Mobile networks and spectrum

Meeting future demand for mobile data

Meeting future demand for mobile data – Welsh overview

DISCUSSION PAPER

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1. Overview

Demand for mobile services[1] has grown rapidly over the last decade and we expect that growth to continue with people expecting to access good quality mobile services wherever they live, work and travel. Innovation continues to drive the development of new mobile devices and applications and we expect increasing use of wireless data by machines and devices in the future. Mobile networks will need to expand capacity and improve quality to meet these future business and consumer needs.

Radio spectrum (the invisible waves that enable wireless technology) is a key and finite resource which is essential for mobile networks. Large amounts of spectrum have been made available for mobile: between them, the Mobile Network Operators currently hold 1152 MHz (roughly 30%) of all spectrum below 3.8 GHz. Spectrum is also used across the world to support the delivery of a wide range of other services including TV and radio, transportation and logistics, factory automation and the delivery of public services, as well as monitoring our climate and natural environment.

Demand for spectrum is growing with increasing use of wireless connectivity across different industry sectors, and the impact of technology developments leading to new and innovative applications. This calls for a shift in the way we approach the management of this finite resource.

As the UK's communications regulator, Ofcom has key spectrum management duties to support a wide range of electronic communications services across the UK. Our principal duties are to further the interests of citizens and consumers (where appropriate by promoting competition) and to secure the optimal use for wireless telegraphy of the electro-magnetic spectrum.

[1] A glossary of terms is presented in the accompanying discussion paper setting out our future approach to mobile markets

In this document we set out our initial thinking for discussion and seek stakeholder views - we are not making any proposals at this stage. We hope to encourage longer-term thinking about how public mobile networks in the UK may need to evolve to meet future demand, in light of expected growth and demand for spectrum from other users. In summary we note:

- Mobile data traffic has grown by an average of 40% year on year in recent years and we expect it to continue to grow. However, there is a high degree of uncertainty about the rate of future growth, particularly beyond 2030.
- Mobile networks will need to evolve to meet future demand and deliver the quality of experience needed by consumers and businesses. There are a number of ways in which they might do this, including:

1. More extensive deployment of existing spectrum holdings and planned future spectrum for mobile e.g. in the millimetre wave (mmWave) bands. We will consult on our approach to making mmWave spectrum available shortly;

2. Using technology upgrades to increase the efficiency of the spectrum they use;

3. Network densification – deploying more cell sites – in particular using small cells to leverage the capacity offered by the large bandwidths available from mmWave spectrum.

1.1 This discussion document considers the possible future demand for mobile services to 2035 (in this document we define mobile services as services delivered over public mobile networks). We consider options for how those networks could meet future demand taking account of spectrum, technology developments and potential deployment strategies. Our aim is to encourage longer-term thinking about spectrum for mobile networks and how they can deliver for consumers and business, within the wider context of increasing demand for spectrum from other users.

1.2 Overall, we anticipate that existing mobile spectrum holdings and spectrum already planned for release are likely to be broadly sufficient to meet future demand to 2030, if MNOs were to (i) continue to upgrade network technology; (ii) make full use of their spectrum holdings; and (iii) deploy new mmWave spectrum on a densified network using small cells, in particular in busier areas. There is a greater level of uncertainty in the period beyond 2030.

1.3 Additional new mobile spectrum beyond the existing pipeline of spectrum could help facilitate the provision of additional capacity, but would not on its own be expected to be sufficient to meet future mobile data traffic growth in all areas. Further, making additional spectrum available for high-power outdoor mobile use would likely require clearing bands of existing users. We think there may be opportunities for mobile networks to share spectrum with other users, for example through more localised access or lower power use.

1.4 Alongside this document we have published a discussion paper setting out our future approach to mobile markets, in which we anticipate that significant ongoing investment in mobile networks will be needed to expand capacity, improve quality and deliver new uses to meet future customer needs. Densifying mobile networks as part of this, including with potentially significant numbers of small cells, would be a change in how mobile networks are deployed in the UK. We believe this change will be needed in the medium to long-term to meet anticipated growth in demand, and to optimise the use of mmWave spectrum in capacity-constrained locations.

1.5 We welcome stakeholder inputs on this initial thinking, including on the potential opportunities and challenges associated with network densification in the UK and whether there are opportunities for more spectrum to be made available for mobile use on a local basis. We will take stakeholder inputs into account as we develop our future strategy for mobile spectrum. We plan to set out our initial conclusions by the end of 2022.

This Overview is a simplified high-level summary only. Our thinking is set out more fully in the rest of the document. We invite interested parties to consider the initial analysis we set out in this document and to let us know their own views.

2. Introduction and background

2.1 People and businesses rely increasingly on mobile services for many aspects of everyday life including work, keeping in touch with friends and family, getting around and entertainment.

2.2 In light of this, and our strategic priorities, we want to see continued improvements in the delivery of strong, secure mobile networks to meet the future needs of customers and the country; and the widespread availability of reliable mobile services to keep people and businesses connected wherever they live, work and travel.

2.3 This discussion document sets out our initial thinking on the implications of anticipated future demand for mobile data services for the use of radiofrequency spectrum. It sits alongside our discussion paper setting out our future approach to mobile markets, which outlines our initial thinking on the key changes taking place in the UK mobile market. It also builds on the vision and objectives we identified in our spectrum management strategy.

2.4 Our main focus is on how public mobile networks in the UK may need to evolve to meet future demand and deliver a good quality of experience, in light of growth and demand for spectrum from other sectors. We also consider the potential growth of more localised solutions such as private networks, and mobile device use of other wireless technologies such as Wi-Fi, in so far as they may relate to demand for public mobile network spectrum.

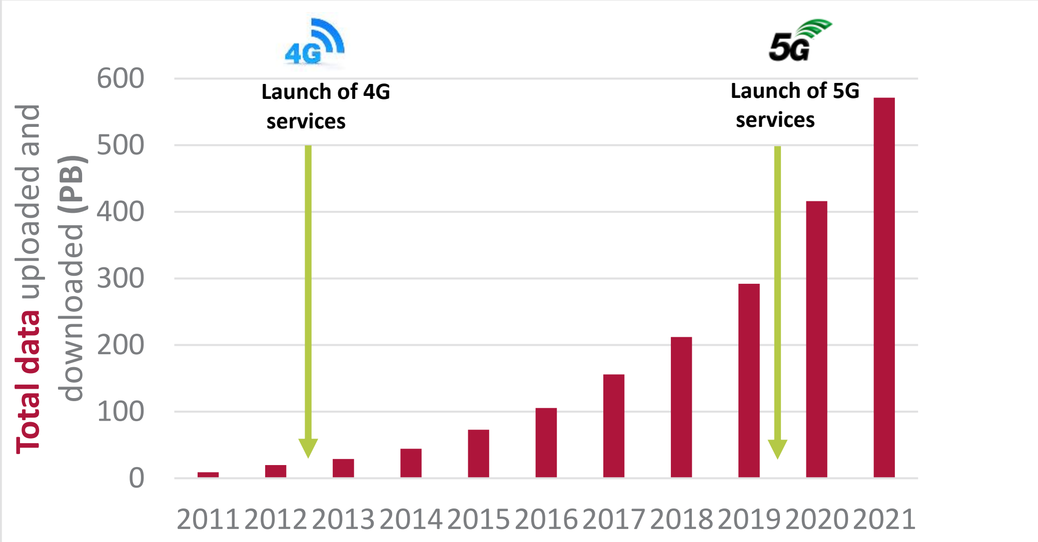
The growth of mobile

2.5 In the UK there are four Mobile Network Operators (MNOs) - EE, Three, Virgin Media O2 and Vodafone. The MNOs also provide wholesale mobile access to many mobile virtual network operators (MVNOs), such as Tesco, iD (Carphone Warehouse), Sky Mobile and others.

2.6 In recent years we have seen an average 40% year-on-year growth in demand for mobile services provided over public mobile networks. This growth has been driven by the development of new applications and enabled by evolving technologies and consequent changes in consumer behaviour.

2.7 We expect demand for mobile data will continue to grow as we rely on it ever more to carry out daily activities like shopping, gaming, banking and watching movies. Demand is likely to be stimulated further as new and more sophisticated applications are developed, and by the development of machine-to-machine and machine-to-device applications.

Figure 1: Growth of monthly mobile data demand 2011-2021



Source: Ofcom analysis from data in annual Connected Nations reports

The role of spectrum in enabling wireless services, including mobile

2.8 Radio spectrum is a key and finite resource used to carry data wirelessly from place to place. As well as mobile, it is vital for a range of communications and other services for people and businesses, including different kinds of wireless broadband connectivity - such as Wi-Fi and Bluetooth - and other technologies such as Zigbee, Sigfox and LoRaWAN.

2.9 Spectrum features daily in all our lives and is a vital element in keeping us all connected and safe. It enables a broad range of services beyond mobile communications and wireless broadband, including the wireless microphones and cameras that support news reporting and entertainment events and systems such as radar used by air traffic control. Spectrum is used for systems that monitor and control road traffic and the utilities we use every day. It enables satellite services that provide TV and navigation systems alongside monitoring the earth and space to deliver accurate weather forecasts and provide data on climate change. Spectrum is also critical to support the emergency services and our armed forces.

2.10 As the UK's communications regulator, Ofcom has key spectrum management duties to support a wide range of electronic communications services across the UK. Our principal duties are to further the interests of citizens and consumers (where appropriate by promoting competition) and to secure the optimal use for wireless telegraphy of the electro-magnetic spectrum.

2.11 Demand for spectrum is growing with increasing use of wireless connectivity across different industry sectors, and the impact of technology developments leading to new and innovative applications. This calls for a shift in the way we approach the management of this finite resource. Accordingly, in our spectrum management strategy for the 2020s we set out our spectrum management vision which outlines how we will enable further innovation by promoting more flexible and efficient use and increased sharing of spectrum while meeting the requirements of local and national services.

2.12 The MNOs hold around 30 % of all spectrum below 3.8 GHz. Until now, growth in demand for mobile services has largely been met by the provision of additional spectrum, deployed at high power levels; the deployment of technology upgrades; and the offloading of traffic onto fixed networks via Wi-Fi. The number of mobile masts has increased only relatively slowly in recent years, and mainly in response to a need to increase coverage rather than to provide additional capacity.

2.13 However, in the future, additional spectrum may not be available or deployed in the same way as in the past, in view of the growth in demand for spectrum across multiple sectors, changing needs and the wider range of frequencies which might be used for mobile.

Why have we published this document?

2.14 Our aim for this discussion document is to encourage longer-term thinking about how public mobile networks in the UK may need to evolve to meet future demand, in light of expected growth and demand for spectrum from other users.

2.15 The document sets out our initial assessment of the expected growth in demand for mobile services up until 2035. Our focus is on the UK's public mobile network operators (the MNOs) and options for how they could meet future demand taking account of spectrum, technology developments and potential deployment strategies.

2.16 While we expect demand for mobile services to continue to grow, there is considerable uncertainty about the growth rate of future demand, in particular beyond 2030. In view of this we have considered three scenarios, with a medium growth scenario based on continued 40% year-on-year growth.

2.17 Overall, we anticipate that existing mobile spectrum holdings and spectrum already planned for release are likely to be broadly sufficient to meet future demand to 2030 if MNOs were to (i) continue to upgrade network technology; (ii) make full use of their spectrum holdings; and (iii) deploy new mmWave spectrum on a densified network using small cells, in particular in busier areas. There is a greater level of uncertainty beyond 2030.

2.18 Additional new mobile spectrum beyond the existing pipeline of spectrum could help facilitate the provision of additional capacity, but would not on its own be expected to be sufficient to meet future mobile data traffic growth in all areas.

2.19 In this document we set out our initial thinking for discussion. We welcome stakeholder inputs on this initial thinking, including on the potential opportunities and challenges associated with network densification in the UK and whether there are opportunities for more spectrum to be made available for mobile use on a local basis. We will take account of stakeholder inputs as we develop our future strategy for mobile spectrum. We plan to set out our initial conclusions by the end of 2022.

Environmental sustainability

2.20 Environmental sustainability will be an important consideration for the mobile industry going forwards, as it is for all businesses and services.

2.21 The Government has set a UK target of net zero carbon emissions by 2050. Many mobile service providers have already responded in a range of ways, such as by signing up to net zero pledges; integrating environmental sustainability principles into business decisions; championing schemes to reduce waste; and working with supply chains to reduce wider impacts.

2.22 The mobile telecoms sector presents particular sustainability challenges and opportunities. Although an increase in the number of physical sites and equipment will have an environmental impact, the mobile telecoms sector is likely to have a unique role in enabling other sectors to de-carbonise themselves - the energy, agriculture, manufacturing and logistics sectors will make use of mobile telecoms to improve their energy efficiency and reduce wastage.

2.23 We will continue to engage with industry to understand approaches to running networks sustainably, and how companies are affected by environmental change.

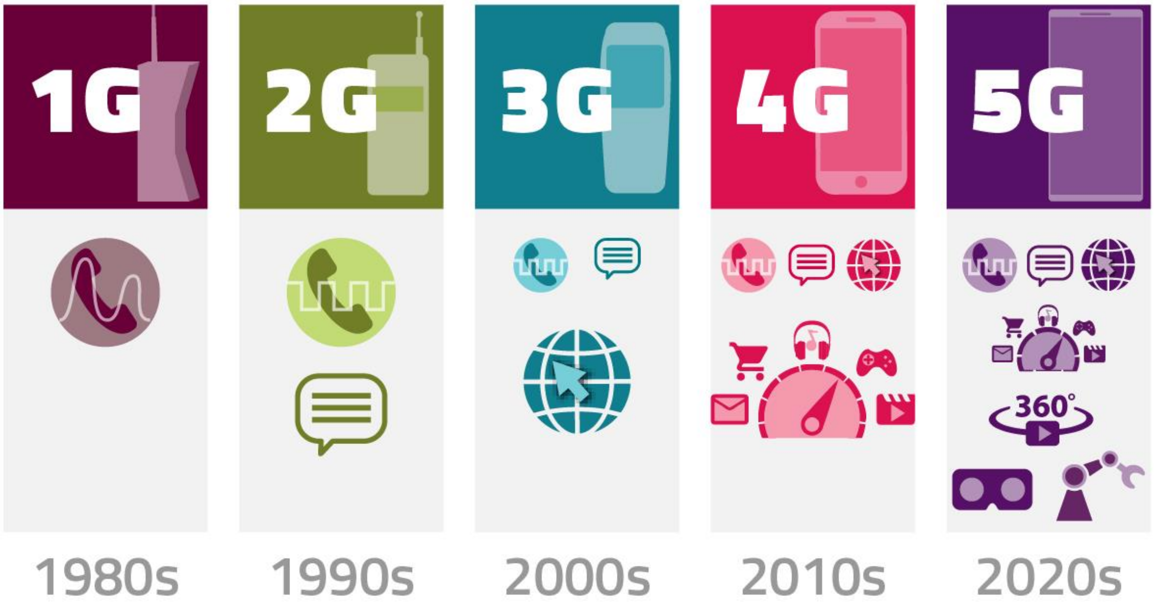
How we set out this discussion

2.24 There are three main parts to this document. Firstly, we set out our initial analysis of the **growth in demand for mobile data** and how MNOs have met that demand; secondly, we consider the potential **future demand for mobile data services**; and finally, we present our initial thinking on the **options for meeting future capacity requirements**.

3. The growth of UK demand for mobile data

3.1 The UK mobile market is operating effectively and serving customers well, with strong competition between the four MNOs and comparatively low prices compared to markets in similar economies overseas. The UK has the lowest standalone mobile prices in a comparison with France, Germany, Italy, Spain and the USA.[2]

Figure 2: Illustration of the development of mobile phone technology



3.2 Each new mobile generation has encouraged and supported the development of new applications and services. While early mobile phones were used only for calls and messaging, modern devices are expected to deliver a wide range of services, the majority of which rely on internet access, such as streaming services, movie downloads, gaming and smart home controls. Mobile has become integral to the productivity of many organisations and crucial to the provision of public services.

3.3 Mobile data traffic has grown significantly over the last 10 years, from less than 500 MB (Megabytes)[3] per mobile data user per month in 2013 to a monthly average of 5.3 GB (Gigabytes)[4] of mobile data use per data user in H1 2021,[5] as mobile technology has evolved from 2G and 3G to 4G and 5G. The total of monthly UK mobile data traffic in 2021 (571.3 Petabytes (PB))[6] is equivalent to 816 million hours of standard definition video streaming.

[2] The UK ranked first overall across three mobile connections using data provided by Teligen (Pricing Trends Report, p60).
[3] One Megabyte (MB) = 1,000,000 bytes
[4] One Gigabyte (GB) = 1,000 MB
[5] Operator data provided to Ofcom, contains estimates where Ofcom does not receive data from operators.
[6] One Petabyte (PB) = 1,000,000 GB

3.4 The growth in traffic has been driven by the evolution of mobile technologies; the wide adoption and use of sophisticated smartphones and the development of new applications making use of the greater capabilities of mobile networks. For example, image sharing was followed by video streaming and sharing and then by the addition of augmented reality interfaces and filters.

Figure 3: Hours per day spent online

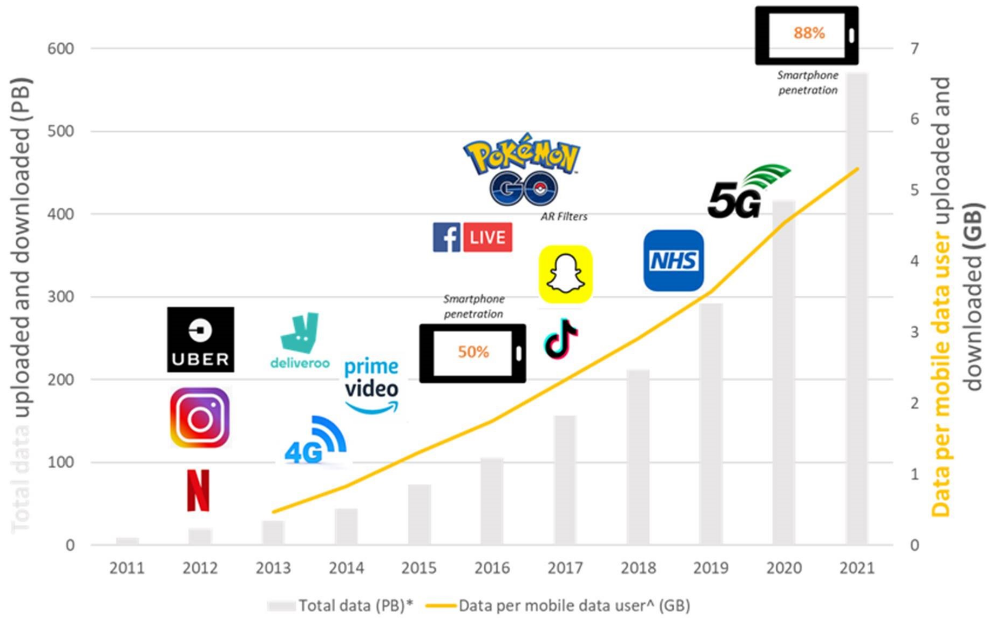
3.5 Ofcom's research shows that by 2021, smartphone take-up was at 88%.[7] Demand has also been stimulated by unlimited data bundles and an improved customer experience of video and other high data applications.

3.6 Tik Tok was launched in the UK in September 2017 but didn't become widely adopted until 2019, when there was a more than 200% growth in downloads of the app. The number of active UK users hit 4.9 million at the beginning of 2019 and continued to grow to more than 6 million active users in May 2020.[8] There is also now a greater penetration of gaming applications that work on smartphones.

3.7 Another technology that drives data demand is Fixed Wireless Access (FWA). FWA can be provided via mobile networks to support the delivery of broadband connections, with services sharing the network capacity with mobile users. Of the four MNOs, only Virgin Media O2 does not offer FWA services. The vast majority of UK premises have potential access to an MNO FWA service.[9] FWA is also offered by other providers.

[7] Source: Ofcom Communications Market Report 2021 interactive data: Market In Context - device and service take-up and use.
[8] Source: Statista. TikTok monthly active users UK 2017-2020 | Statista
[9] See Connected Nations 2021, page 16.

Figure 4: Timeline for use of mobile data (monthly) alongside smartphone penetration and UK launch of apps



**Source: Based on data in annual Connected Nations reports*
^ Source: Operator data provided to Ofcom, contains estimates where Ofcom does not receive data from operators. 2021 figure for H1 2021 only

Mobile networks have evolved in response to growth in demand

3.8 Mobile networks today reflect MNOs' deployment decisions informed by a range of factors including available spectrum capacity in a given area, geography, practical feasibility, and the expected returns on any investment.

3.9 Around 99% of UK premises have outdoor coverage from all MNOs and 92% of the UK landmass is now served by at least one MNO. Between 90% and 95% of premises are predicted to have indoor 4G coverage[10], falling to between 68% and 80% for rural areas as of September 2021.

3.10 While demand for mobile data has grown across the UK over the last ten years, data traffic density has remained highly correlated with where people live, work and travel. For example, in 2021 an average dense urban site carried five times as much data traffic as an average rural site.

3.11 MNOs have primarily addressed growing demand for more and higher quality data-intensive services by increasing the capacity[11] of their networks. This has been primarily achieved by upgrading equipment to the latest technology to deliver greater data traffic

[10] The mobile coverage figures provided are based on predictions which the MNOs supply to Ofcom, with Ofcom undertaking regular testing to ensure the predictions provided are suitable for national and regional reporting. We recognise that there will be some local variations in coverage.
[11] In this discussion paper we use the term capacity to cover both the addition of bandwidth and also improvements in user throughput, reliability and experience associated with extra bandwidth or other upgrades. This is important to the concept of network quality discussed in our discussion paper setting out our future approach to mobile markets.

per unit of spectrum and by the deployment of additional spectrum as it has been made available.

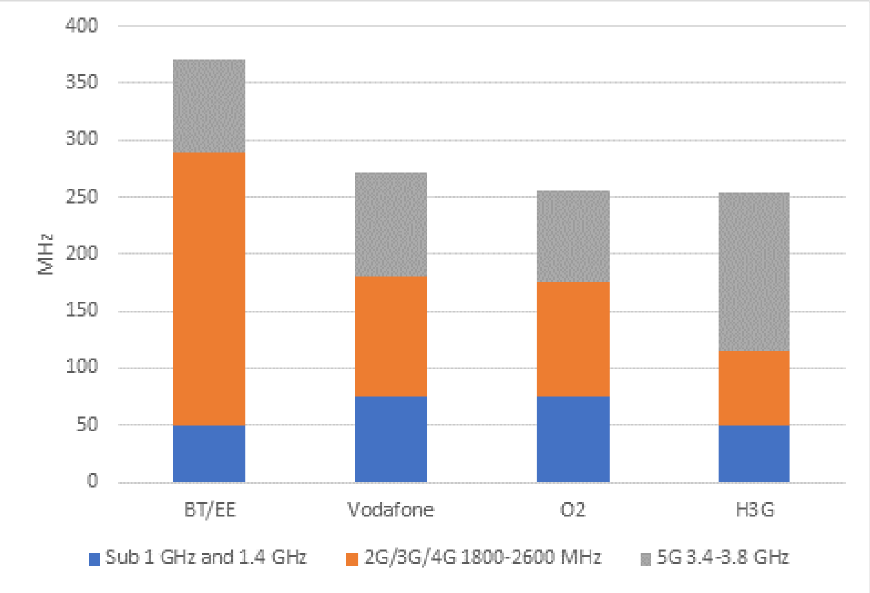
Large amounts of spectrum have been made available for mobile

3.12 MNOs need a balance of spectrum holdings to meet demand for different services and in different locations. In general, **lower frequencies are best for delivering wider coverage** to customers and carrying signals deeper indoors; while **higher frequencies have greater capacity to carry data**, enabling more applications, but provide less good coverage.

3.13 Large amounts of spectrum have been made available for mobile: between them, the MNOs currently hold 1152 MHz (roughly 30%) of all spectrum below 3.8 GHz. Ofcom has generally awarded spectrum for mobile on a UK-wide basis through auctions for national licences.

3.14 As additional spectrum has become available, the MNOs have been able to respond to growing demand through a corresponding increase in network capacity at the same time as increasing their coverage.

Figure 5: Spectrum holdings of UK Mobile Network Operators



Network topologies reflect the uneven spread of demand for mobile data

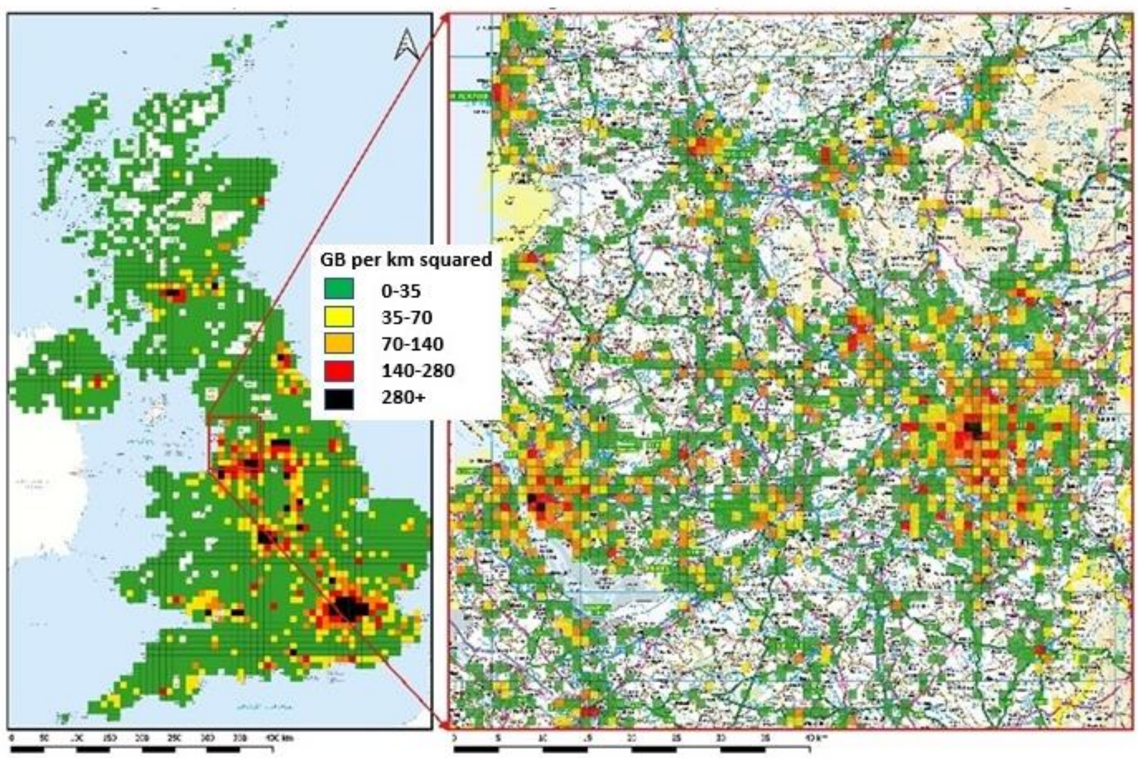
3.15 Current network deployments reflect the uneven geographic spread of mobile data traffic. For example, the MNOs have not deployed all their spectrum holdings in all areas. In less densely populated areas MNOs have often been able to meet local demand without needing to deploy all of their spectrum holdings.

3.16 The overall uneven distribution of mobile data traffic can be seen from the 10x10 km map of the UK shown below. Across all four MNOs total average hourly data traffic across the UK is 260 GB in a single 10x10 km grid square – but data traffic up to 26,000 GB per hour can be seen in the busiest square.

3.17 The uneven distribution of mobile data traffic becomes clearer at a more granular level - as seen in the map of the Liverpool-Manchester corridor shown below, which shows data traffic for 1x1 km grid squares.

3.18 Using Liverpool as an example, we can see that even within the busiest 10x10 km areas, there are pockets of low data traffic revealed at the 1x1 km scale. It is also apparent that the highest levels of demand are being driven by a very small number of dense locations. For example, the two highest traffic grid squares in Liverpool are near the main train stations and retail and leisure areas in the city centre. This highlights that demand can arise in very localised areas. The networks take this uneven spread into account in their deployments.

Figure 6: Total average hourly data traffic: shown for the UK over a 10 km grid and for the Liverpool-Manchester corridor over a 1 km grid



These maps provide a grid view of the UK with aggregated traffic from all MNOs and for all sites. Where there are no MNO sites in a grid square, no shaded grid square is displayed. No sites being present does not indicate no data traffic consumption in a square, but that traffic is served by other nearby sites.

5G is being rolled out in more locations

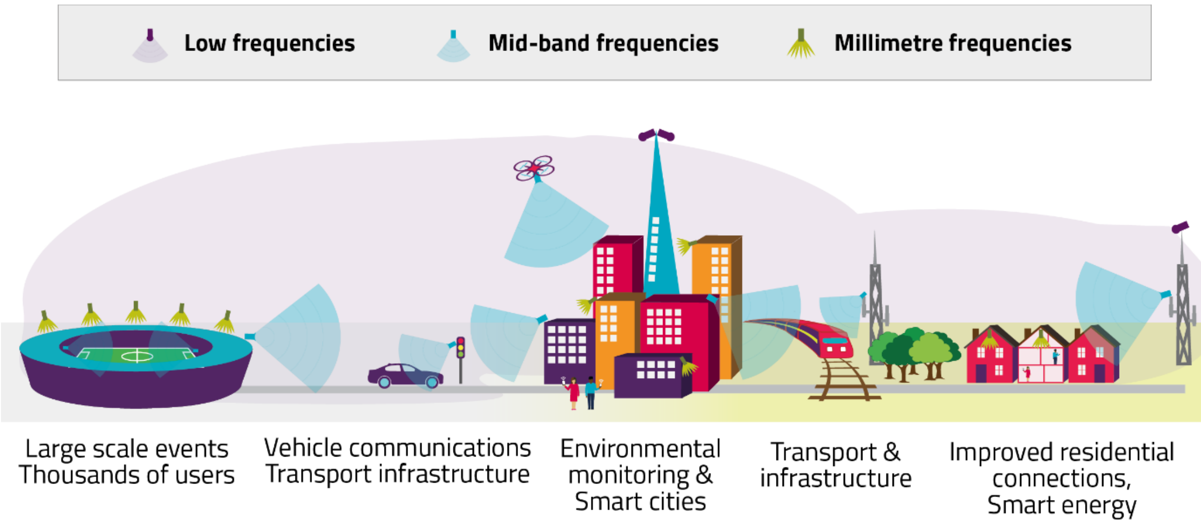
3.19 5G is the latest generation of mobile technology and has the potential to deliver greater reliability than 4G, together with even faster data speeds and very low latency to large numbers of devices, which can enable innovative new services across different industry sectors. It is increasingly being used for the Internet of Things (IoT), connecting wireless gadgets to each other and to the internet.

3.20 Following its UK launch in May 2019, the MNOs have continued to rollout 5G services. It is now available from at least one MNO in approximately half of UK premises and remains largely focused on adding capacity in urban areas.[12]

3.21 The number of sites providing 5G services more than doubled in 2021 to more than 6,500 sites across the UK. It is deployed on around 20% of sites in urban areas and we are increasingly seeing deployments in hotspot suburban areas and busy transport corridors.

3.22 The diverse set of services and applications enabled by 5G require access to different spectrum bands with different characteristics. Spectrum at lower frequencies such as 700 MHz enable 5G coverage to wider areas, while mid-range spectrum (including in the 3.4-3.8 GHz range) provides the necessary capacity to support a high number of connected devices. Even greater capacity will be available when millimetre wave frequencies above 24 GHz (mmWave bands) are released for mobile.

Figure 7: Illustration of how different frequency bands can be used for different functions



Some services offered by mobile networks are being delivered by other technologies

3.23 Most data consumption in homes and offices relies on a fixed broadband connection, often distributed wirelessly within the premises by Wi-Fi rather than mobile. In the last decade, the average volume of data traffic consumed per fixed connection rose from 17 GB a month in 2011 to 453 GB a month in 2021.

[12] Connected Nations 2021 Main report (p34)

3.24 By comparison, the average monthly mobile data use per data user over public mobile networks was 5.3 GB a month in H1 2021.[13] In fact, most of the time, mobile devices are connected to Wi-Fi, which in large part reflects the availability of Wi-Fi at indoor locations such as home, work and school.[14]

Wi-Fi

3.25 Wi-Fi is the preferred option for accessing data-hungry applications like movies and gaming on mobile devices in situations where users don't require wide-area mobile connectivity - particularly indoors. Cisco predicts that by 2023, 69% of all networked devices in Western Europe will be wired or connected over Wi-Fi, compared to 31% connected over mobile.[15]

3.26 All UK MNOs now offer Wi-Fi calling which enables users to make and receive voice calls and SMS over a Wi-Fi network with the same experience as connecting directly to a mobile network (although it may not be available for all devices and tariffs). The percentage of voice calls made using voice over Wi-Fi was between 2% and 16% per MNO in 2021.[16] Wi-Fi can now be the default setting on devices where both cellular and Wi-Fi are available, depending on carrier and customer preferences.

3.27 Wi-Fi can also be used to access online services enabled by innovations in mobile devices and networks and largely driven by technology companies. They have given users a greater choice over how to perform traditional tasks e.g. sending messages or making voice calls via messaging applications such as WhatsApp; or interacting with voice services like Siri and Alexa.

3.28 However, developments such as the roll-out of unlimited data plans may mean that in future there could be less incentive for consumers to use Wi-Fi. In a 2021 study, for example, Ofcom found that people using the Three network used a higher proportion of data over mobile (33% mobile compared with 67% Wi-fi) than customers using the other networks which may be driven by higher take-up of high and unlimited data tariffs among Three customers.

3.29 Wi-Fi is also becoming increasingly important for smart home device connectivity, with the number of installed smart home Wi-Fi devices forecast to reach 17 billion globally by 2030[17], and is also used in a range of business and industrial settings.

[13] Based on operator data provided to Ofcom combined with estimates where Ofcom does not receive data from operators.
[14] Crowdsourced data collected from around 280,000 Android devices between 1 January and 31 March 2021 showed that 73% of connections were made on Wi-Fi and 27% were made on mobile networks. These figures are rounded to the nearest whole percentage and refer to the proportion of connection tests run every 15 minutes; not data traffic. For more information see Ofcom, Mobile Matters, 2021.
[15] See Cisco, Annual Internet Report (2018 – 2023) White Paper.
[16] Connected Nations 2021, p. 40.
[17] Smart Home Market Data (strategyanalytics.com).

Other wireless technologies

3.30 Wi-Fi is only one of a number of technologies that can deliver wireless services to people and businesses. Others that are often used for consumer devices include Bluetooth and Zigbee: for instance, smartwatches usually connect to a smartphone using Bluetooth. Technologies such as NB-IoT, Sigfox, and LoRaWAN are often used in business or wider area settings.

3.31 Many of these technologies use frequency bands that are predominantly used on a licence exempt basis such as 2.4 GHz and 5 GHz ('licence exempt spectrum')[18] to deliver services including control of home devices, street lighting and traffic lights, water and waste management and automated factory processes.

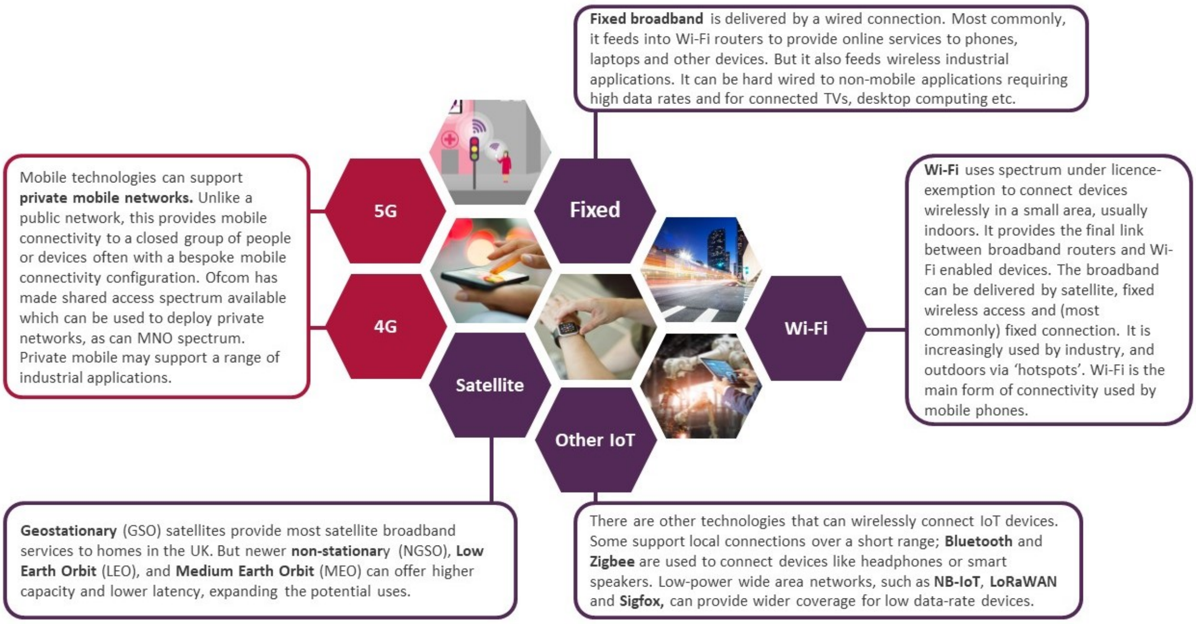
3.32 There are also other 4G/5G standards and technologies which can use spectrum under licence exemption in the bands which are also used by Wi-Fi technology. These technologies are aimed at use by existing MNOs under the banner of Licenced Assisted Access (LAA) and New Radio Unlicenced (NR-U), where an operator will integrate these technologies into its Core Network and make available any additional data rate that is available at any given location and time to the network users as necessary. There is substantial spectrum available both below 7GHz (around 1163 MHz) and in the millimetric bands (14 GHz in 57-71 GHz) for these technologies.

3.33 The emergence of non-Geostationary satellites (NGSO) has enabled satellite to offer lower latency broadband services to customers operating in remote locations. These can either be used for backhaul to extend the reach of mobile and fibre networks or direct-to-home broadband services for consumers. There is also work under way to establish whether satellites could connect directly to non-modified mobile handsets, thus providing emergency connectivity and/or extending the coverage of mobile networks.

3.34 All of these technologies have different characteristics; their suitability for use will depend on a user's requirements for coverage, data throughput, latency, reliability, security and cost. In some circumstances they may be used instead of mobile technology, but they will often be used alongside mobile technology. For example, the Liverpool 5G testbed created a 5G mesh network using mmWave, Wi-Fi, LoRaWAN and existing fibre to explore how these technologies could contribute to health and social care provision.

[18] In this document we use the term "Licence exempt spectrum" to refer to frequency bands that can be used by certain devices without the need for prior authorisation or an individual right of use.

Figure 8: Illustration of how different technologies can support wireless communications



4. Mobile data traffic is expected to keep growing, but the pace is uncertain

4.1 Building on our analysis of how data traffic has grown over the last decade we now consider potential patterns for future growth, up until 2035. This will inform our understanding of potential future demand for mobile services and any implications for future spectrum use.

Mobile data traffic will continue to grow

4.2 Our consideration of future growth in mobile data traffic is informed by a series of factors that suggest a trend of growth may continue for some time.

International trends

4.3 Internationally, a number of leading 5G markets, such as South Korea, Saudi Arabia and Taiwan, have higher per user mobile data consumption than the UK, and continue to demonstrate sustained year-on-year growth.[19]

4.4 Compared with the fastest adopters of 5G, UK take-up of 5G is relatively modest. As of September 2021, there were around 6 million active 5G handsets across all MNOs, up from 800,000 a year previously.[20] By comparison, in South Korea there are more than 20 million 5G subscriptions in a population of 52 million.[21]

4.5 In the UK, active 5G handsets only represent around 10% of all active mobile devices, but as newer handsets are increasingly 5G-compatible by default, this should increase quickly. International comparisons suggest this may increase mobile data traffic. There are some indications that 5G users use more data than 4G users[22] and that some 5G users rely less on Wi-Fi after upgrading,[23] suggesting increased uptake might drive UK mobile data traffic growth.

Demographic shifts

4.6 There is a clear correlation between an individual's age and their data usage. For example, our research[24] shows that people over 65 are much less likely to use a smartphone than

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[19] See Quantifying the impact of 5G and Covid-19 on mobile data consumption, OpenSignal (pg8)
[20] See Connected Nations 2021 (pg34)
[21] See https://www.koreatechtoday.com/5g-users-in-south-korea-surge-to-20-million/
[22] See Quantifying the impact of 5G and Covid-19 on mobile data consumption, OpenSignal (pg4). We note early adopters may be more likely than others to use large amounts of data and that as 5G user numbers grow, this may impact the speeds 5G users experience and as a result mobile data traffic.
[23] See Five ways to a better 5G, Ericsson
[24] Today only 55% of 65s or older use a smartphone to go online compared to 85% all adults; Ofcom's Adults' Media Use and Attitudes Report 2020/21 (pg7)

adults more generally. By contrast, today's teenagers and younger adults have grown up using mobile devices and online applications as a matter of course.

4.7 Over time digital native generations will represent a larger proportion of the population, embedding behaviours that consume mobile data. The younger generations of the future will likely play a similar role, driving new technologies which might consume even more mobile data.

Greater coverage and additional capacity

4.8 We expect improvements in mobile **coverage** to continue. Under the Shared Rural Network (SRN) programme, the UK Government is partnering with the MNOs to improve rural 4G coverage with a download speed of at least 2 Mbps. This speed allows browsing the internet; using social media and messaging applications; making one-on-one video calls; listening to music online; and watching TV in standard definition.

4.9 The central aim is for each MNO to reach 88% coverage of the UK landmass by 2024, and 90% by the start of 2027. The Government expects the programme will see the 'at least one operator' footprint reach 95% of UK landmass by 2025. It is expected that as a result the MNOs will deliver coverage to 280,000 more premises, and 16,000 km of road.

4.10 Alongside this, we expect MNOs to add **capacity** to their networks to meet demand, e.g. through building new sites, upgrading equipment to the latest technology and deploying additional spectrum. The further rollout of 5G will increase capacity. Ofcom has already made the 700 MHz and 3.4 – 3.8 GHz bands available for mobile services including 5G, and will consult shortly on proposals to make millimetre wave (mmWave) spectrum available. MNOs can also make use of much of their current spectrum holdings for 5G through refarming or dynamic use of 4G and 5G in the same bands.[25].

4.11 Improved coverage and greater capacity will result in access to higher quality mobile internet in more places, where people live, work and travel. This is likely to lead to consumers going about their lives and businesses and other organisations planning and designing services based on an expectation of higher quality connectivity.

4.12 As a result, it is likely that mobile services will increasingly be expected to support a range of applications that require wide coverage. For example, connected vehicles will likely increasingly use mobile networks to access things like real-time HD maps, traffic or hazard warnings, and entertainment while travelling. Looking further forwards, consumers, businesses and public services may make greater use of mobile networks on the move; healthcare workers may run diagnostics and upload information from remote locations for real-time processing at a hospital, while engineers may receive real-time support or information via augmented reality headsets.

[25] Through dynamic spectrum sharing technology.

Standalone 5G, 5G-Advanced and 6G

4.13 5G is currently being rolled out in non-standalone (NSA) mode, relying on a 4G core network.[26] Although this limits the full capabilities of 5G, NSA 5G can offer faster speeds than 4G circumstances.

4.14 In the longer term, we expect MNOs to deploy standalone (SA) 5G, with some already trialling this technology. SA 5G can enable additional features, such as ultra-low latency, that may enable applications that are not possible over today's networks. 5G will also continue to evolve, for example '5G-Advanced', which we expect to arrive in the next few years,[27] will offer a range of new features.

4.15 Looking further forwards, 6G networks may begin to be deployed by the late 2020s. While 6G's characteristics are unknown, we expect it to offer a range of new features, including far higher throughput, connectivity for many more devices in a given area and improved latency which may enable an even greater range of applications. 6G may also make greater use of AI and might use even higher frequency spectrum, for example in the Terahertz range.

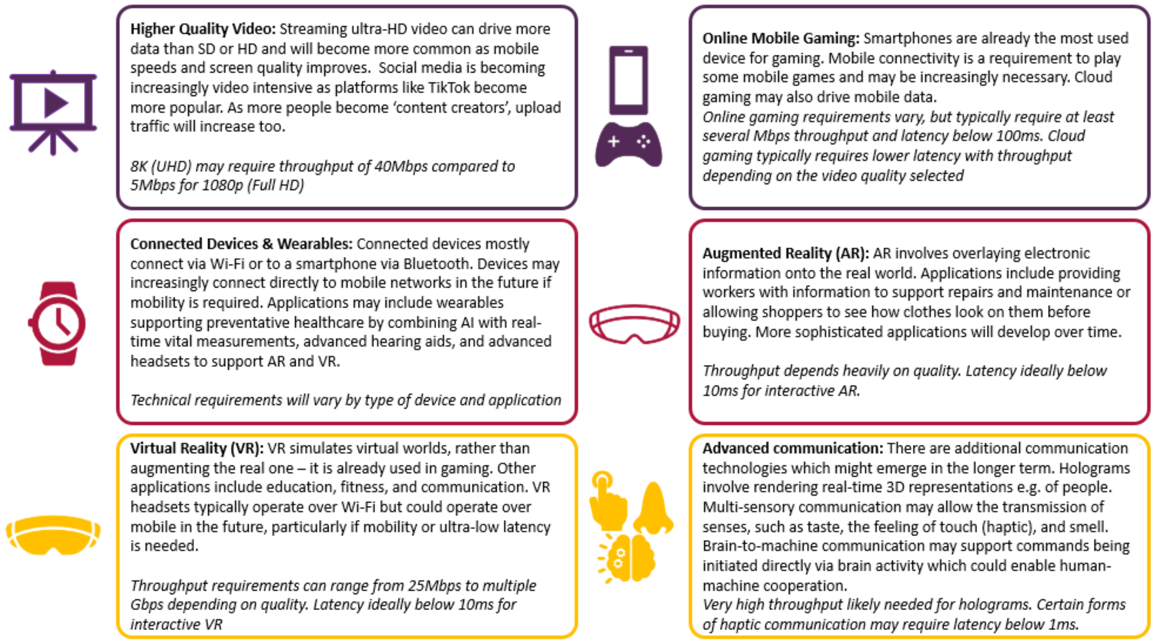
Innovative applications will continue to be a key driver of mobile data traffic

4.16 As we have seen, mobile data traffic growth to date has been driven by the increasing use of data heavy applications such as video streaming and sharing and gaming. We expect increased data usage coming from wider adoption of existing applications over time, alongside new and even more data demanding applications.

[26] Non-standalone 5G refers to the deployment of a 5G Radio Access Network (e.g. base stations, antennas) combined with a 4G core network (which manages control and signalling information). By contrast, a standalone 5G network does not require a 4G core network. Instead, a 5G core is used, which virtualises network functions and provides the full range of 5G features.

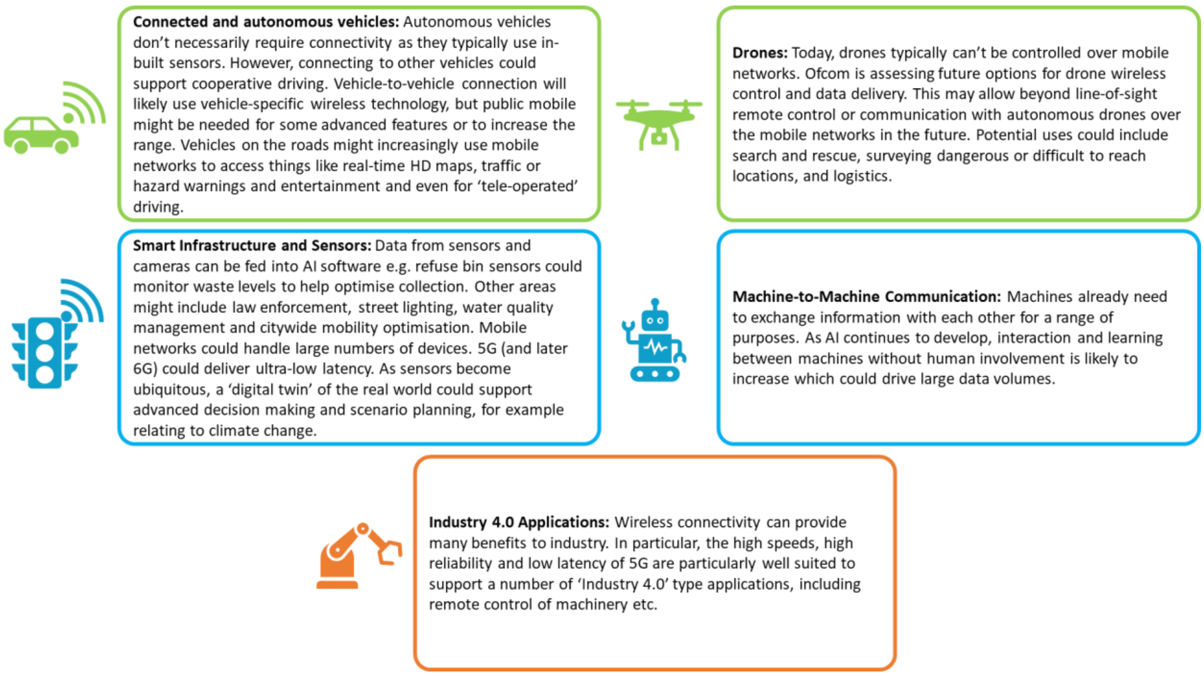
[27] 3GPP is the body that generates technical specifications and requirements for cellular mobile technologies (4G, 5G, etc.) in the form of Releases. 3GPP is expecting to use '5G-Advanced' from its Specification Release 18. See Release-18 – 3GPP for more detail

Figure 9: Examples of applications likely to drive data use



4.17 In addition to the above, there are a range of applications that will likely be deployed first by industry, in some cases then being used for consumer products. Where used on a specific site such as a business premises or in a campus environment, these may be deployed using private mobile networks.

Figure 10: Examples of commercial/industrial applications likely to drive data demand

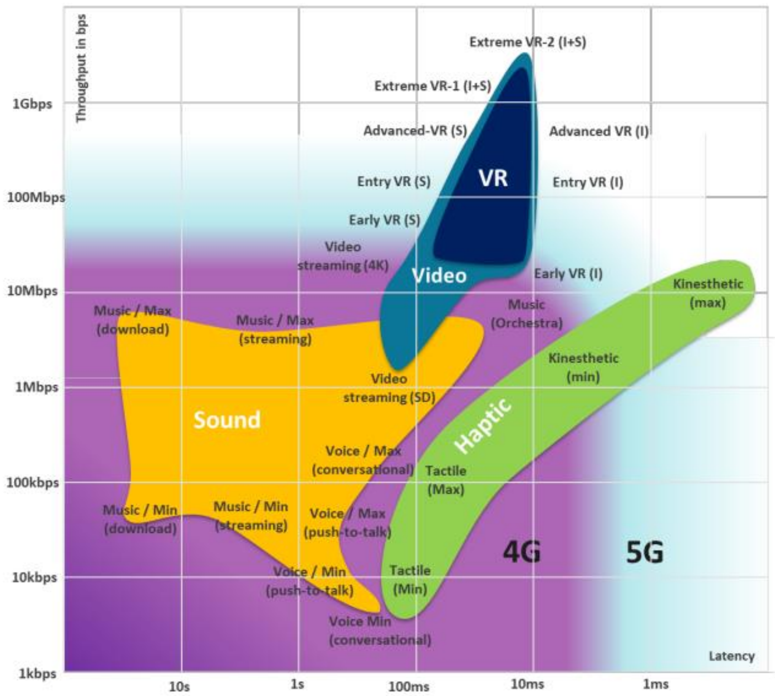


4.18 These applications each have different technical requirements. Some may have throughput and latency requirements that can be met by 4G. Others, for example various forms of VR, may require the ultra-low latency and throughput that SA 5G offers. Some, such as particularly advanced forms of VR or certain forms of haptic communication, may have requirements that go beyond 5G's current capabilities. These applications may therefore not be possible over mobile networks until 5G-Advanced or 6G is deployed.

4.19 The data throughput requirements of each application, alongside adoption and usage patterns, determines the impact it might have on mobile data traffic; VR can drive far more data than sound or video. Additionally, the split between upload and download traffic will vary by application; for example, those that involve interaction rather than just streaming content will drive greater upload traffic.

4.20 Below we provide an estimate of these requirements for various forms of sensory communication.[28]

Figure 11: Estimate of minimum throughput and reciprocal latency requirements for delivery of each form of sensory communications[29]



Source: Ofcom

There is uncertainty about the rate of growth for mobile data traffic

4.21 Although there are many reasons to think that the world of 2025, 2030 or 2035 will use more mobile data than today, there are uncertainties in predicting just how much more:

[28] See Ofcom's Technology Futures report for more detail. Haptic refers to the communication of movement and touch. (S) refers to 'streaming' and (I) refers to 'interactive'.
[29] Note that the 1 ms and 10 ms represent over-the-air interface latency for or 4G and 5G, respectively. Real-world latency might be larger, depending on where relevant core network functions are implemented. e.g. a deployment with core functions at the edge will be able to achieve latencies closer to the numbers indicated in the figure.

Uncertainty around new applications: We can only make predictions about applications we know about. New applications are bound to emerge in future, as happened with the release of 4G (e.g. Uber, Netflix etc.). The further into the future we look the greater the uncertainty and difficulty in predicting technologies and consequent data demand.

Uncertainty around application and device take-up: It is difficult to predict the popularity of particular applications or devices in the future. Past experience shows that new products can go from launch to ubiquity extremely quickly e.g. it has taken only 15 years from the launch of the iPhone in 2007 for smartphones to become the centre of our digital lives. Looking ahead it is hard to say now whether the 'metaverse', and its use of augmented and virtual reality, will become ubiquitous or remain more niche.

Investment and deployment: Mobile data consumption may be affected by network quality, which depends on factors like the level of MNO investment. For example, gamers may play online games on the go if they have access to the required level of mobile service, but play offline games if they don't. The deployment of edge computing may be needed to support ultra-low latency features – although the impact on demand is uncertain (wide availability could drive *greater* mobile data, or maybe result in *reduced* mobile data traffic if technologies transmit intelligently only what is needed).

Pricing decisions: The future cost of data packages will influence demand for mobile services. If a high price premium is set for large or unlimited packages, fewer consumers may select them; a low-price premium is likely to mean the opposite. The size of data packages may influence behaviour. For example, consumers with more data may be less concerned about data allowances and therefore less pro-active about connecting to Wi-Fi where it is available.

Uncertainty around traffic location: The location of demand can change over time, sometimes unexpectedly. Covid-19 shifted demand from urban areas to suburban areas during lockdown,[30] and there may now be a sustained shift in demand patterns due to flexible working.[31] The future role of Fixed Wireless Access (FWA) may impact the geographic distribution of mobile data traffic: FWA could be used to provide services in areas where high quality fixed broadband is not available; or in urban areas as a back-up network to guarantee connectivity.

Developments in other technologies: As already noted, public mobile represents just one of many approaches that can connect people and devices. The extent to which other technologies and models are used instead of public mobile will influence mobile data traffic. For example, a farm or factory may choose to use either a public mobile network or its own private mobile network, with consequent impacts on demand for mobile data. The image we presented earlier in this document is used below to show how the technologies we identified might develop in the future.

[30] See Connected Nations 2020

[31] See Behaviour change and infrastructure beyond Covid-19, National Infrastructure Commission

Figure 12: Illustration of how different technologies may support wireless communications in future

We have considered three scenarios for the growth in mobile data traffic to reflect uncertainty

4.22 We have analysed three scenarios for total mobile data traffic up to 2035:

a) **Low growth:** 25% increase per year to 2030, 20% increase per year from 2030 - 2035

b) **Medium growth:** 40% sustained increase per year to 2035

c) **High growth:** 55% increase per year to 2030, 60% increase per year from 2030 - 2035

4.23 These scenarios are not predictions, but instead cover a wide range of possible growth rates, to account for the uncertainty we have outlined above. They are not meant to represent predictions of specific future growth paths. The **medium growth** scenario represents a continuation of the year-on-year growth (40%) in mobile data traffic use seen in recent years.

4.24 The **low growth** and **high growth** scenarios represent what we see as the possible extremes, taking into account stakeholder input, analyst predictions and international precedent. For example, we looked at particularly high growth countries like South Korea to inform our high growth scenario.[32] South Korea's recent mobile data traffic growth has been facilitated by factors such as rapid 5G deployment and take-up aided by high urban population density and the bundling of data-hungry applications with 5G subscriptions.

[32] We considered highly developed countries with data consumption at the start of the period either at or above the UK's current level. For example, Singapore and South Korea's data use grew at 49% and 53% respectively year-on-year from 2019 – 21. See Quantifying the impact of 5G and Covid-19 on mobile data consumption; we note that OpenSignal uses a different methodology to our Connected Nations report, collecting data directly from smartphones rather than from MNOs.

4.25 In these scenarios**,** we have also included an inflection point at 2030. This doesn't represent an expectation that growth will either increase or decrease in the 2030s. Instead, it introduces a widening range in our scenarios to represent the fact that uncertainty increases even further beyond this date, as the characteristics of technologies such as 6G are unknown.

4.26 We describe the kinds of factors that might drive a **low growth** or **high growth** extremes over the next decade in the table below, noting these represent just one set of possibilities.

Figure 13: Examples of factors which may drive low and high growth demand scenarios

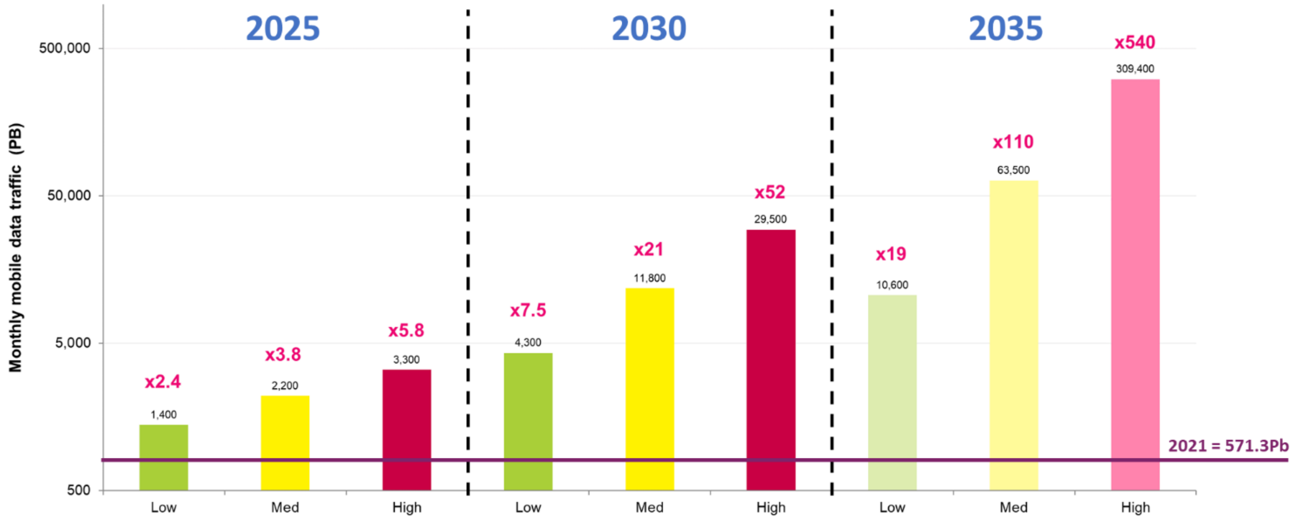
Low Growth	High Growth
Where possible, many consumers choose to stick with 4G. Those with 5G typically use modest amounts of data.	5G rollout continues at a high pace. Consumer uptake grows rapidly, with many making use of large amounts of data.
New data-intensive applications typically fail to hit the mainstream and remain niche, used by a subset of early adopters. Few unforeseen applications arise. Use of wireless data by machines, sensors and devices does not grow substantially.	A range of new, data-intensive applications hit the mainstream and are used day-to-day, supported by advanced new devices. This includes various applications that had not been previously considered. Use of wireless data by machines, sensors and devices grows rapidly.
The most popular applications use limited mobile data. For example, many do not require mobility beyond the home and offer good functionality even when offline. Machines, sensors and devices do not typically require mobile connectivity, instead using alternatives e.g. wired connections.	The most popular applications are highly mobile data intensive and require a high degree of mobility. For example, cloud gaming over 5G becomes the norm for mobile gaming. Machines, sensors and devices increasingly connect via mobile.
Wi-Fi speeds grow at a fast rate, supported by growing gigabit capable and full-fibre fixed availability and adoption. Wi-Fi remains the default for indoor connectivity, and greater hotspot coverage and quality increases Wi-Fi usage on the move.	Mobile remains the default for on the move connectivity due to faster speeds and ease of connectivity. Indoor mobile coverage improves meaning 5G is perceived as better than Wi-Fi in some locations. Consumers often opt to connect to mobile even when Wi-Fi is available.
Industry increasingly uses non-mobile connectivity technologies or selects standalone private mobile networks instead of relying on MNO networks.	Industry increasingly uses MNO networks or MNO provided network slices to support connectivity. Standalone private mobile networks remain niche.
Alternative connectivity technologies support an increasing range of applications. For example, low-power wide-area networks are the default for IoT, and satellite supports an increasing range of applications.	Mobile technology supports an increasing range of applications. For example, 5G becomes the default for IoT connectivity and satellite typically supports applications only in remote areas lacking mobile connectivity.

What could this mean for future mobile data traffic?

4.27 Based on the three scenarios we have outlined, we have modelled what total mobile data traffic could look like in 2025, 2030 and 2035. We note again that the future becomes increasingly uncertain given the time period covered, meaning the figures should be seen as indicative. This is particularly the case as we look beyond 2030, due to the uncertainty around the applications that 6G may enable.

4.28 While the high and low figures represent what we think could be the outer ranges of what might take place, the medium figures still represent very large increases in mobile data traffic. For this to occur, a range of new data-intensive applications alongside wide take-up of future mobile technologies, including 6G from the late 2020s, would be needed.

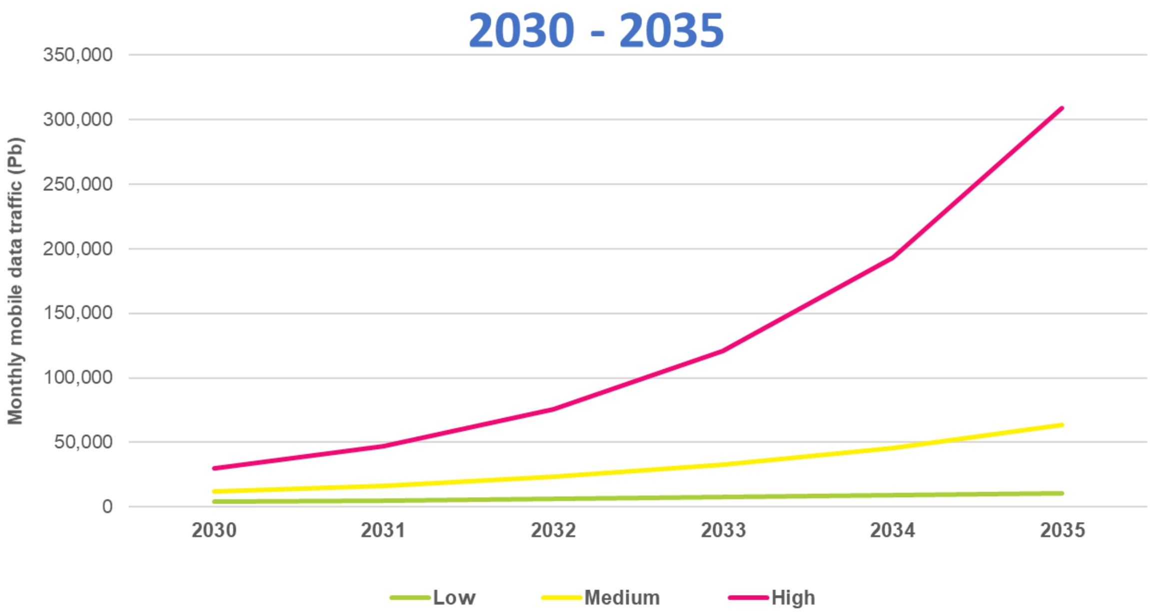
Figure 14: Illustration of data traffic growth over time in our low, medium and high scenarios



Note: multiples are relative to 2021 monthly mobile data traffic (571 PB); Y-axis is logarithmic, starting at 500 PB, some figures rounded. 2035 bars shaded to indicate significant uncertainty.

4.29 In these scenarios, the range of mobile data traffic widens significantly as we look further forwards. In 2025, high growth scenario data traffic is 2.5 times the low growth scenario, but by 2035 it is 29 times higher. The graph below gives a sense of the extent of this divergence beyond 2030.

Figure 15: Illustration of how data traffic growth diverges over time across our low, medium and high growth scenarios



4.30 While we cannot say for certain, our expectation is that the mobile data traffic will most likely be somewhere close to the medium growth level, with the low and high growth levels representing the outer bounds of an uncertain future. Across all the scenarios, mobile data traffic is expected to grow many times over the coming years. However, the implications for mobile networks could vary quite substantially according to the eventual growth rate and where the growth arises.

5. Substantial growth in network capacity will be needed to meet future demand

Networks will need more capacity, but more spectrum is not the only way to deliver this

5.1 Mobile networks will need to continue to expand their capacity to meet future demand for good quality mobile services for people and businesses. The mobile industry has called for further spectrum (beyond that already in the pipeline) to be made available to support this. However, new spectrum is not the only way for network operators to increase capacity. It can also be delivered through:

a) upgrading to the newest (more spectrally efficient) technologies;

b) deploying current spectrum holdings more widely on the current network grids (and making use of planned spectrum releases); and

c) deploying spectrum on more sites (densification).

5.2 In some circumstances MNOs may also look to offload traffic onto other access networks (such as LAA/NR-U and Wi-Fi) that use licence exempt spectrum to provide additional capacity. Given the importance of indoor mobile traffic, we consider indoor connectivity separately at the end of this section.

Technology upgrades will help provide more capacity

5.3 New technologies can enable better spectral efficiency[33], so more data can be carried over a given quantity of spectrum. Two key opportunities for mobile networks are upgrades in technology and antenna systems.

5.4 System upgrades such as changing the use of a band from 4G to 5G, and then the roll-out of SA 5G will boost spectral efficiency, with even greater gains from moving from a band being used for 2G/3G technology to 4G/5G. MNOs have confirmed they do not intend to offer services using 2G and 3G after 2033 at the latest to free up current 2G/3G spectrum for 4G/5G. EE has said it plans to phase customers off 3G by 2023 and Vodafone will begin to retire its 3G network in 2023. Further uplifts can be expected with future upgrades.

5.5 As consumers and operators shift technology, Dynamic Spectrum Sharing (DSS) can optimise efficiency by allowing bands to be used for both 4G and 5G at the same time – dynamically switching between the two depending on the capabilities of the users' devices.

5.6 Deploying antenna technologies such as Active Antenna Systems (AAS) and higher order massive MIMO[34] can enable substantial capacity gains. These technologies increase the

[33] Spectral efficiency is the amount of digital information that can be transmitted over a certain bandwidth (bits/Hz).
[34] MIMO or Multiple Input Multiple Output is an antenna technique in which multiple transmit and receive antenna elements are used to improve the capacity of a radio link.

number of transmitting and receiving antenna elements in radio equipment and exploit spatial multiplexing and beamforming[35] to carry multiple data streams simultaneously and increase spectral efficiency.

5.7 The scope for capacity gains through upgrading antennas varies by frequency band. Today, massive MIMO and beamforming techniques are mostly exploited in mid-band spectrum (between approximately 2 GHz and 10 GHz).

5.8 At lower frequencies (below about 2 GHz) the physical size of antenna elements limits the number of elements that can practically be accommodated in a single base station antenna. Spatial multiplexing can still be exploited, but with more limited MIMO techniques[36].

5.9 Antennas at mmWave frequencies can accommodate a very large number of antenna elements compared to low or mid-band. Beamforming at mmWave using high order massive MIMO antennas should allow even greater spectral efficiencies.

5.10 We expect future technology improvements will increase spectral efficiency over time and average spectral efficiencies in the period to 2035 could potentially be in the following ranges[37]:

Figure 16: Spectral efficiency of cells

	Approximate average spectral efficiency per cell, in bits/s/Hz		
	Low-band (below approx. 2 GHz) for macro cells	**Mid-band (approx. 2 to 10 GHz) for macro cells**	**mmWave (above 24 GHz) for small cells**
2022 to 2025	1.5 - 3	3 - 11	10 – 12
2025 to 2030	3 – 5	11 - 12	12 – 13
2030 to 2035	5 - 6	11 - 12	13 – 16

[35] Beamforming is an antenna technique in which multiple antenna elements are combined to create a signal beam in a specific direction.

[36] However, we are aware of techniques such as Modular Massive MIMO that are being considered for future (6G) systems that might enhance antenna performance at low frequencies.

[37] The table gives an overview of the average spectral efficiencies which might be achievable in different spectrum ranges and on different types of base station in the period out to 2035. These are mainly driven by the configuration and number of elements and MIMO technology likely to be commercially available in base station and user equipment. Average spectral efficiencies for macro sites may be lower than for small cells which are often targeted at specific locations. Likewise, average spectral efficiencies for macro sites covering large sparsely populated areas may be lower than for macro sites covering smaller urban or suburban locations. These spectral efficiency values are derived from a number of sources, including engagement with radio and antenna equipment manufacturers and a review of the literature for instance **5G Technology: 3GPP New Radio** (December 2019) Harri Holma, Antti Toskala and Takehiro Nakamura https://www.wiley.com/en-us/5G+Technology%3A+3GPP+New+Radio-p-9781119236290.

Longer term technology changes are uncertain but could have significant impacts on network deployments and spectral efficiency

5.11 In our 2021 Technology Futures publication we cast a spotlight on a number of technology developments which may have implications for mobile networks in future. There is potential for some radical changes in the medium to long term which could enable greater reuse of spectrum such as cell-free networks, the use of Artificial Intelligence (AI) for end-to-end network optimisation and intelligent reflecting surfaces.

5.12 While there is uncertainty, there is increasing potential for innovation to change how networks operate – and boost service quality and spectral efficiency – as we look towards the end of the period to 2035.

Networks can boost capacity with spectrum

5.13 There are several ways in which MNOs can use spectrum to boost capacity in their networks.

Fuller and wider use of current spectrum holdings

5.14 In the first instance, deployment of more of MNOs' existing spectrum holdings on the current macro cell grid can boost capacity, for example by continuing to expand the areas where the 3.4-3.8 GHz band is deployed.

5.15 However, there are some practical constraints on how much spectrum can be deployed on a single site. For example, MNOs must ensure compliance with international guidelines setting limits on the exposure of the general public to electromagnetic fields (EMF)[38]. We believe that some MNOs may have experienced challenges around EMF limits when upgrading some of their existing macro sites to add additional spectrum. This is likely to be an increasing problem in the future if they need to load sites with more and more spectrum.

5.16 Practical constraints can also arise owing to factors such as antenna equipment size, weight and wind loading. New multiband antennas can help remedy some of these, by using a single antenna enclosure for several frequency bands. We are also aware, that as technology advances, the weight of massive MIMO panels will likely reduce – for instance today's massive MIMO antenna panels at 3.4-3.8 GHz are significantly lighter than they were only a couple of years ago.

5.17 Separately, operators may choose to trade spectrum holdings if they believe this will enable them to realise benefits e.g. in spectral efficiency. This could help remove some fragmentation and allow wider contiguous blocks in certain bands. However the spectral efficiency and hence capacity gains would likely be relatively small overall, compared with making full use of mmWave, for example.

[38] All uses of radio spectrum generate EMF and there are internationally recognised guidelines to help ensure services operate in a way that will not adversely affect health.

Ofcom has identified a pipeline of further mobile spectrum which will boost capacity, and will consult on specific proposals

5.18 With demand for mobile services continuing to grow we have already identified a large amount of additional spectrum for mobile in the mmWave frequencies. The 26 GHz band (24.25-27.5 GHz) was globally identified for mobile services in 2019 and is a pioneer 5G band in Europe with harmonised technical conditions.[39] In addition, the 40 GHz band (40.5-43.5 GHz) was also identified for mobile and as a future 5G band in Europe, with work ongoing to develop harmonised technical standards for 5G.

5.19 This high frequency spectrum can provide very wide carriers to support the use of high-bandwidth applications and offer a sizeable boost to network capacity in localised areas. However, because of propagation limitations, it can be poor for delivering wide area coverage.

5.20 We also plan to award the 1.4 GHz band (1492-1517 MHz), which is internationally-harmonised for downlink-only wireless broadband (supplemental downlink). This spectrum can supplement sub-1 GHz for coverage and deep indoor services.

5.21 The release and authorisation of the spectrum bands already planned will be the subject of separate consultations. We will be consulting on proposals to enable mmWave bands to be used for new and innovative services, including 5G, in Q1 2022/23.

The mobile industry calls for more mobile spectrum in the future, beyond the current pipeline

5.22 As already noted, the mobile industry has suggested that more spectrum, in addition to the bands already in the pipeline, will be needed in the medium to long term. Any release of more spectrum for mobile for high power outdoor use would likely require us to clear some further frequencies of current users. It would also likely require the relevant band to be harmonised internationally for mobile to provide the economies of scale necessary for equipment and device availability.

5.23 The process for clearing frequency bands of current users usually takes around 6-8 years. It would be subject to consultation and may require an impact assessment of the costs, benefits and risks involved. We would need to take account of relevant factors e.g. the on-going value to the UK of existing uses of the frequencies, and the potential value of alternative non-mobile uses which could use the spectrum.

5.24 In Europe the mobile industry is focusing on two bands, each under consideration for identification as spectrum bands for mobile communication services either globally or regionally (i.e. for Europe, the Middle East and Africa) at the 2023 World Radiocommunication Conference (WRC-23):

- The '600 MHz band' is being promoted by some in the mobile industry as a means to improve coverage in rural areas due to the characteristics of radio signals, which travel for longer distances at these frequencies compared to mid and higher frequency bands.

[39] See Decision 2019/784, as amended by Decision 2020/590

It is also being suggested that this band could help with deep indoor coverage. However, the quantum of spectrum here would be limited. The 600 MHz band sits within the 470–694 MHz frequency range currently used for digital terrestrial television (DTT) to deliver Freeview services to millions of UK homes, and for use by PMSE and White Space devices. The UK Government has put in place legislation to enable Freeview licence extensions until 2034, subject to a break clause in 2030. Ofcom maintains that there is a need for DTT to continue until at least 2030 and probably beyond, in the UK.

- The 6425-7125 MHz band ('the upper 6 GHz band') is being promoted by the mobile industry primarily as a means of enabling additional capacity for 5G in towns and cities, similar to 3.4-3.8 GHz deployments. In parallel, the Wi-Fi industry is also arguing that it requires future use of this band, and a number of international markets have made this spectrum available for licence exempt Wi-Fi type use. This band is currently used by a number of sectors including radio astronomy, satellite, fixed links, the MOD and PMSE. Any future use of this band by mobile operators would likely require some level of clearance and/or the imposition of technical constraints to allow the band to be shared. This could limit operators from using the same type of network deployment as, for instance, used in the 3.4-3.8 GHz band.

5.25 Ofcom, under Ministerial direction, is actively participating in the international preparations for WRC-23, including technical compatibility activities for the upper 6 GHz band and gauging views from interested UK stakeholders. Ofcom will consult shortly on our preparatory considerations for WRC-23.

5.26 Over the longer term, we anticipate further consideration of a wider range of bands to enable mobile connectivity (including 6G), such as the 7-20 GHz range and 'Terahertz' bands above 100 GHz.[40]

5.27 We are also interested in exploring whether there may be options for mobile to share bands with other users for example through geographic sharing (where an incumbent or incumbents operate in only one part of the country, enabling mobile use elsewhere) or by using dynamic spectrum management systems. Different solutions may be feasible for lower power small cells compared with higher power macro site mobile deployments.

Densifying networks by deploying more cells could enable a substantial increase in capacity

5.28 Capacity can be expanded by adding additional sites to a network, using macro sites or small cells. To date UK networks have largely relied on macro site deployments, but network planning considerations and access to new locations for macro sites can be challenging, particularly in dense urban and urban areas.

[40] Unlocking the potential of Terahertz radio spectrum (ofcom.org.uk)

5.29 Small cells operate at lower powers than macro sites and cover a smaller area. They are typically installed below rooftop level or in indoor locations. They can either make use of the same spectrum bands deployed on the macro layer in that area, or different bands. The mmWave spectrum may be particularly suited to deployment on small cells, providing high capacity and speeds in localised areas, but other bands such as 2. 6 GHz and 3.4-3.8 GHz could also be used.

Figure 17: Illustration of macro sites and small cell deployments

5.30 Operators in countries such as the USA and South Korea are already pursuing densification, including the use of small cells. South Korea is reported to have approximately 162,000 5G base stations as of October 2021.[41] Further, by the end of 2020 the US had more than 417,000 sites;[42] the CTIA has cited estimates that there may be more than 800,000 small cells by 2026.[43]

5.31 So far, UK network operators have made very limited use of small cells compared with some operators overseas. Deploying small cells has been perceived as more challenging and costly than deploying a macro cell grid. We discuss this further below.

Future growth scenarios for mobile data demand illustrate that networks will need to evolve to increase capacity

5.32 To inform our initial thinking on how mobile networks might evolve to meet the range of future possible mobile data traffic scenarios, we have considered some of the options

[41] 5G Scorecards – 5G Observatory
[42] CTIA, Annual Survey Highlights (2021) CTIA - 2021 Annual Survey Highlights
[43] CTIA, The State of Wireless (2018) CTIA_State-of-Wireless-2018_0710.pdf; https://www.ctia.org/news/a-year-of-accelerated-wireless-infrastructure-investment. CTIA is a US trade association for the wireless communications industry.

which are available to MNOs to grow capacity, and how they might enable mobile networks to meet future demand in the low, medium and high growth scenarios we have identified (as described in section 4).

5.33 We have focused on the medium growth scenario, but have considered the implications of the low and high scenarios alongside this, given the uncertainty about future developments.

5.34 Taking 2021 network topologies and traffic levels as a starting point, we have explored three strategies, both on their own and in combination, to deploy further capacity:

a) Making more use of existing spectrum holdings by deploying these on current macro sites;

b) Densifying networks by making use of mmWave spectrum on small cells; and

c) Densifying networks by increasing the number of macro sites.

5.35 We have considered the scope for these strategies to meet future demand. Our considerations do not capture the full range of options available to MNOs – for example, they could also create additional capacity through deploying a small cell layer using other spectrum (e.g. in the 3.4-3.8 GHz band); mmWave deployments on macro cells; using spectrum under licence exemption with technologies such as NR-U; or increasing the number of sectors on macro sites. Nonetheless, they provide initial insight into what might be possible.

5.36 We have also considered a case in which further mid-band spectrum were, hypothetically, available for use by mobile operators, and how this might be deployed alongside the three strategies outlined above.

5.37 Our analysis of the current distribution of data traffic (see section 3) highlighted the need to consider different geographic areas differently. For example, dense urban and urban locations see greater demand than rural areas. We have considered how the nature of demand and deployment solutions might differ by area e.g. in some areas it might become more challenging to deploy high frequency spectrum such as mmWave on small cells.

Our findings point to a need to think about a new approach to expanding capacity in mobile networks in the coming period

5.38 Our findings, outlined below, suggest that while technology upgrades and the use of current spectrum holdings more efficiently and extensively will address some level of demand, some network densification will be necessary in all growth scenarios.

5.39 Densification will likely be needed on a wide scale in our medium and high growth scenarios, in which data traffic is expected to continue to grow at a similar or faster pace to recent years. Additional mid-band spectrum - which is not currently available - could help meet future demand in some areas but would not be sufficient on its own.

5.40 The following options for increasing network capacity are discussed below:

- Upgrading technologies and antenna capabilities together with making more extensive use of existing spectrum holdings on existing macro sites;
- Densifying networks by adding additional macro sites as needed;
- Using mmWave spectrum on small cells;
- A combination of macro site densification and mmWave spectrum on small cells;
- Additional mid-band spectrum deployed on macro sites;
- A combination of additional mid-band spectrum deployed on macro sites and mmWave spectrum on small cells.

5.41 All the potential options for increasing network capacity discussed below assume the operators would over time and as needed:

- make more extensive use of their current spectrum holdings;
- upgrade the technology deployed to improve spectral efficiency - for instance by migrating from earlier generations such as 2G and 3G to the latest technology 4G and then to 5G; and upgrading antennas to keep pace with the latest available MIMO capabilities;
- look into ways to increase a site’s capacity if demand exceeds a certain percentage of current capacity on that site on a sustained basis.

Without additional spectrum or small cell densification using mmWave operators could run out of capacity in some areas by around 2025

5.42 More extensive deployment of existing spectrum holdings and upgrading sites to the latest technology are options available to MNOs to accommodate growth in demand for data traffic.

5.43 While this would enable some capacity growth, without some other action MNOs would nevertheless likely run out of capacity in some areas at some point between 2025 and 2035. This is because in all three growth scenarios demand would outpace the improvement in capacity that is likely to be achievable through upgrading sites to improve spectral efficiency and more extensive use of existing spectrum holdings.

5.44 The timing and extent of the capacity challenge would be determined by the actual growth rate. Dense urban and urban areas would be capacity limited in the period between 2025 and 2030 in our medium growth scenario, and earlier for the high growth scenario. Other areas would likely become constrained beyond 2030 in our medium growth scenario, and earlier in our high growth scenario. In contrast, a low growth scenario would likely see only busy sites in dense urban and urban areas constrained beyond 2030.

Macro site densification using current spectrum is unlikely to be a feasible long-term strategy to meet demand

5.45 Densifying networks by simply adding macro sites is unlikely to be a feasible long-term strategy to meet demand. For example, in our medium growth scenario, an operator would likely need to double the number of macro sites in busy dense urban and urban areas by

2030 and multiply the number by almost 10 times by 2035 in those areas. This level of macro site densification in busy areas does not seem feasible.

5.46 In our low growth scenario, operators might be able to cope with traffic demand through a moderate level of macro site densification until about 2030. However, after 2030 the number of additional macro sites needed would rise significantly.

Densifying by using mmWave spectrum on small cells could meet demand, but would not suffice on its own in a high growth scenario

5.47 The deployment of small cells, particularly in busy environments has the potential to deliver significant capacity uplifts. Small cells can provide a localised, high-capacity solution where demand for mobile traffic is high. In particular, using mmWave spectrum on small cells can bring significant benefits as capacity in this frequency range can be very large given the bandwidth potentially available. However, mmWave is limited in coverage terms and any small cells would need to be carefully located in order to match local demand hot spots.

5.48 In view of this, we have considered the deployment of up to 1 GHz of mmWave spectrum on small cells as a means to boost capacity.

5.49 In our medium growth scenario, many thousands of small cells per operator would be likely to be needed in busy areas by 2030 - and potentially 30,000-50,000 spread across most areas except less busy rural areas by 2035. This reflects the fact that small cells, while having the potential to carry a significant amount of traffic, can only cover a small area and therefore are best used to meet localised demand in busy environments.

5.50 In a high growth scenario, even more mmWave small cells would be needed, with potentially more than 10,000 cells per operator by 2030. After 2030, very high numbers of small cells would be required, possibly in excess of 100,000 per operator by 2035. If such growth in data traffic were to become a reality, a different network strategy is likely to become necessary.

5.51 Our medium and high growth scenarios would suggest that a substantive change in small cell deployment by MNOs may be needed to meet the growth in mobile data traffic in the medium to long term. We discuss further considerations relating to this later in this section. In our low growth scenario, it is unlikely that a significant deployment of small cells would be needed until after 2030.

A combination of macro and small cell densification might be more practical, taking account of different locations

5.52 In practice, operators might wish to use a combination of mmWave spectrum deployed on small cells in dense urban and suburban locations, accompanied by macro site densification in suburban and rural locations. This strategy would reflect the greater challenges of finding locations for new macro sites in dense urban and urban areas relative to suburban and rural areas, and the lower population density in suburban and rural areas.

5.53 As an illustrative example, if an operator were to increase the number of macro sites (relying on current spectrum holdings) in capacity constrained suburban and rural areas by 50%, the overall number of mmWave small cells needed across the network to meet demand would be smaller – perhaps around a third less than in a case without macro site densification.

Additional mid-band spectrum added to macro sites could help meet demand but would not be sufficient on its own

5.54 We have also considered a scenario in which, hypothetically, further mid-band spectrum were available. We have considered the potential capacity benefit of an additional 150 MHz of mid-band spectrum per operator deployed on existing macro sites.[44]

5.55 In our medium growth scenario, busy dense urban locations would still likely run out of capacity by 2030 and in many other locations between 2030 and 2035. To fully meet demand using solely mid-band spectrum on macro sites, in our medium growth scenario, each operator would likely require more than 150 MHz of additional mid-band spectrum, in the order of many hundreds of MHz.

5.56 In our high growth scenario, the quantity of additional mid-band spectrum an operator might need would be extremely high, in the order of a GHz by 2030 and significantly more than that by 2035. However, in our low growth scenario, 150 MHz of additional mid-band spectrum deployed on macro sites might be sufficient to meet demand until 2035.

Additional mid-band spectrum combined with other capacity boosting measures including mmWave small cells could slow the rate of small cell deployment needed in the near term

5.57 In the medium growth scenario, making use of an additional 150 MHz of mid-band spectrum on macro sites alongside mmWave spectrum on small cells could significantly reduce the need for small cells needed to meet demand in the period up to 2030. This strategy could require fewer than 1,000 small cells potentially being needed per operator by 2030; beyond 2030, the number of small cells would be roughly half that which might be needed using mmWave on small cells alone.

5.58 In our high growth scenario, there would likely be only a modest reduction in the number of small cells needed by both 2030 and 2035, so an additional 150 MHz of mid-band spectrum on macro sites alongside mmWave on small cells would bring less incremental benefit.

5.59 At present, consideration of scenarios making use of further mid-band spectrum are purely hypothetical. Making available additional mid-band spectrum for outdoor high-power use on macro sites would likely require clearing bands of other uses and, as already noted, such a process usually takes around 6-8 years and would be subject to consultation.

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[44] We chose 150 MHz for this example as it represents roughly the quantity of spectrum being discussed internationally in the upper 6 GHz band, if it were to be split equally between four operators.

Consequently, it is likely that some small cell deployments will be needed during this decade.

Meeting future demand will require some degree of densification

5.60 Operators will need to take a view on the most appropriate mode of densification to pursue in practice, according to the characteristics and anticipated demand of a particular area. In dense urban areas and busy locations such as a sports stadium, small cells with mmWave or existing mid-band spectrum might be preferred. Small cells could be deployed in busier rural or suburban areas, but in some contexts operators might prefer to deploy new macro sites.

Further considerations on small cell deployments

5.61 More extensive use of small cells would represent a shift in UK deployments, notwithstanding the extensive use in some other countries. We outline below some of the considerations that might be associated with this, and are seeking stakeholder inputs on these areas, considering both the opportunities and where there may be barriers to small cell deployment.

Practical considerations

5.62 Small cell deployments involve the same practical deployment considerations that apply to new macro sites, such as backhaul and acquiring and setting up multiple sites, but in greater numbers. These include:

- *Network planning and securing suitable sites* - deploying small cells may require new sites to be deployed within relatively small areas to optimise the delivery of capacity against demand and lift traffic off the macro layer. Commercial negotiations will then be required to secure each site.
- *Planning and permissions* - de minimis rules generally apply to small cells, which exempt them from requiring specific approval, but there are a range of permissions involved in delivering new sites. Effective collaboration with a number of partners including landlords, building/site owners and local authorities is needed to manage these processes and site installation.
- *Backhaul (or fronthaul) and power supply* - greater availability of fibre across the UK alongside the development of Integrated Access and Backhaul technologies should facilitate deployment of small cells. Individual small cells require low power and can typically be powered by an existing local supply. In some cases, operators may have to consider alternative solutions, like remote line power, which are already being used in the US, where power is consolidated at centralised locations and delivered to small cells via copper or fibre cables.

5.63 There are also specific network planning considerations when introducing a small cell layer underneath an existing macro site layer. These include managing handover between cells and the risk of interference between small cells and macro sites where these use the same frequencies.

5.64 Improvements in network management technology have provided functionality to implement seamless handover between small cells and macro sites. Self-organising networks (SON) can help to minimise risks from interference between cells. Alternatively, an operator could choose to deploy different bands (such as mmWave) on small cells and the macro layer in a given location.

Cost considerations

5.65 Deploying small cells at scale has a different cost profile to macro site deployments. The upfront capital expenditure for deploying new spectrum on a new small cell is cheaper than deploying new spectrum on an existing macro cell. In cases where it is not feasible to deploy additional antennas on an existing macro site, for example owing to EMF requirements, the upfront cost for deploying a new macro site will be considerably higher than that of deploying a number of small cells.

5.66 However, the number of users potentially served by the deployment of a new small cell will be lower than the number who could receive signals from new spectrum on an existing macro cell in the same location. Small cells are likely to require higher ongoing operating costs in capacity/area terms, compared to a macro cell.

5.67 We recognise there is a risk that if the relative cost to MNOs of deploying small cells to meet demand were higher than previous deployment models this could result in a lower quality of service or higher prices for consumers. However, this risk may be mitigated by competition among MNOs creating a strong enough incentive to invest such that there is no degradation of service.

5.68 MNOs also have options to reduce costs which could alleviate these potential impacts. For example, while it is important that any sharing arrangements preserve competition between networks, there are a number of potential sharing models which could be adopted, including infrastructure sharing or working with a third party such as a neutral host, who would build and operate part of the network for one or more operators. This could use mobile operator spectrum, spectrum accessed by the neutral host directly or under licence exemption. Some form of sharing offers the potential to increase the capacity of MNO networks and offer seamless connectivity to consumers at a lower cost, with fewer additional sites at street level and potentially more flexibility compared to traditional models of macro cell infrastructure sharing.

5.69 While arrangements for infrastructure sharing or working with a third party can be complex, approaches can be found to simplify these. For example, the industry has agreed the Joint Operator Technical Specifications for Neutral Host In-Building (JOTS NHIB) to provide a technical framework for installing these types of solutions, which establishes a process for the co-operation of multiple parties including the landlord and building owner. This should facilitate the deployment of neutral host solutions indoors.

5.70 Overall, greater use of sharing approaches for small cells, while a departure from how UK operators have operated in the past, may offer a practical route to greater deployment of small cells in the UK at lower cost. Further, this model could also be used to provide additional capacity in a range of areas where there is a localised peak in demand, including rural communities.

Improving indoor connectivity will require greater use of ‘indoor in’ solutions

5.71 Indoor coverage is a specific challenge because the ability of mobile signals to penetrate through buildings depends on factors including the thickness of walls, and the types of materials used in construction. Overall indoor coverage sits between 90% and 95% across the MNOs but only between 68% and 80% for rural areas.

5.72 However, these figures apply an average building loss of 10 dB across buildings which may obscure an even more complex picture.[45] The challenge is going to increase as buildings become more energy efficient. Additionally, the higher frequencies that are increasingly being used to provide bandwidth for 5G increase the difficulty of propagation.

5.73 MNOs have to a large extent relied on an ‘outdoor in’ solution to this problem, using their lower-frequency spectrum to provide indoor coverage from outdoor cells. However, there is not enough of this spectrum to address capacity demand in future, even if more were made available.

5.74 Therefore, it is likely that indoor solutions will play an important role in addressing connectivity challenges inside buildings in the future and could also free up outdoor macro layer spectrum for outdoor use. Wi-Fi is already a popular indoor solution, with many consumers able to use Wi-Fi calling to make and receive calls and texts/SMS over a Wi-Fi network.

5.75 There are several alternative solutions where Wi-Fi is unavailable or unsuitable. As noted above, neutral host solutions can provide the means for multiple operators to provide indoor coverage to larger buildings through third-party infrastructure.

5.76 Alternatively, network operators may be willing to supply additional technology like femtocells and picocells which create mobile hotspots from a fixed broadband connection. Most existing femtocells rely on 3G but the market is now also producing a range of 4G and 5G femtocells.

5.77 Some people opt to use self-installed repeaters which boost the signals between a network operator’s base station and a mobile phone, and so improve access to mobile services without requiring a broadband connection. Ofcom enabled the use of certain mobile phone repeaters for indoor use on a licence-exempt basis in 2018.[46]

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[45] Ofcom, Connected Nations 2021
[46] Ofcom, Mobile Phone Repeaters (2021)

Summary of our initial thinking

5.78 Mobile data traffic is expected to continue to grow over the coming years. However, the specific implications for mobile networks could vary quite substantially according to the eventual growth rate and where the growth arises.

5.79 We anticipate that mobile networks will need to evolve to meet future demand for mobile data and deliver a good quality of experience. A number of strategies are available including technology upgrades, making full use of existing spectrum holdings, and densification, including by deploying new mmWave spectrum using small cells.

5.80 We believe that densification will be needed in the medium to long term to meet anticipated growth in demand, including the use of mmWave spectrum in capacity-constrained locations. We are interested in stakeholder views on the potential opportunities and challenges associated with network densification in the UK.

5.81 Overall, we anticipate that these strategies, together with existing mobile spectrum holdings and spectrum already planned for release are likely to be broadly sufficient to meet future demand to 2030, with a greater level of uncertainty beyond 2030.

5.82 As we have noted, spectrum is a finite resource: we need to consider demand from other users and ensure it is used efficiently. Additional new mobile spectrum beyond the existing pipeline of spectrum could help facilitate the provision of additional capacity, but would not on its own be expected to be sufficient to meet future mobile data traffic growth in all areas.

5.83 Making additional spectrum available for high-power outdoor mobile use would likely require clearing bands of existing users. The process for clearing frequency bands of current users usually takes around 6-8 years. It would be subject to consultation and may require an impact assessment of the costs, benefits and risks involved. We would need to take account of relevant factors e.g. the on-going value to the UK of existing uses of the frequencies, and the potential value of alternative non-mobile uses which could use the spectrum.

5.84 However, we think there may be opportunities for mobile networks to share spectrum with other users, for example through more localised access or lower power use. We are interested in stakeholder views on whether there are specific frequency ranges which should be considered for mobile access to support capacity provision in the future – including opportunities for more spectrum to be made available for mobile use on a shared or more localised basis.

6. Next steps

6.1 In publishing this paper, we hope to start a discussion about the best ways to meet the growing demand for mobile data, thinking about how public mobile networks in the UK may need to evolve to meet future demand, in light of expected growth and demand for spectrum from other users.

6.2 In parallel Ofcom has published a discussion paper setting out our future approach to mobile markets which outlines our initial thinking on the key changes taking place in the UK mobile market; how likely it is to deliver good outcomes in the future; and how our regulatory approach should adapt.

6.3 We have set out our assessment of how UK mobile networks have developed until now, and our initial analysis of how networks may need to evolve in future to meet the potential growth in data traffic demand and deliver a good quality of experience.

6.4 We want to know what others think about the opportunities, options and solutions presented by a world where use of mobile data is so central, driving demand for additional capacity. We will take account of stakeholder inputs as we develop our future strategy for mobile spectrum. In particular, we invite stakeholder views on our initial thinking in the following areas:

- Future demand for data through mobile networks (as opposed to demand for data more generally);
- The potential opportunities and challenges associated with network densification in the UK;
- Whether there are specific frequency ranges which should be considered for mobile access to support capacity provision in the future - including opportunities for more spectrum to be made available for mobile use on a shared or more localised basis.

6.5 We welcome anyone with views or suggestions on these areas, or any other views on meeting future demand for mobile data, to submit comments and evidence to: MobileSpectrumDemand@ofcom.org.uk.

6.6 We encourage potential respondents to let us know their views within an eight-week window from today until Friday 8 April 2022. We will take stakeholder inputs into account as we develop our future strategy for mobile spectrum. We plan to set out our initial conclusions by the end of 2022.

6.7 Ofcom plans to publish a number of documents relevant to the scope of this discussion paper in the coming months. These include:

- A consultation on enabling millimetre wave bands to be used for new and innovative services, including 5G;
- A consultation on our preparatory considerations for WRC-23; and
- A spectrum roadmap reflecting our short-term priorities and longer-term market and technology trends.

A1. Responding to this discussion document

How to respond

A1.1 Ofcom would like to receive views and comments on the issues raised in this document, by 5pm on 8 April 2022.

A1.2 You can download a response form from https://www.ofcom.org.uk/consultations-and-statements/category-3/discussion-paper-meeting-future-demand-for-mobile-data. You can return this by email or post to the address provided in the response form.

A1.3 If your response is a large file, or has supporting charts, tables or other data, please email it to MobileSpectrumDemand@ofcom.org.uk, as an attachment in Microsoft Word format, together with the cover sheet.

A1.4 Responses may alternatively be posted to the address below, marked with the title of the discussion paper:

Mobile Spectrum Demand Team
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A1.5 We welcome responses in formats other than print, for example an audio recording or a British Sign Language video. To respond in BSL:

- send us a recording of you signing your response. This should be no longer than 5 minutes. Suitable file formats are DVDs, wmv or QuickTime files; or
- upload a video of you signing your response directly to YouTube (or another hosting site) and send us the link.

A1.6 We will publish a transcript of any audio or video responses we receive (unless your response is confidential)

A1.7 We do not need a paper copy of your response as well as an electronic version. We will acknowledge receipt of a response submitted to us by email.

A1.8 You do not have to answer all the questions in the discussion paper if you do not have a view; a short response on just one point is fine. We also welcome joint responses.

A1.9 It would be helpful if your response could include direct answers to the questions asked in the discussion paper. It would also help if you could explain why you hold your views.

A1.10 If you want to discuss the issues and questions raised in this discussion paper, please contact the Mobile Spectrum Demand team by email at MobileSpectrumDemand@ofcom.org.uk.

Confidentiality

A1.11 We usually publish responses on the Ofcom website at regular intervals during and after the consultation period.

A1.12 If you think your response should be kept confidential, please specify which part(s) this applies to, and explain why. Please send any confidential sections as a separate annex. If you want your name, address, other contact details or job title to remain confidential, please provide them only in the cover sheet, so that we don't have to edit your response.

A1.13 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and try to respect it. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A1.14 To fulfil our pre-disclosure duty, we may share a copy of your response with the relevant government department before we publish it on our website. This is the Department for Business, Energy and Industrial Strategy (BEIS) for postal matters, and the Department for Culture, Media and Sport (DCMS) for all other matters.

A1.15 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's intellectual property rights are explained further in our Terms of Use.

A1.16 If you wish, you can register to receive mail updates alerting you to new Ofcom publications.

Ofcom's consultation processes

A1.17 Ofcom aims to make responding to a consultation as easy as possible. For more information, please see our consultation principles in Annex 2.

A1.18 If you have any comments or suggestions on how we manage our consultations, please email us at consult@ofcom.org.uk. We particularly welcome ideas on how Ofcom could more effectively seek the views of groups or individuals, such as small businesses and residential consumers, who are less likely to give their opinions through a formal consultation.

A1.19 If you would like to discuss these issues, or Ofcom's consultation processes more generally, please contact the corporation secretary:

Corporation Secretary
Ofcom
Riverside House
2a Southwark Bridge Road
London SE1 9HA
Email: corporationsecretary@ofcom.org.uk

A2. Ofcom's consultation principles

Ofcom has seven principles that it follows for every public written consultation:

Before the consultation

A2.1 Wherever possible, we will hold informal talks with people and organisations before announcing a big consultation, to find out whether we are thinking along the right lines. If we do not have enough time to do this, we will hold an open meeting to explain our proposals, shortly after announcing the consultation.

During the consultation

A2.2 We will be clear about whom we are consulting, why, on what questions and for how long.

A2.3 We will make the consultation document as short and simple as possible, with an overview of no more than two pages. We will try to make it as easy as possible for people to give us a written response.

A2.4 We will consult for up to ten weeks, depending on the potential impact of our proposals.

A2.5 A person within Ofcom will be in charge of making sure we follow our own guidelines and aim to reach the largest possible number of people and organisations who may be interested in the outcome of our decisions. Ofcom's Consultation Champion is the main person to contact if you have views on the way we run our consultations.

A2.6 If we are not able to follow any of these seven principles, we will explain why.

After the consultation

A2.7 We think it is important that everyone who is interested in an issue can see other people's views, so we usually publish the responses on our website at regular intervals during and after the consultation period. After the consultation we will make our decisions and publish a statement explaining what we are going to do, and why, showing how respondents' views helped to shape these decisions.

A3. Consultation coversheet

BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

Please tick below what part of your response you consider is confidential, giving your reasons why

Nothing ☐

Name/contact details/job title ☐

Whole response ☐

Organisation ☐

Part of the response ☐

If there is no separate annex, which parts? ____

____

If you want part of your response, your name or your organisation not to be published, can Ofcom still publish a reference to the contents of your response (including, for any confidential parts, a general summary that does not disclose the specific information or enable you to be identified)?

DECLARATION

I confirm that the correspondence supplied with this cover sheet is a formal consultation response that Ofcom can publish. However, in supplying this response, I understand that Ofcom may need to publish all responses, including those which are marked as confidential, in order to meet legal obligations. If I have sent my response by email, Ofcom can disregard any standard e-mail text about not disclosing email contents and attachments.

Ofcom aims to publish responses at regular intervals during and after the consultation period. If your response is non-confidential (in whole or in part), and you would prefer us to publish your response only once the consultation has ended, please tick here.

Name Signed (if hard copy)