
# Virgin Media O2 response to Ofcom's discussion paper

# Mobile networks and spectrum:

# Meeting future demand for mobile data

**Non-Confidential version**

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# EXECUTIVE SUMMARY

Virgin Media O2 ("VMO2") welcomes the opportunity to respond to Ofcom's discussion paper on mobile networks and spectrum: meeting future demand for mobile data.

Ofcom specifically invites views on demand for data through mobile networks (as opposed to demand for data more generally). We wish to emphasise that as a Mobile Network Operator ("MNO") we provide data and services to a wide range of customers with a diverse range of needs. This includes consumers, business of all sizes including large enterprises spanning a variety of different sectors, utility providers, public sector bodies, emergency service providers, as well as the supply of services to wholesale MVNO customers, and the provision of Internet of Things ("IoT") and Machine to Machine ("M2M") capability.

VMO2 supports Ofcom's aim to encourage longer-term thinking about the evolution of public mobile networks in the UK. This is key to understanding the challenges facing MNOs in respect of investment decisions, the ability to meet growing demand, and the availability of suitable spectrum – a critical resource which will directly influence the extent to which MNOs can continue to deliver a high-quality mobile experience to consumers and serve an increasingly diverse range of business needs, right across the UK.

Whilst the UK mobile market has delivered quality networks a wide range of good outcomes, underlying conditions and economic prospects are now less favourable. This casts doubt on the ability of MNOs to continue with the current level of investment in their mobile networks and provide the capacity needed to deliver high-quality services that customers in all areas currently expect.

We agree with Ofcom that mobile networks will need to evolve to meet future demand for data and continue to deliver a good quality of experience. This will require a level of network densification. However, looking forward the investment case is challenging. Whilst 5G services will become widely available, the combination of stagnant revenue, mobile saturation, the significant cost of rolling out 5G at scale and densifying the network to meet the relentless growth in demand, means that mobile network investment will not always deliver the capacity to provide the highest quality service or support the full suite of use cases everywhere.

In addition to investing heavily in both 4G and 5G rollout, and undertaking network densification, we have made great efforts and will continue to do so, in making the most efficient use of our existing spectrum, through the implementation of complex and innovative solutions and the adoption of new technologies to maximise efficiency and deliver the greatest benefit.

Despite all these concerted efforts, over the next few years, existing spectrum will become rapidly exhausted by the continuous growth in demand for mobile data, fuelled by increased adoption of 5G and greater usage of existing services, as well as newly developed ones. In addition to densification, in the medium term (from 2025), MNOs will require additional spectrum to meet demand if they are to avoid significant congestion in key areas.

It is important that Ofcom takes full account of the well-evidenced, ongoing growth in demand for mobile services provided over public mobile networks, when it is assessing the likely extent of future demand, and in its preparatory consideration for the allocation of spectrum for mobile use.

Availability of suitable mid-band spectrum, in addition to Ofcom's planned release of Millimetre wave ("mmWave") spectrum, will be crucial if MNOs are to successfully meet future demand, deliver the capacity required to maintain high-quality 5G services in key areas, and close the gap between the 5G networks that the UK will expect and the networks it will get.

Ofcom should commit to release more mid band spectrum for mobile use and set out a clear timetable for doing so. This should include a proper cost/benefit analysis to determine the most efficient use of the spectrum. By doing so, Ofcom will be able to effectively carry out its duty to secure the optimal use of spectrum and maximise the economic and social value derived. This will support investment in high-quality mobile networks and services, and facilitate good outcomes, delivering significant benefits for UK consumers and businesses.

In parallel to this response, we have responded to Ofcom's discussion paper on its future approach to mobile markets[1]. Our submission sets out the economic challenges that MNOs face and the need for regulatory and policy action, absent which, competition and the market will not deliver the high level of investment required to deliver good outcomes. In our response, we also identify suitable levers that can be pulled to support efficient investment, to deliver a more ambitious vision of high-quality mobile connectivity across the UK.

[1] https://www.ofcom.org.uk/__data/assets/pdf_file/0027/231876/mobile-strategy-discussion.pdf

# MAIN RESPONSE

## DEMAND FOR DATA THROUGH MOBILE NETWORKS

### Historical growth

When considering the demand for data through the UK's mobile networks, it is informative to look back at previous forecasts, alongside the actual growth in demand and usage. In its 2014 Mobile Data Strategy Statement[2] Ofcom stated that the long-term demand for mobile data services is subject to a high degree of uncertainty and there are a wide range of forecasts both in terms of traffic levels and the subsequent implications for future spectrum requirements. At the time, Ofcom said it would therefore continue to develop its view of future growth in mobile data demand, taking account of a range of factors including consumer demand and willingness to pay for mobile data, technology developments (e.g. new devices) that may stimulate demand, and the geographic distribution of traffic and international trends.

In its 2014 Data Strategy statement, Ofcom quoted a forecast which predicted that data carried on mobile networks in the UK, could increase 25 times to 2030, an implied annual rate of growth of 22%.

In the 2016 update to its Mobile Data Strategy[3] Ofcom acknowledged that actual mobile data traffic had in fact increased eight-fold from 2011 to 2015, with very high annual growth rates, which it said were around 60% per year, recently. Ofcom explained this exceeded the forecast it quoted in its 2014 Statement.

Ofcom then considered three potential scenarios, which implied an annual growth rate of 25%, 33% and 42%, between 2014 and 2025. It explained this was an upwards revision to reflect new use cases and the impact they may have on mobile data traffic, as 4G penetration and use increases, and the early adoption of 5G services takes place.

VMO2 believe it is important to highlight this. The highest forecast annual growth rate of the three scenarios considered (42%), almost matches the actual observed average annual growth rate for services provided over public mobile networks (40%), that Ofcom identifies as being observed in recent years, driven by the development of new applications, and enabled by evolving technologies and changes in consumer behaviour.

The UK's mobile networks have coped well in response to this relentless growth in demand for data. They have risen to the challenge through continued investments in network capacity involving spectrum acquisition, network densification and technology upgrades. This has taken place in parallel

[2] https://www.ofcom.org.uk/__data/assets/pdf_file/0027/58347/Mobile-Data-Strategy-statement.pdf

[3] https://www.ofcom.org.uk/__data/assets/pdf_file/0033/79584/update-strategy-mobile-spectrum.pdf

to extensive improvements in mobile coverage and the rollout of 4G, which is now widely available, driven principally by private investment but extended even further, aided by the Government's actions to improve deployment conditions and further collaboration with the Government through the Shared Rural Network initiative ("SRN").

## Future demand

In its current discussion paper on meeting future demand for mobile data, Ofcom repeats the view that there is a high degree of uncertainty about the future rate of growth, adding this is particularly so when looking beyond 2030. VMO2 agree that estimating the rate of growth *beyond* 2030 is a difficult task. However, not only is there well-evidenced consistent growth in recent years, driven by increased 4G adoption and use of existing services, the progressive rollout of 5G and the corresponding increase in adoption of 5G devices (enabling higher throughput) will see a persistent increase in usage per user, when compared to 4G, as evidenced in other countries.

In addition to this, we expect further usage of existing services, as well as the development and corresponding take-up of new ones. Thus we fully expect to see a continuation of significant growth in demand for data for the foreseeable future.

We anticipate annual traffic growth to persist along the lines that we have experienced on our network in the most recent years, and within the bounds of Ofcom's forecasts. Growth rates of this magnitude mean that total traffic more than doubles every three years. This is something that is not just evident in the UK, but has also been seen across Europe, as customers demand for mobile connectivity and services remains strong.

Whilst the magnitude of increase over the longer term (beyond 2030) is naturally more uncertain, it is evident that the growth in traffic will continue to be significant, and MNOs will only be able to fully accommodate for such growth and maintain the availability of high-quality services, by investing in network capacity and having access to a sufficient amount of suitable spectrum.

Ofcom's current consideration of the potential level of future growth, presents an analysis of three scenarios for total mobile data traffic up to 2035, which comprise the following:

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

Ofcom explains that these scenarios are not predictions, but instead cover a wide range of possible growth rates, to account for the uncertainty it outlines. Nevertheless, we observe that the medium growth scenario represents a continuation of the 40% year-on-year growth in mobile data traffic use that has been evident in recent years. Furthermore, across all three scenarios envisaged, mobile data demand is expected to grow many times over.

It is important to consider that a very large share of data traffic on the UK's mobile networks originates from use of the services provided by a small number of big Over-The-Top ("OTT") providers. The impact that this has on capacity, imposes very substantial costs on MNOs, which are expected to invest to accommodate this traffic to the benefit of the OTTs, yet the funding for this investment comes from customer subscriptions.

The absence of efficient price signals to these users of the network could lead to over consumption of network resources and consequently an inefficiently high demand for spectrum. Ofcom has a specific duty to secure the optimal use of spectrum and the application of that duty is not confined to spectrum policy alone. If regulatory rules elsewhere are leading to inefficient use of spectrum, then Ofcom has a duty to tackle the problem at source.

## 4G demand

In addition to the rollout of 5G and the increase in 5G adoption that will take place, 4G will continue to play a significant role in the delivery of mobile connectivity and capacity across the UK, for many years to come. From a capacity perspective, we continue to see strong growth in 4G data demand, **[✂]**. This has implications for the extent to which we are able to adapt to growth in 5G demand, for example, **[✂]**

From a coverage perspective, 4G will remain a fundamental part of mobile connectivity right across the UK. The Shared Rural Network will provide extended 4G mobile connectivity over the coming years, to many areas that are currently either partial, or total not spots. These are areas that will benefit from first-time or improved 4G coverage but are unlikely to see 5G before 2030.

## 5G and use cases

Over the next few years, we expect that 5G will gradually become the major technology for delivering mobile connectivity and will drive continued strong demand for data. 5G has the capability to offer a step up in many dimensions of mobile network performance, including reliability, speed, and latency. In so doing, it has the potential to enable new use cases which can further evolve with 5G roll-out and network and technology developments.

The progressive increase in 5G rollout in the UK, will facilitate its adoption. In turn, this will result in an uplift in customers data usage, when compared to 4G use. **[✂]**. We note that in its current discussion document, Ofcom observes that when it looked at particularly high growth countries like South Korea, to inform its high growth scenario, it identified that 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.

We fully expect take-up of 5G, as well as new use cases, to grow over time and this will continue to drive demand for data. An increasing number of use cases will require connectivity that supports very high speeds and low latency; plausibly above the level that 4G and 'basic' speed 5G can support. This means that the network used to deliver mobile connectivity must have enough capacity to accommodate for growing traffic levels, and that connectivity must support the use cases and enhanced experience that customers will expect and grow accustomed to.

'Basic' 5G can be delivered using low band spectrum. Strong propagation of this spectrum means that it can be deployed on a smaller number of sites, when compared to mid-band spectrum. This makes basic 5G a cost-effective way to expand 5G coverage. Higher quality 5G requires delivery using mid-band (and over time, mmWave) spectrum. This supports greater speed and capacity yet lower propagation means that deployment at a single site delivers connectivity to a much smaller area, so achieving similar coverage as basic 5G necessitates deployment from more sites.

Whereas basic 5G is an upgrade to 4G, in the end, only higher quality 5G can support a wider range of use cases and a higher quality of service. However the very high costs involved with the delivery of higher quality 5G, means that MNOs will initially limit deployment to high-demand (typically urban) areas, and other key areas where they face capacity constraints.

The role of mobile connectivity as an enabler of our economy and society will only grow over time, and we expect mobile to become even more central and crucial to people's lives. Consumers and businesses will make greater use of mobile services and increasingly rely on mobile connectivity to communicate, access content and to take advantage of an expanding range of use cases. Meeting the evolving needs of customers will require mobile connectivity to be widely available and to provide enough capacity to deliver a high level of quality and reliability.

Consumers and businesses will want high-quality mobile connectivity to be widely available. They will not want to be constrained in what they can use mobile connectivity for, depending on where they are. Instead, they will expect mobile connectivity to support their needs wherever they go.

Use of mobile data will continue to grow significantly. The increase will initially be driven by people spending more time on their mobile device and making greater use of existing 'data hungry' applications, such as video streaming and calling. Increased 5G rollout and adoption of 5G devices (enabling higher throughput) will see a step-change in data usage, when compared to 4G. In addition, over time, new use cases will develop and be adopted that will give rise to a further increase in mobile data demand, with some use cases likely to involve very high data consumption.

There are two major implications of this trend. Firstly, its impact on the growth in traffic that mobile networks need to accommodate for, thus requiring investment in the core, backhaul and radio segments of mobile networks. Secondly, the emergence of use cases that require higher quality 5G because of the higher speed or lower latency that they can provide. This means that 'Basic' 5G will not be able to support such use cases to the same extent, thus potentially limiting their take up.

Our expectation is that new and more demanding applications will be developed and adopted over time. There are three core areas where 5G will enable use cases and applications:

**Enhanced Mobile Broadband (eMBB)** which supports bandwidth-driven use cases that require high data rates for a better user experience. For consumers this means seamless connectivity and a range of new connected applications. It will also expand to industrial applications to process data faster, leading to productivity benefits for smarter cities, homes, and workplaces.

**Massive Machine Type Communication (mMTC)** will connect many low-power Internet of Things ("IoT") devices to the cellular network, up to one million devices per square km, which is roughly ten times the maximum amount possible with 4G. This will enable hyper-connected living, working, and travelling environments that are not constrained by infrastructure limitations.

**Ultra-Reliable Low Latency Communications (URLLC)** is expected to provide ultra-high network reliability of more than 99.999% and a very low latency target of around 1 millisecond for data packet transmission. It is envisaged to be applied in mission-critical use cases such as smart grids and remote surgery.

Supporting URLLC use cases that require consistent and ultra-low latency, will require a different network architecture to the existing ones. The network will need to embrace processing and computing at the edge of the network, close to where the data is being generated and consumed.

These capabilities can develop and deliver new use cases to both consumers and businesses. The emergence of specific use cases that require higher quality 5G because of the increased speed, or lower latency that they require, will also require, or benefit from, delivery of 5G Stand Alone ("SA"). As a result, basic 5G, (or existing 4G), will not be able to support such use cases to the same extent, thus limiting their take up.

## HOW MOBILE NETWORKS ARE LIKELY TO EVOLVE

### Investment Focus

Previous investment by MNOs should not be taken for granted, nor be used as an indicator of how future investment will be directed. The climate for MNOs is very challenging and the financial constraints that we face, mean that we will have to adjust our investment and other spend on an annual basis. This includes diverting investment to areas where we face existing or new regulatory or public policy obligations or commitments, and prioritising investment where it is likely to deliver most economic benefit. In practice, this means that MNOs will invest less in areas that would have previously been expected or planned – this is the opportunity cost of achieving public policy objectives, where they do not align with commercial ones.

VMO2 will continue to invest in both 4G capacity and coverage, given the importance of maintaining the quality of 4G services which are widely used, and to meet our commitments to further extending 4G coverage as part of the SRN programme.

In relation to 5G, MNOs have some commercial incentives to invest in its roll-out as it brings efficiency gains, reduces some costs, and can accommodate for growing traffic more efficiently through the deployment of newly acquired spectrum. **[✂]**

On the supply-side, economics and commercial interests are more favourable for deploying mid-band spectrum in dense urban areas, less so outside these areas. On the demand-side, network traffic will be greater in areas with a higher population, and as a function of usage by customers residing in these areas. This reality will prompt MNOs to prioritise investment in urban areas as the combination of commercial benefits and deployment costs will be more favourable. As a result, the requirement to focus investment on the deployment of higher quality 5G, will open-up a divide in user experience between urban areas and less densely populated areas of the UK.

The fact is that just because MNOs have some commercial incentives and plan to invest, it does not mean that the market, or competition, will deliver the required investment. In such challenging conditions, MNOs proposed deployments (subject to funding being available) will lead to an evolution of networks delivering mobile connectivity which will vary across the following three areas:

- **Dense urban**: large cities **[✂]**. Deployment will comprise of existing low and mid-band spectrum initially, accompanied by investment in densification and very high capacity backhaul (where available). Once it comes to market, there is likely to be a focus on deployment of mmWave spectrum from small cells. **[✂]**. The availability of additional mid-band spectrum in the future will be crucial to provide capacity and prevent congestion in these areas, where the deployment of mmWave spectrum is not technically suitable, or economically feasible. **[✂]**

- **Urban / suburban**: cities and towns **[✂]**. Compared to the dense urban areas, deployment of mid-band spectrum and supporting infrastructure (e.g. densification and very high capacity backhaul) will be lower and focused on targeted sites, when and where it is required **[✂]**

- **Rural**: outside cities and towns, **[✂]**. These areas will start with targeted deployment of low band spectrum, gradually expanding to provide basic 5G to a large part of the population. **[✂]**

## Quality divide

This highlights two important points: firstly, basic 5G will become widely available across the UK (although uncertainty remains on how wide). Secondly, availability of higher quality 5G will be mostly confined to urban areas.

This second aspect is key. Under the current trajectory, absent strategic changes, it means that many consumers and businesses will not be able to take advantage of the full 5G potential **[✂]**. This will create a digital 'quality divide', with the best services only being available in urban areas **[✂]**

Even when investing in the capacity of their networks, MNOs will not be able to deliver the same quality of experience across the UK. Growth in traffic will lead to a variation of user experience, across different areas. Restricted connectivity in particular geographic areas will either be because MNOs have insufficient mid-band spectrum that they can deploy to meet high local demand or because 5G is delivered using only low band and no mid-band spectrum, due to economic constraints.

In areas that are less densely populated, where MNOs cannot commercially justify the densification required to deploy mid-band spectrum, 5G will be delivered using only low band spectrum. This has implications for the resulting user experience as MNOs will not be able to accommodate for increasing traffic, with user experience suffering accordingly and it means that the potential of 5G will be substantially restricted.

## 5G Non-Stand Alone (NSA) and 5G Stand Alone (SA)

Initial and ongoing deployment of 5G is on a NSA basis. It involves deploying a new 5G RAN alongside the existing 4G RAN (which acts an 'anchor' to the 5G layer). It also uses the existing 4G core network. This supports some improvements compared to 4G, most notably by delivering an increase in capacity, thus helping MNOs to deal with growing traffic and preventing degradation of service quality.

MNOs will upgrade to deliver 5G on a SA basis over the next couple of years. This requires them to build a separate 5G core in addition to their existing 4G core. Some MNOs have started trialling 5G SA and we anticipate that all MNOs will upgrade to 5G SA, and it will eventually become the primary mode of delivering 5G.

New use cases that require ultra-low latency, must be delivered by 5G SA. As such, 5G SA will increase the range of use cases, support delivery of higher quality services, and enable advanced virtual network functions.

## Extensive and efficient deployment of existing spectrum

VMO2 strongly supports the principle of efficient use of spectrum. As a mobile network operator, we were the first to reuse our 2G spectrum for 3G use, and since then **[✂]**

We have always worked very hard to implement innovative solutions to maximise the efficient use of our spectrum holdings. **[✂]**

**[✂]**. We will continue to embrace the newest generations of mobile standards, as well as adopt the latest developments in technology and equipment, to extract maximum efficiency and deliver a reliable and high-quality service.

In the section below, we set our existing use for each of the spectrum bands that we currently hold, with respect to the technology (2G, 3G, 4G, 5G) and how it is deployed, along with an outline of our expected use going forward.

[✂]

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

## Spectrum usage

### 800 MHz

It is important to note that 4G will continue to play a major role in the delivery of mobile connectivity for many years to come. **[✂]**

We will continue to invest in both 4G capacity and coverage over the next few years, given the importance of maintaining the quality of 4G services which are widely used and will continue to be in demand, and to meet our commitments to further extending 4G coverage as part of the SRN programme.

**[✂]**

We continue to see strong growth in 4G data volumes, as well as voice, **[✂]**. This has implications for the extent to which we will be able to adapt to the growth in 5G demand. For example, **[✂]**.

### 2300 MHz

In Ofcom's 2018 award of the 2.3 and 3.4 GHz bands, we invested £205m in the acquisition of 40 MHz of 2300 TDD spectrum. **[✂]**.

**[✂]**

As we continue to see strong growth in both 4G data and voice traffic, **[✂]**, we will continue to require using this spectrum as a capacity layer to meet demand, avoid congestion and maintain a good level of quality.

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

[✂]
[✂]
[✂]

[✂]

[✂]

700 MHz

In Ofcom's 2021 award of the 700 MHz and 3.6-3.8 GHz spectrum bands, we invested £280m in 2 x 10 MHz of 700 MHz spectrum. [✂]

The fundamental requirement for NSA deployment to have a connecting 4G anchor, means that all 700 MHz spectrum deployments in NSA mode will include concurrent use of 4G and a corresponding 4G spectrum band, for example 2100 MHz, 800 MHz, 900 MHz, or 2300 MHz.

[✂]

Our 5G rollout is starting with the largest towns and cities in the UK which have the highest population density and therefore the most demand. [✂]

[✂]

[✂]

[✂]

[✂]

1800 MHz

We hold a small amount (2 x 5.8 MHz) of 1800 MHz spectrum. As a result, it only has a limited capacity capability. Nevertheless, we use it as extensively as we are able to, in an economically efficient way. This currently includes using it as support on 4G macro cells, microcells, small cells, and in-building solutions.

[✂]

[✂]

Currently, in order to meet the strict requirements of Ofcom's General Conditions, 1800 MHz in-building deployments that deliver primary coverage (i.e. where there is no existing macro coverage inside the building) must be supported by 3G 2100 MHz in-building femtocells, in order that non-VoLTE devices and emergency calling can be made via Circuit Switched Fall Back ("CSFB"). For 1800

MHz deployed on outdoor small cells, where CSFB to surrounding macro cells can be assumed, then there is no need for the 3G 2100 MHz to be deployed.

**[✂]**

2100 MHz

We hold 2 x 10 MHz of 2100 MHz spectrum. This spectrum band is one of the most supported bands within the device base. It therefore provides the maximum flexibility in terms of band combinations and technologies that can be allocated to it.

We currently use this spectrum for both 3G and 4G, across our macro estate. **[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

2600MHz

In 2020, we acquired 25 MHz of 2600 TDD MHz spectrum from BT/EE. This spectrum has application for both 4G and 5G use. Currently, the upper 5 MHz of this spectrum acts as a guard band with the neighbouring FDD downlink **[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

[✂]

[✂]

[✂]

[✂]

[✂]

3400 MHz and 3600 MHz

In Ofcom's 2018 award of the 2.3 and 3.4 GHz bands, we invested £317m in the acquisition of 40 MHz of 3400 MHz spectrum. In Ofcom's 2021 award of the 700 MHz and 3.6-3.8 GHz spectrum bands, we invested a further £168m in the acquisition of 40 MHz of 3600 MHz spectrum.

[✂]

[✂]

[✂]

[✂]

[✂]

We have made great efforts, and will continue to do so, in respect of making the most efficient use of our existing spectrum, by implementing complex and innovative solutions and focussing investment and resource to deliver the greatest benefit. However, despite all these concerted efforts, existing spectrum will become rapidly absorbed by the continuous growth in demand for mobile data.

[✂]

Ofcom has correctly identified that making additional spectrum available for high-power outdoor mobile use, would likely require clearing bands of existing users. Given the significant amount of time it is expected to take to clear and repurpose such spectrum (which Ofcom believe will be around 6-8 years), it is critical that Ofcom commences the required preparatory process now, to start the groundwork and lay the foundations for release in the future. This includes carrying out vital work to prepare for WRC-23, including applying a particular focus on candidate mid-band spectrum and having a clear UK Government position on mobile designation for the upper 6 GHz band.

## Technology upgrades

### Antenna systems

[✂]

[✂]

[✂]

As the current Ofcom out-of-band emission requirements for the 2300 MHz band are different than the European requirements, the network vendors will need to produce a special product for the UK market. This adds an additional hurdle in deploying equipment on this spectrum, and limits economy of scale benefits.

[✂]

[✂]

### Dynamic Spectrum Sharing (DSS)

DSS capability enables 4G and 5G to share a common carrier frequency in the same spectrum band. The network divides the available radio resources and allocate them dynamically between 4G and 5G users depending on traffic split, number of devices and prioritisation criteria.

4G and 5G have control and signalling channels that need to be broadcasted by the network and received successful by the device. However combining 4G and 5G control and signalling channels on a common bandwidth through DSS introduces overhead which results in loss of spectral efficiency, leading to less capacity compared to not using DSS. The magnitude of capacity loss is dependent on several factors including carrier bandwidth and ratio between 4G and 5G. Loss is more pronounced with small carrier bandwidths, such as 10MHz.

Additionally, DSS is not currently supported for TDD spectrum, due to greater level of complexity on the device side to support it. Furthermore, DSS forces 5G to use the same 5G numerology (i.e. subcarrier spacing) as 4G, which only supports subcarrier spacing of 15 KHz. The inability to use different numerology for 5G with DSS, imposes restriction on supporting ultra-low latency use cases that requires different, shorter time slots and hence different numerology than 15 KHz.

[✂]

## NETWORK Ddensification – OPPORTUNITIES AND CHALLENGES

### Existing investment

In recent years, we have made significant investments in a wide range of mobile infrastructure upgrades. This includes the acquisition of spectrum and densification of our network to expand our coverage and add capacity across the UK to keep up with growing demand and ensure that we deliver the best possible service to our customers.

We will continue to invest in further improving coverage, and quality, by extending our 4G service to more rural areas through our commitment to the SRN. We welcome the Governments recent proposed changes to planning laws, which will assist with this, and help to strengthen our ability to provide the digital infrastructure that is required to deliver better coverage and quality.

**[✂]**

**[✂]**

**[✂]**

**[✂]**

### Densification is necessary

We agree with Ofcom that, going forward, further network densification will be necessary, and this will be the case in all growth scenarios. Certainly, densification is a key part of providing reliable high-speed data services using 4G as well as 5G, something that customers will expect now, and into the future.

The key drivers we see for densification, are:

(1) Providing a higher quality 5G experience:

- Densification will be critical to provide continuous mid-band (and mmWave) 5G coverage;
- This spectrum has shorter coverage range, risking inconsistent service experience at the edge;
- Mid-band (and mmWave) spectrum deployment on an existing grid, mainly designed for low band spectrum, would also deliver unreliable and inconsistent coverage, therefore a denser grid (alongside other techniques) will provide superior coverage and indoor experience.

**[✂]**

**[✂]**

**[✂]**

**[✂]**

**[✂]**

We have a strong ambition to build towards a high speed, high capability 5G future. However, this presents an economic challenge, as to achieve this widely, it will require a significant level of densification, and thus be very costly.

The performance of a mobile network will depend, amongst other things, on which spectrum is deployed and from how many sites. Basic 5G can be delivered using low band spectrum such as 700 MHz. The strong propagation of this spectrum means that it provides greater coverage and so can be deployed on a fewer number of sites. Higher quality 5G requires delivery using mid-band (and over time, mmWave) spectrum. This supports greater speed and capacity, yet its lower propagation means that deployment at a single site delivers coverage to a smaller area. Achieving similar coverage as basic 5G thus necessitates deployment from more sites. **[✂]**

**[✂].** As we have previously outlined, in such challenging conditions, proposed deployments (subject to funding being available) will lead to an evolution of networks delivering mobile connectivity which will vary across geographic areas.

**[✂]**

**[✂]**

**[✂]**

The level and nature of densification is also dependent upon the unique characteristics of each immediate area. Each area will have a bespoke assessment and solution applied, depending upon its current and future demand profile, indoor and outdoor traffic type, and customer behaviour, as well as geospatial characteristics.

In its discussion document, Ofcom observes that one option to increase network capacity is through a combination of macro site densification and small cells. We believe that such an approach, which would provide a blend of capability, from 'full stack' macros[4] through to small cells, will be important. **[✂]**

Looking ahead, the delivery of higher quality 5G services will require the deployment of additional spectrum beyond the low bands. Two critical factors in this regard are firstly, the amount of spectrum used, and secondly, the number of sites that we would deploy this spectrum from. **[✂]**

[4] Macro sites with all available wide area spectrum deployed

**[✂]**

**[✂]**

**[✂]**

**[✂]**[5]

**[✂]**

**[✂]**

## Small cells

In 2017, we started to deploy outdoor small cells in localised clusters, mainly centred around London and the M25 area. **[✂]**. These require very careful planning and deployment to avoid interference issues with our existing macro cells, which the small cells are designed to complement.

**[✂]**

**[✂]**

**[✂]**

In its discussion document, Ofcom suggests that in its medium growth scenario, 30,000-50,000 small cells would be required nationally per operator. In its high growth scenario, it says that this increases by potentially more than an additional 10,000 per operator, possibly in excess of 100,000 per operator, by 2035. Under the existing scenario of four MNOs, this suggests between circa 600 to circa 7700 additional small cells, per operator, every year, for thirteen years. Whilst small cell acquisition and deployment may not be as difficult as that for macro cells, there are still considerable financial and practical considerations involved in meeting these growth scenarios.

At this sort of scale, collaboration will also be key. **[✂]**

The introduction of de minimis rules for small cells has been helpful, but as Ofcom identifies in its discussion document, there are still a range of permissions involved in delivering new sites. We agree with Ofcom that this necessitates effective collaboration with a number of stakeholders including landlords, building owners and local authorities, to facilitate approval and proceed with deployment. This collaboration is key, and we work with several third-party wireless infrastructure providers to assist with the process of finding and securing suitable sites.

[5] **[✂]**

In addition to **[✂]**, the long lead times for technical assessment, field-based assessment, planning, acquisition, and backhaul, the suggested run rates for the required amount of additional small cells, are simply unrealistic when considering economic constraints and investment conditions.

## Macro cells

**[✂]**

Densification on such a large scale has significant economic challenges and practical limitations, including:

- Finding suitable locations
- Planning and acquisitions that have long lead times and involve multiple stakeholders
- The significant amount of capital required
- Sustainability considerations and increased energy consumption

The above considerations apply for any type of site capability.

The SRN is one example of densification, with the driver being geographical coverage rather than capacity or indoor population coverage. The SRN is the most comprehensive, effective, time efficient programme to deliver the target of reaching 95% geographic coverage, whilst minimising the environmental impact of more masts and delivering for the Government in terms of value for money and increased numbers of customers having access to 4G. However, this programme will cost hundreds of millions of pounds and take several years to deliver the 222 planned sites (albeit in hard-to-reach places), yet it highlights the difficulty and timeframe for network densification, at scale.

It is important that Ofcom takes into consideration the significant economic and practical challenges that we have outlined above, when it is examining the potential scale of densification that may take place. In addition, it must also reflect upon this when determining the amount of suitable spectrum that must be made available in the future for mobile use, which will be essential to deliver the capacity required to meet the growth in demand.

## Network sharing

Network sharing is an important tool which enables MNOs to improve their capability to fund rollout to extend coverage, and increase capacity through densification, by sharing costs. Ofcom should remain open minded to such arrangements and proposals, as they can increase prospects for efficiencies and cost reductions that MNOs cannot achieve in a different way.

Our Beacon network sharing agreement with Vodafone has delivered substantial benefits and underpinned significant levels of network investment. **[✂]**

**[✂]**

Network sharing will become especially important if demand continues to increase at the current high level, as **[✂]**

Network sharing will continue to be a distinguishing feature of mobile infrastructure markets. Sharing networks allows MNOs **[✂]**

The existing framework for assessing compliance of proposed network sharing with competition law has enabled MNOs to achieve substantial efficiencies in current agreements. Such assessment can involve understanding the elements of differentiation, investments, innovation, and customers access to improved services. For example, taking into account the possibility of technical and commercial differentiation especially as MNOs evolve towards IP-based networks and network virtualisation, and the competition parameters and infrastructure innovation move beyond the existing RAN equipment.

## Neutral Hosts

Ofcom recognises the advantages offered by the neutral host model, which has the potential to increase the capacity of MNOs networks and provide connectivity to consumers at a lower cost, when compared to traditional models of macro cell infrastructure sharing, especially in indoor locations which have very localised high levels of demand.

We agree that this model has the potential to support the provision of mobile connectivity in areas where it would otherwise be too costly or complex for multiple networks to be deployed. Ofcom correctly identifies that arrangements for infrastructure sharing or working with a third party can be complex, but approaches can be found to simplify these. For example, we contribute to this by participating in the Joint Operator Technical Specifications (JOTS), which will enable potential hosts to understand what is required to act as a neutral host.

However, there is a substantial risk that in some circumstances, a neutral host can act as a monopoly provider of sites; **[✂]**, a neutral host can leverage its control over the only sites suitable for delivery of mobile services. In such circumstances, such a host might seek to exploit a dominant position in a specific geographic area. We trust that Ofcom will be alert when it comes to the risks posed by monopolies in the supply of site locations.

## Backhaul

Meeting the growing demand for mobile data and ensuring the delivery high quality 5G services will require substantial network development, not only in the core and radio access network, but also in backhaul links, which will require significant upgrades in order to deliver increased capacity and support faster speeds. The roll-out and adoption of 5G will place even greater demands on the capability, capacity, and performance of our network and increased backhaul capacity will be a key requirement to avoid bottlenecks and ensure higher throughput.

This requirement will be needed most in dense urban areas, **[✂]**

Existing 1 Gbps backhaul requirements quickly become 10 Gbps, and small cells require 1 Gbps, rather than 100 Mbps connections. This has two implications for our mobile backhaul needs: first, we require more higher-speed connections, and secondly, we need to connect to a larger number of small cells.

The challenge is that, whilst we know that an increase in capacity will be required, we cannot determine when and where with any real granularity. To meet our customers 5G demands, we therefore require access to an affordable, scalable, and *flexible* fibre infrastructure.

The shift from existing backhaul to that of very high bandwidth requirements, will increase costs. **[✂]**. Access to cost-effective very high-capacity fibre is therefore key to meeting the challenge of growth in demand and in enabling the rollout of high quality 5G services.

Following the establishment of our joint venture, VMO2's fibre reach is extensive and expanding, but it is clear that we will continue to require wholesale access to fibre, to complement our reach and so support our national mobile network.

Openreach is due to complete its 'full' launch of Dark Fibre Access ("DFA") on 1 June 2022. This could and should, have the potential to support Area 3 cell site backhaul locations.

**[✂]**

In particular, the prohibition on using DFA for traffic aggregation (by connecting to an intermediate node) or to a Point of Presence ("PoP"), significantly limits the extent to which a cell site connected via DFA could be incorporated into broader network deployment plans.

Openreach does not permit onward fibre routes to emanate beyond the cell site that was backhauled using DFA. It also requires a written agreement from Openreach where a DFA-backhauled cell site is connected wirelessly to another cell site that is connected to a Fibre to the Premise ("FTTP") network. Furthermore, there are few, if any, real-world use cases where DFA could be used in concert with Physical Infrastructure Access ("PIA") as a result of these product restrictions.

As backhaul capacity demands increase and new sites are deployed to support densification, we think Ofcom should consider whether the current, permitted, usage restrictions on DFA are impeding the effectiveness of the remedy. If Ofcom does consider that these product rules inhibit innovative use cases or dampen adoption of the product, we would encourage Ofcom to consider whether improvements to DFA are required to ensure it can be used by MNOs to cater for future mobile demand and deliver the high-quality services that people will expect.

## AVAILABILITY OF SUITABLE MOBILE SPECTRUM TO MEET DEMAND

### Planned spectrum release for mobile use

#### (mmWave - 26 GHz and 40 GHz)

In dense urban areas, where the highest levels of demand exist, MNOs are increasing capacity through a combination of rapid deployment of existing mid-band spectrum, such as that in the 2300, 2600 and 3400-3800 MHz bands, as well as through increased cell densification. However, existing mid-band spectrum will be quickly absorbed. This will happen due to the ongoing growth in demand for data, fuelled by current applications and corresponding increased smartphone usage, and the adoption of 5G. This is expected to be further driven by enhanced applications and new use cases over the coming years.

To meet continued growing demand in these areas, there will be a focus by MNOs on densification and a corresponding need to deploy additional suitable spectrum to maintain a high-quality mobile service. **[✂]**.

**[✂]**

**[✂]**

It is worth noting that there is still some uncertainty around the device support for mmWave bands in Europe, including the 26 GHz and the 40 GHz band. This uncertainty and the time it will take for support to reach scale in the installed base of devices, means that effective deployment of mmWave may be some years away. Notwithstanding, we think that mmWave spectrum could be important in the future for the provision of very high throughput services and to meet the highest levels of demand in a limited number of location types.

#### 1.4 GHz band (1492-1517 MHz)

We note Ofcom's plan to award spectrum between 1492-1517MHz. This spectrum is part of the wider 1.4 GHz band (1427 – 1518 MHz) that was identified for mobile use at WRC-15, and later flagged as a high priority for release by Ofcom. It is technically harmonised for mobile use and 1452-1492 MHz is already used to deliver 4G mobile services in the UK.

Whilst we welcome suitable spectrum being made available for mobile use by Ofcom, we observe that 1492-1517MHz only represents a total of 25 MHz of spectrum. Furthermore, this spectrum is supplementary downlink spectrum (SDL) only and is therefore limited in capability and scope. SDL bands more generally, are difficult to make good use of and device support is also limited. Technology considerations and carrier aggregation support is also a concern with this particular band.

## Specific frequency ranges for future mobile access

Even with a multitude of measures and efforts including **[✂]**. It is our expectation that this trend will continue for the foreseeable future and thus a sufficiently long-term view and plan is required by Ofcom in respect of spectrum release for mobile use.

The combination of ongoing growth in data demand and evolving user needs means that MNOs, over time, will require additional spectrum across a *range* of bands, to both improve their connectivity and to ensure that congestion does not degrade the service that they otherwise would be able to deliver. We set out below the specific bands and frequency ranges that we consider relevant, along with a view of their respective importance.

### Upper 6GHz band (6425-7125 MHz)

Existing mid-band spectrum will be quickly absorbed by the ongoing demand for mobile data. Given the limitations outlined above in relation to the deployment of mmWave spectrum, MNOs face a future challenge in the coming years, **[✂]**

**[✂]**

**[✂]**

**[✂]**

A recent study by Coleago Consulting[6] confirmed this conclusion and identified the scale of the additional mid-band spectrum required. Based on a thorough analysis of long-term 5G mid-band spectrum needs, it concluded that:

*"Additional mid-band spectrum would enable the 5G NR experienced 100/50 Mbit/s data rate to be delivered in an economically feasible manner in the cities we examined, anytime, anywhere, citywide thus delivering not only the 5G experience for smartphone users but also enabling the smart city".*

**[✂]**

Coleago concluded that 2 GHz of additional mid-band spectrum is needed for mobile operators to deliver high-quality mobile connectivity across urban and suburban areas.

**[✂]**

**[✂]**

[6] https://www.coleago.com/app/uploads/2021/09/Estimating-Mid-Band-Spectrum-Needs.pdf

In its discussion document, Ofcom correctly identifies that making additional spectrum available for high-power outdoor mobile use would likely require clearing bands of existing users. Given the significant amount of time it is expected to take to clear and repurpose such spectrum (which Ofcom believe will be around 6-8 years), it is critical that Ofcom commences the required preparatory process now, to start the groundwork and lay the foundations for release in the future. This includes carrying out vital work in relation to preparations for, and having a clear UK Government position on, WRC-23, in relation to the upper 6 GHz band.

The band is currently being studied for IMT identification (mobile use) as part of preparations for WRC-23. Designation to the IMT system is the most effective way to ensure that a band can be used on a large scale for delivery of mobile services. It ensures that the required ecosystem develops and is at a scale that supports efficiency and innovation.

**[✂]**. In 2020, Ofcom allocated 500 MHz of spectrum in the lower 6 GHz band, to Wi-Fi. This almost doubled the amount of spectrum available for Wi-Fi use. **[✂]**

We strongly urge Ofcom to support designation of the upper 6 GHz band for mobile use and that it makes UK Government's position clear on the band as part of its preparations for WRC-23. This is critical for a mobile ecosystem to develop for this band, which is a requirement for it being used to deploy mobile services. This will be a critical part of creating the right conditions to encourage greater investment in 5G and deliver the level of ambition that the country will expect in terms of the availability of high-quality mobile services.

## Lower 2300 MHz band (2310-2350 MHz)

The 2300 MHz band is harmonised for mobile broadband use and there is an appropriate ecosystem involving equipment and devices. The lower 2300 MHz band is currently used by the Ministry of Defence (MoD), **[✂]**. This results in sub-optimal use, when considering how useful this spectrum could be when used to deliver mobile connectivity.

We urge Ofcom to help facilitate release of this spectrum. If made available for high power mobile use, it could be deployed immediately to provide capacity and help to meet the growing demand for data now, as well as over the coming years.

Ofcom should consider all options to make this band available, either by clearing the spectrum and assigning it to mobile use, or by putting a system in place whereby the MoD shares unused spectrum in a way that allows it to be used effectively for mobile use, when not used by the MoD. **[✂]**

We think that there is an opportunity for Ofcom to add this spectrum to the existing pipeline of spectrum it has planned for release, for example by releasing the spectrum at the same time as the 1492-1517 MHz spectrum.

In its 2019 Statement of Strategic Priorities[7], the Government identified the release of additional public sector spectrum as a strategic priority. Previous collaboration between Government and Ofcom in this area, led to the release of the upper 2300 MHz band, and the 3400 MHz band. Since then, it appears that there has been little progress with further spectrum release.

In its current discussion document on meeting future demand for mobile data, Ofcom does not consider the lower 2300 MHz band in the context of potential opportunities for mobile providers to share spectrum with other users. Neither does Ofcom consider it in its recently published spectrum roadmap discussion document[8]. We find this surprising, as the lower 2300 MHz band is a prime candidate for sharing, given the ecosystem that exists.

Ofcom has made clear its strategic aim of promoting spectrum sharing and encouraging users to share access to spectrum with other users. In its 2021 statement on spectrum management strategy for the 2020s[9] Ofcom set out its spectrum management vision to enable further innovation by promoting more flexible and efficient use and increased sharing of spectrum while meeting the requirements of local and national services. VMO2 believes that a policy that seeks to encourage spectrum sharing (which as a principle, we support) should be multi-directional. That is, it should not just focus on granting non-mobile users' access to mobile bands but apply equally to bands allocated to other use types. It should also aim to remove unnecessary barriers that make it challenging for existing licence holders and access seekers to agree on commercial terms for granting access.

Given Ofcom's stated strategic aim, we are disappointed with the lack of progress and examination of bands such as the lower 2300 MHz, and the 3.8-4.2 GHz band, for sharing which would include the potential for high power mobile use. This leads us to consider whether Ofcom's current spectrum sharing framework is sufficiently multi-directional. Whilst spectrum sharing opportunities into MNOs existing spectrum by third parties have been enabled, opportunities for MNOs to share spectrum used by other spectrum users, do not appear to have not been properly examined, nor progressed, and we think that more action is required.

We believe that Ofcom should actively explore the potential of re-purposing and release, or sharing of, spectrum bands that are underutilised and which could be used more efficiently and to deliver greater value. Ofcom should carry out scoping work to assess the feasibility of high-power mobile services being authorised to use spectrum such as the lower 2300 MHz band and the 3.8-4.2 GHz band, including through examination of existing barriers and potential co-ordination mechanisms.

## 3.8-4.2 GHz band

We believe that the 3.8 - 4.2 GHz also band has strong potential for high power mobile use. However a large part of this band is currently set aside for shared use on a low or medium power basis only,

[7] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/952627/SSP_-_as_designated_by_S_of_S__V2.pdf

[8] https://www.ofcom.org.uk/__data/assets/pdf_file/0021/234633/spectrum-roadmap.pdf

[9] https://www.ofcom.org.uk/__data/assets/pdf_file/0017/222173/spectrum-strategy-statement.pdf

under Ofcom's spectrum sharing framework. Whilst existing sharing opportunities currently exist, they only provide benefit at the margin. Ofcom's existing spectrum sharing framework is essentially an experiment. As with any experiment it is important to review the results and draw conclusions. Ofcom should carefully monitor and evaluate take up of the spectrum within the framework, and if there is relatively little usage, we believe that Ofcom should be agile and actively explore alternative ways to ensure its optimal use. Ofcom should set out its view of what conditions have to be present for it to consider that the existing sharing, has or hasn't, been a success (for example, number of licences issued by a certain date).

In the near term, whilst the shared licensing experiment continues, Ofcom should carry out work to assess the feasibility of high-power mobile services being enabled to use the spectrum, through conducting a cost-benefit analysis for mobile use and/or examination of potential spectrum sharing co-ordination mechanisms. Ofcom should be mindful that spectrum rights that are artificially restricted by aspects such as power, can foreclose alternative sharing opportunities, reducing the value of the spectrum and resulting in sub-optimal use. Sharing mechanisms should therefore seek to ensure compatibility with high power use, for example through use of databases that can be used to manage co-existence between sharers and maximise efficiency.

## Low band UHF spectrum (600 MHz)

As we have previously outlined, in the future, mobile connectivity delivered using 5G will be widely available, but it will typically not be of the highest quality in rural areas. **[✂]**

**[✂]**

Making additional low band spectrum available in the form of the 600 MHz band, will help to address this problem and reduce the quality divide between rural and urban areas. In addition, this spectrum can be deployed across a wide range of areas in order to provide even greater coverage and better indoor performance, whilst adding additional 5G capacity.

A recent study by Plum Consulting[10] examined the current and future use of the UHF band between 470 MHz and 694 MHz, considering both mobile demand and broadcast viewing habits, and challenged whether allocation of this spectrum should be changed. In relation to rural areas, the report states that:

*"…the economics of networks ensure that operators find it challenging to justify further investment…This threatens to open a new type of digital divide, where those in urban areas are able to access services that rural inhabitants are excluded from".*

The report also states:

[10] https://plumconsulting.co.uk/the-future-use-of-uhf-in-itu-region-1/

*"…The only way to provide these high-quality services in deep rural areas is through greater use of sub-1 GHz UHF spectrum, which will provide network operators with the ability to dedicate further bandwidth on existing site infrastructure to 5G or future mobile technologies. This will not only benefit deep rural areas through the availability of new technologies – although the benefits in those areas are very large by themselves – but it will also benefit those on transport routes and the development of connected vehicles. It will help with economic wellbeing and with societal targets of inclusion and equality…".*

**[✂]**

**[✂]**

If the current users of this spectrum (i.e. the public service broadcasters and multiplex licensees) wish to vacate it ahead of the 2034 licence expiry, driven by changes in funding models and a substantial shift in TV consumption patterns (to IP and application delivery) we believe that Ofcom should be agile and move to close down DTT, before licence expiry, *if desired* by the public service broadcasters. Ofcom can then expedite releasing this spectrum for mobile use and ensure its optimal use.

In the meantime, Ofcom should support a co-primary designation to mobile at WRC-23, as a first step. A move to mobile co-primary designation will assist with developing the ecosystem ready for standardisation. This will put the UK and other countries on the trajectory of this spectrum being assigned to mobile when it is appropriate to do so. Once released for mobile use, it can then be used by MNOs to improve the quality of 5G connectivity they can deliver in rural areas and help to close what will be a significant and growing quality divide.