve the consumer end premise and where the customer would expect to pay a standard installation charge for that connection

HD or **HDTV** High-definition television. A technology that provides viewers with better quality, high resolution pictures.

IP Internet Protocol. This is the packet data protocol used for routing and carrying data across the internet and similar networks.

IoT Internet of Things. Embedded connectivity in everyday things, enabling them to send and receive data.

LTE Long Term Evolution. This is 4G technology which is designed to provide faster upload and download speeds for data on mobile networks.

M2M Machine to Machine. Wired and wireless technologies that allow systems to communicate with each other.

MNO Mobile Network Operator, a provider who owns a cellular mobile network.

Not-spot An area which is not covered by fixed or mobile networks.

PSTN Public Switched Telephone Network. The network that manages circuit switched fixed line telephone systems.

SIM Subscriber Identity Module. A SIM is a small flat electronic chip that identifies a mobile customer and the mobile operator. A mobile phone must have a SIM before it can be used.

Smartphone A mobile phone that offers more advanced computing ability and connectivity than a contemporary basic 'feature' phone.

Superfast broadband A data service that delivers download speeds of at least 30 Mbit/s.

UHD Ultra High Definition television, providing a resolution of 3840 x 2160 pixels (4K).

Ultrafast broadband A data service that delivers download speeds of greater than 300 Mbit/s.

Usage cap Monthly limit on the amount of data that users can download, imposed by fixed and mobile operators for some of their packages.

VDSL Very High Speed DSL. A high speed variant of DSL technology, which provides a high headline speed through reducing the length of the access line copper by connecting to fibre at the cabinet.

VoIP Voice over Internet Protocol. A technology that allows users to send calls using internet protocol, using either the public internet or private IP networks.

wifi A short range wireless access technology that allows devices to connect to a network through using any of the 802.11 standards. These technologies allow an over-the-air connection between a wireless client and a base station or between two wireless clients.

xDSL The generic term for the Digital Subscriber Line (DSL) family of technologies used to provide broadband services over a copper telephone line.