Three's response to Ofcom's Mobile Spectrum Demand Consultation

Non-confidential

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Executive Summary.

Spectrum, cell sites and technology are the key building blocks of an MNO's network. We require a combination of these to provide the capacity to serve our customers.

We have seen an explosion of traffic growth in recent years and expect further growth as 5G brings faster speeds and new data-hungry applications. We have plans to deploy additional sites and increase the efficiency of our existing spectrum holdings in the face of this growth, but that alone will be insufficient without access to more spectrum.

Our network modelling, based on a conservative traffic forecast, [✂]. Ofcom's view is that MNOs can relieve this congestion without additional spectrum, beyond that already in the pipeline. Instead, each MNO would deploy 'many thousands' of small cells with mmWave spectrum by 2030 and 30-50k by 2035 in its medium demand scenario. Our experience from industry engagement and small cell trials is this would not be possible for two reasons.

Firstly, the costs of deploying small cells are prohibitive. It is significantly more expensive for an MNO to build a network of small cells than to deploy macro sites.

Secondly, it would be impractical to deploy a small cell network at the scale Ofcom assumes. Small cells need to be very precisely located to successfully offload traffic from a macro site and in many cases, it will not be possible to deploy a small cell in the correct location. Even where this was possible, connecting the small cell to an MNO's core network will often be problematic.

Our view is that only the allocation of additional spectrum for mobile use can resolve the congestion issues that we are forecasting from 2025. The 600MHz and 6GHz bands are ideal candidates and should be assigned to mobile as soon as practically possible:

- The continued rise of IPTV will mean that the use of the **600MHz** band for digital television will no longer be justifiable by the time Ofcom can revoke DTT licences in 2030. By this time, the highest value use of the band will be to relieve mobile congestion in hard-to-reach areas. We ask that Ofcom publishes proposals to repurpose the band for mobile use, issues licence revocations and aims to award the band in 2028.
- The **6GHz** band has ideal propagation characteristics which strike the balance between coverage and capacity. There are large bandwidths available in the upper 6GHz band which could help resolve congestion issues in urban areas if assigned for mobile. The spectrum has also been earmarked as a pioneer 6G band. We ask that Ofcom supports the allocation of the upper 6GHz band for licenced mobile use at WRC-23 and awards the spectrum to MNOs by 2026.

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1. Spectrum is and will remain critical to meeting mobile network demand.

Executive Summary

Spectrum, alongside mobile cell sites and technology, is a critical resource that MNOs need to provide capacity on their networks. The traffic growth we've recently experienced has meant that MNOs have had to heavily invest in all three resources just to keep our networks running.

We do not see this changing in the future. Despite plans to deploy many new sites, deploy existing spectrum more widely and upgrade network technologies, we expect that MNOs will continue to need significant amounts of additional spectrum with various propagation characteristics to avoid congestion on our networks.

This is contrary to Ofcom's finding that UK MNOs do not require additional spectrum beyond additional holdings and the 1400MHz and 26GHz bands to meet capacity demands by 2030. We discuss why we disagree with this finding in the remainder of the document.

Spectrum is a critical network resource to provide the capacity that consumers demand

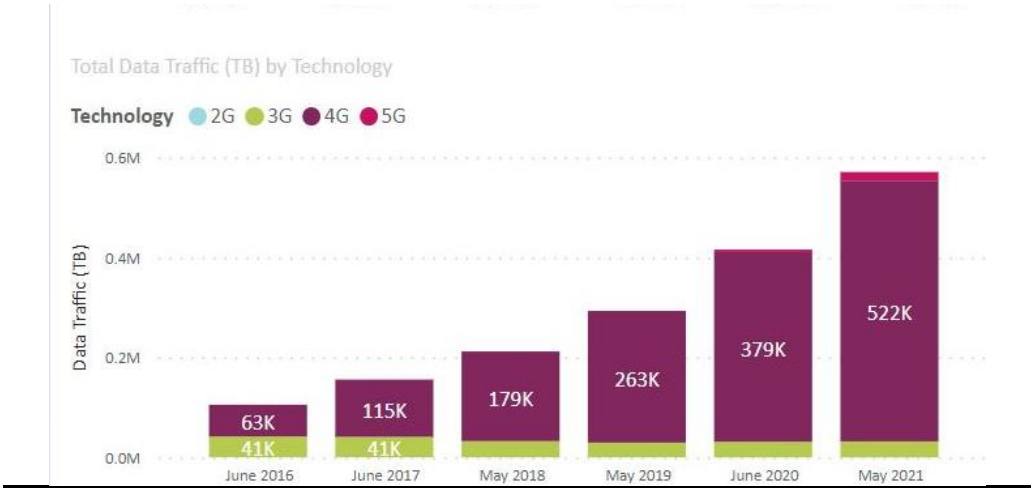
Mobile network operators (MNOs) require three network resources to provide the network capacity to serve their customers:

- **Spectrum.** The airwaves over which mobile services are provisioned. MNOs need a portfolio of spectrum with different propagation characteristics to provide capacity to customers in different locations.
- **Mobile cell sites.** A typical UK MNO deploys its spectrum on 15,000-20,000 macro mobile sites. In the future, MNOs may also deploy small cells where feasible to provide additional capacity in very busy areas.
- **Spectral efficiency**. The quality of service (measured as the amount of data carried per MHz of spectrum) that an MNO can provide to customers over its spectrum. This is largely driven by the equipment technology used to transmit data (i.e. 3G, 4G, 5G etc.).

MNOs need a combination of these inputs to run a mobile service. Once an MNO has a certain amount of spectrum, number of mobile sites and technology, these resources are, to some extent, theoretically substitutable. That is, capacity could be expanded by deploying additional sites, spectrum or upgrading technology.

Mobile traffic has been increasing by an average of 40% every year over the past five years.

Figure 1: Historic UK mobile traffic growth



Source: Ofcom Connected Nations Interactive Report 2021

In practice, this explosion in traffic growth has meant that MNOs do not have the luxury of investing in only one of these resources to meet capacity demands. Instead, we have needed to increase utilisation of all three. Three UK has done this in recent years by:

- Purchasing 20MHz of 5G **spectrum** in the 2018 3.4GHz auction, a further 20MHz of 700MHz spectrum in 2021 and deploying it alongside our other holdings (including 120MHz in the 3.4-3.8GHz band).
- [✂]
- [✂] We are also planning to shut down our 3G network to refarm spectrum to the more efficient 4G technology by the end of 2024.

Ofcom has historically recognised the requirement for additional mobile spectrum to meet this demand, alongside other means of expanding capacity. As a result, it has allocated significant quantities of new spectrum for mobile use approximately every three to five years.

Figure 1: Ofcom mobile spectrum awards (2013-2021)

Year	Spectrum bands awarded	Total bandwidth awarded
2013	800MHz and 2.6GHz	250MHz
2018	2.3GHz and 3.4-3.6GHz	190MHz
2021	700MHz and 3.6-3.8GHz	200MHz

MNOs have complemented the spectrum won in these auctions by adding to their portfolios in other ways. For example, Three UK gained access to 120MHz of 3.4-3.6GHz spectrum and significant mmWave holdings with our acquisition of UK Broadband in 2017 and bought 20MHz of 1400MHz spectrum from Qualcomm in 2015.

Even with these regular additions to their spectrum portfolios and extensive network deployments, MNOs have struggled to stay on top of network congestion over this period.

Spectrum will remain a critical network resource in the future

We expect the explosion in traffic growth to continue or even increase over the next few years, as 5G provides faster speeds and new data-hungry applications are developed. Ofcom's mid-case estimate of future mobile traffic growth assumes a 40% year-on-year increase in traffic between now and 2035. We agree that there is great uncertainty around this growth: future applications and use cases could feasibly push traffic beyond this level.

Future growth can be met to some extent by network densification, technology upgrades and more widely deploying our existing spectrum holdings. We plan to continue doing this, but there is a limit to how many additional sites we can feasibly build and how much of our existing spectrum portfolio we can efficiently utilise. We expect that MNOs will also require additional spectrum before 2030 to relieve the congestion that future traffic growth will bring.

Not all spectrum is equal. In hard-to-reach rural and indoor areas, customers need access to low frequency spectrum which propagates over greater distances and through walls. In areas which are easier to reach (e.g. urban and suburban areas), mid and high band spectrum with larger bandwidths are able to provide much greater capacity at the expense of travelling shorter distances. We anticipate that MNOs will not just require one type of additional spectrum in the future. More likely, we will require a mix of additional spectrum in different bands.

Ofcom's initial view is that MNOs can meet capacity demands by 2030 without additional spectrum (beyond current holdings and 1400MHz/26GHz spectrum)

Ofcom's discussion paper[1] gives its view on the extent to which MNOs will require additional mobile spectrum to serve their customers by 2030.

It begins by claiming that '*the UK mobile market is operating effectively and serving customers well'*, particularly in reference to pricing outcomes.[2] Our view is that, although mobile prices in the UK sit in the lower to middle range of European countries, UK mobile network quality is comparatively poor and UK consumers have lower levels of satisfaction with mobile than consumers in other countries. We expand on these views in our response to Ofcom's Mobile Strategy Review discussion paper.

Ofcom's forward-looking assessment then looks at a variety of factors which suggest mobile data traffic will continue to grow in the future, including new mobile applications. From this, it generates three mobile data traffic growth scenarios: low, medium and high growth. The low and high growth scenarios reflect its view of the possible extremes, while the medium scenario assumes a continuation of the growth in recent years.

Ofcom considers three ways in which MNOs can expand capacity to meet demand in these scenarios:

- Deploying existing spectrum holdings on current macro sites;
- Densifying networks by using mmWave spectrum on small cells; and
- Densifying networks by increasing the number of macro sites.

It concludes that, without additional spectrum or small cell densification, operators could run out of capacity by around 2025.

In its view, MNOs can meet future demand with network densification alongside technology upgrades, the award of spectrum in the 1400MHz and 26GHz bands and by making full use of existing spectrum holdings. In its medium demand case, it assumes that each MNO does this by deploying 'many thousands' of small cells with mmWave spectrum by 2030 and 30,000-50,000 by 2035.

Our assessment is that, contrary to Ofcom's initial analysis, MNOs will require further spectrum to meet capacity demands by 2030

We have carried out our own analysis using Ofcom's medium growth scenario. [✂] we do not agree that this can feasibly be resolved without access to additional mobile spectrum over and above the planned release of the 1400MHz and 26GHz bands.

In the rest of this document:

[1] Ofcom 2022, Mobile Networks and Spectrum: Meeting future demand for mobile data
[2] Ofcom 2022, Mobile Networks and Spectrum: Meeting future demand for mobile data, paragraph 3.1.

- In section 2, [✂].
- In section 3, we discuss why alternatives to additional spectrum are impractical and uneconomic.
- In section 4, we discuss why Ofcom must allocate the 600MHz and 6GHz bands for licenced mobile use as soon as possible.

2. [✂].

Executive Summary

Ofcom's analysis indicates that UK MNOs' networks will start to become congested by 2025. In this section, we report the results of our own congestion analysis using Ofcom's medium traffic growth scenario across the two layers of our network (which are determined by the propagation properties of our spectrum).

[✂]

[✂]

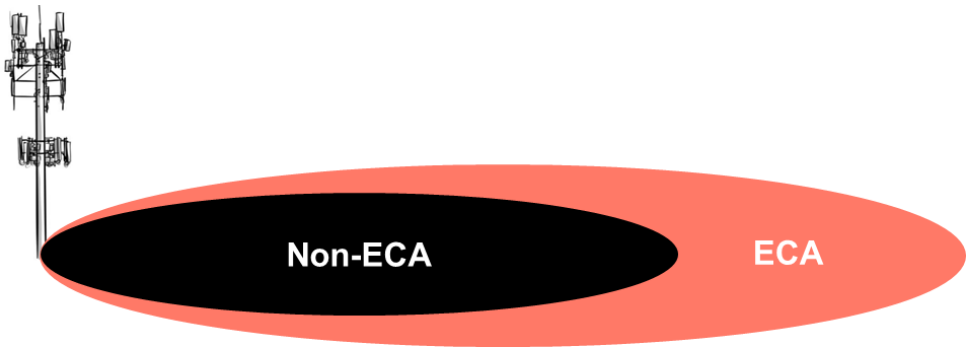
We determine our spectrum requirements by modelling future network congestion

When assessing our requirement for future spectrum, we estimate the extent to which predicted traffic growth will drive congestion[3] with our current spectrum holdings and deployment plans. We do this across two areas based on our spectrum portfolio's propagation characteristics:

1. The extended coverage area (ECA) is all locations which can only be served by our low frequency spectrum (700MHz, 800MHz and 1400MHz).
2. The non-ECA is all other areas which are within the coverage of our mid-band spectrum (1800MHz, 2100MHz and 3.4-3.8GHz).

[3] A site in our analysis is congested if [✂].

Figure 2: Illustration of Extended and Non-Extended Coverage Areas



Source: Three UK

We then consider the options we theoretically[4] have to relieve this congestion in the absence of new spectrum (typically deploying new macro or small cells in urban areas). Finally, we assess whether it is feasible or economic to use these options rather than additional spectrum.

We have undertaken this analysis using Ofcom's medium traffic growth scenario [✂]

[✂]

[✂]

[✂]

[4] At this stage, we ignore whether these solutions are practical or economic.

Figure 3: [✂]

[✂]

Source: Three UK

[✂]

[✂]

[✂]

[✂]

[✂]

1400MHz and mmWave spectrum releases are unlikely to solve the issue of increasing network congestion by 2030

Ofcom is intending to allocate additional 1400MHz downlink only spectrum and 26GHz mmWave spectrum to mobile by 2030. We welcome Ofcom's recognition that the mobile industry will require additional spectrum to keep their networks running over the next eight years. However, our view is that the spectrum in these bands is insufficient to alleviate network congestion over that time period. We discuss each band in turn.

1400MHz supplementary downlink

We welcome Ofcom's intention to release additional low frequency spectrum for mobile by 2030. Spectrum with these propagation characteristics is rare and vitally important for relieving congestion in the ECA since higher frequency bands cannot reach these areas.

However, since small bandwidths of low frequency spectrum are available for mobile use, the ECA becomes congested relatively easily. [✂].

The release will only amount to an additional 10% of low frequency spectrum [✂]

A further challenge with auctioning downlink only spectrum is that it does not resolve congestion in the uplink. [✂].[5]

Releasing additional low frequency spectrum will also not resolve congestion issues in high footfall areas which are served by mid band spectrum (i.e. the non-ECA). These areas will require additional mid band spectrum to offload traffic instead.

26GHz mmWave spectrum

Ofcom will shortly consult on its proposals to release 26GHz spectrum for mobile use. There may be a role for targeted small cell deployments using this spectrum in the future, but the practical and economic difficulties associated with small cell deployments means that widespread rollout of mmWave spectrum to alleviate congestion is infeasible.

We discuss this subject in more detail in the next section.

[5] This is because the majority of MNOs' traffic uses TCP-based services which require feedback to be given via the uplink. If the uplink is constrained, the downlink speeds that MNOs can offer will be reduced.

3. Alternatives to additional spectrum are not practical or economic.

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Ofcom's finding that MNOs do not require any further spectrum before 2030 (beyond the planned release of the 1400MHz and 26GHz bands) is predicated on an assumption that MNOs will deploy 'many thousands' of small cells with mmWave spectrum by 2030 and 30-50k by 2035 in its medium demand scenario.

[✂] we recognise that there will be localised deployments of small cells in high footfall areas in the future and have engaged in trials and market analysis to understand small cell costs and feasibility.

[✂]

Some industry commentators have made optimistic predictions about future small cell deployments for years. For example, the small cells forum predicted in 2013 that small cells would account for nearly 90% of mobile base stations worldwide by 2016.[6] These predictions have not borne out in the actual deployment numbers we've seen. We do not see any reason to believe that today's predictions are any more realistic.

In this section, we discuss the economic and practical issues we have encountered in our trials which mean that we will not deploy the number of small cells that Ofcom assumes by 2030. We also consider why other alternatives to additional spectrum will not be economic or practical to solve the congestion issue we have highlighted above.

Ofcom is overly optimistic about the economics of small cell deployments

There are several different small cell deployment models, varying from self-build/provision to neutral host models, where the MNO provides only the spectrum. These all have slightly different cost profiles, but our industry engagement has shown that the costs are more prohibitive than macro sites, regardless of the model.

In our experience, the key drivers of small cell costs are:

- RAN equipment for small cells must be more compact than that used for macro cell deployments. This results in expensive equipment with more limited functionality (e.g. each piece of equipment can support only one spectrum band). At this stage, vendors' focus is on competing for market share in the macro cell equipment market rather than small cells. As a

[6] https://www.smallcellforum.org/newsstory-small-cells-to-make-up-almost-90-percent-of-all-base-stations-by-2016

result, the equipment ecosystem has not adapted to the requirements of small cells, either in terms of size or cost.

- [✂]
- [✂]

We have recently engaged with industry to better understand small cell costs. The estimates we have received from five vendors are:

- [✂]
- [✂].[7]
- [✂]

These unit costs can be reduced by grouping together small cells so that they share common costs, such as baseband units (BBUs). The extent to which these costs are shared is determined by how many small cells an MNO can cluster together.

We have compared these costs against those of the macro sites we are deploying in our densification programme. **[✂]**[8]

Figure 4: [✂]

[✂]

Source: Three UK

This illustrates the economic challenges of deploying small cells compared to macro sites. Macro sites are the cheapest solution for all three cost categories

[7] [✂]
[8] [✂]

and, most notably, opex is far lower on a macro site than small cells.[9] In fact, the opex costs of only [✂] small cells are greater than one macro site.

Ofcom appears to recognise the risk of small cell deployments costing more than traditional networks but dismisses this due to '*strong competition among MNOs creating a strong incentive to invest such that there is no degradation of service'*.[10]

We fundamentally disagree with this perspective. Small cells are not a cost-effective substitute for deploying additional spectrum on existing macro sites. The number of small cells that would be required to provide similar capacity and speeds to users would be so large as to be uneconomic. Leaving to one side the time that such rollout would take and the physical impossibility of deploying tens of thousands of small cells where they are most needed (i.e. dense urban areas), the costs of doing so would be exorbitant.

In practice, an MNO cannot address a shortage of spectrum through small cell densification. Faced with high costs of small cell deployment, UK MNOs will have less of an incentive to expand capacity and compete aggressively for new customers and are likely to provide inferior services once their networks become congested.

As we have demonstrated in our response to Ofcom's Mobile Strategy Review discussion paper, competition in the UK does not lead to good network quality. In summary:

- Mobile revenues have been in long-term decline and Three and Vodafone are not covering their cost of capital.
- Investment in the UK is wastefully duplicated across too many MNOs, some of which are too small to take advantage of the available scale economies.
- The UK ranks poorly on network quality metrics against comparator countries in a range of independent studies.[11]

When faced with a decision between investing more money in providing additional network capacity or letting it congest, UK MNOs often appear to choose the latter. An Opensignal study[12] finds that UK networks are some of the most congested in Europe[13], with London being particularly impacted. Ofcom cannot simply rely on MNOs to invest in small cell deployments to relieve congestion if doing so remains prohibitively costly.

[9] As recognised by Ofcom. Ofcom 2022, Mobile Networks and Spectrum: Meeting future demand for mobile data, paragraph 5.66.
[10] Ofcom 2022, Mobile Networks and Spectrum: Meeting future demand for mobile data, paragraph 5.67.
[11] For example, the UK ranks 22nd out of 33 countries on the number of 5G sites per person; 12th and 10th out of 21 European countries on 5G speeds and availability according to Ookla; and 7th and 8th out of 12 European countries on Opensignal's study of 5G experience.
[12] https://www.opensignal.com/sites/opensignal-com/files/data/reports/global/data-2019-02/the_5g_opportunity_report_february_2019_0_0.pdf
[13] It is one of only four countries in the study which cannot maintain minimum download speeds of 20Mbps during busy times.

Ofcom's analysis understates the practicalities of densifying a mobile network

Even if small cell deployments were economic, Ofcom's assumption that we could deploy many thousands of small cells by 2030 is not realistic, in our experience.

Small cells must be in the right location, connected to backhaul and a power source and installed on street furniture (e.g. lampposts, CCTV columns and bus shelters, as well as on the side of buildings). The prevailing model in the UK is one where this infrastructure is operated by a neutral host (e.g. Cellnex, BAI) which acquires rights to assets on which small cells can be placed – e.g. by winning concessions from the asset owners, such as Local Authorities or Tfl in London. The host then markets the small cells to MNOs in specific locations and in some cases shares some of the revenues with the owner of the assets.

Ofcom identifies a number of practical considerations in deploying small cells.[14] It considers that these are the same deployment considerations that apply to macro sites, but in greater numbers. We agree that the categories of these practicalities are broadly the same, however, the challenges can be much more significant for small cell deployments. In this subsection, we discuss some of the main issues we have experienced in our trials.

Small cells must be located very precisely

A key practical concern we have identified in our trials is that a small cell must be very precisely located to effectively relieve network congestion. Macro sites have large coverage areas which typically incorporate both areas of high and low traffic. Small cells have far smaller coverage areas (approximately 100-200 metres), because they transmit at lower power than macro cells.

Given its small coverage area, for a small cell to be effective at offloading congestion from a macro site, it must be placed right inside a traffic hotspot. If an MNO cannot deploy a small cell in the correct location:

- The traffic will remain on the macro site rendering the small cell ineffective; or,
- In some cases, the MNO may be able to inefficiently deploy more small cells around the hotspot with each offloading some of the traffic, at even greater cost.

In both cases, if the right location for a small cell is not available exactly where it is needed, a small cell could actually be detrimental to the running of our network if we deploy the same spectrum on neighbouring macro sites. This is because it could introduce interference between the small cells and macro sites, leading to a loss of capacity on the macro site.

[✂]

[14] Ofcom 2022, Mobile Networks and Spectrum: Meeting future demand for mobile data, 5.62.

This tells us that there will be many areas of the country where we cannot find assets on which to deploy small cells to effectively relieve congestion. It also indicates that a desktop modelling exercise which does not account for the availability of assets in suitable locations cannot realistically predict the extent to which MNOs can offload traffic onto small cells.

Lack of fibre availability and information

Finding an asset on which to deploy a small cell is only part of the problem. An MNO then has the question of how to transmit traffic back to our core network from the small cell. Typically, an MNO will aim to do this using fibre backhaul.

[✂]:

1. **Cost**. Microwave links can be significantly more expensive than fibre.
2. **Reliability**. Microwave links can be less reliable than fibre. For example, connections can be impacted by factors, such as bad weather, which do not affect fibre connections. Microwave connections can be engineered to reduce these reliability issues, but at the expense of throughput.
3. **Practicality**. Microwave backhaul transmitters need to be located within line of sight of their backhaul receivers. This is challenging in dense urban areas where small cells are needed most, as there will typically be obstructions between street furniture and the backhaul receiver (e.g. a macro site located on a rooftop). Furthermore, some microwave transmitters are quite large and cannot be accommodated on small cell assets.

In recent years, fibre availability has grown so that a greater proportion of potential small cell sites will have access to fibre backhaul. However, fibre backhaul is still not close to being available at the density necessary for a widespread small cell deployment.

Even where fibre is available, we have experienced issues identifying it since there is no comprehensive mapping of fibre networks. [✂]

Where there is no fibre connection, MNOs have the options of paying providers to dig from their network to the small cell(s) at considerable cost or using microwave backhaul. Neither option is practical or economic on a large scale.

[✂]

Lack of equipment and device support for Three UK's mmWave spectrum

Ofcom's analysis assumes that MNOs will deploy mmWave spectrum on small cells to relieve network congestion. Three UK currently holds 2GHz of mmWave spectrum in the 42GHz band, but this is far from being useable for widespread small cell deployments.

[✂]

Furthermore, device and equipment support for our 42GHz spectrum is currently non-existent [✂] we will then have to lobby equipment and device

manufacturers to include the band in their products. This will add more time (likely to be measured in years rather than months[15]) to the process.

The upshot of this is that we expect that deployments could possibly begin [✂], all being well. Our experience from other network deployments is that we will not go from zero mmWave small cells to widespread deployment quickly. Instead, there is typically a phasing of the deployment over time. We, therefore, consider it unlikely that we could deploy mmWave spectrum on thousands of small cells by 2030 as Ofcom assumes, even before we consider the other practical and economic issues we have identified.

Other practical issues

We have identified a number of further practical issues from our trials, including:

- Local Authority approval. [✂] We have no reason to believe permissions will be easier to obtain elsewhere. Ofcom's paper understates the planning and permissions challenges when deploying small cells, even on a small scale.
- Site access. The location of small cells (e.g. on street furniture) means that MNOs often do not have 24/7 access to them for deployment and maintenance. This makes it more difficult to deploy the small cells, fix faults and can further inflate operational costs if our workforce has to work unsociable hours.
- Size of the RAN equipment. As we explain above, small cells require bespoke RAN equipment which the ecosystem has not yet fully mastered. The equipment is currently large, meaning that many assets will be unable to support it. It also means that we can only deploy a subset of our spectrum portfolio on each small cell, reducing the amount of capacity they can provide.

It is our view that the combination of these practical issues and the economics of deploying small cells means that a widespread deployment of small cells on the scale that Ofcom's paper assumes is infeasible. This list of issues is unlikely to be exhaustive. We have only undertaken small scale trials of small cell deployments, so it is likely that we have not identified all the issues associated with more widespread programmes.

Alternative ways to meet future traffic growth will not obviate the need for more spectrum

Ofcom variously refers to other ways in which MNOs can increase their network capacity without accessing additional spectrum in its report. We are already planning to use these measures to various extents, but in no case will they realistically replace the need for additional spectrum deployed on existing sites. We discuss each in turn.

Deploying more macro sites

[15] [✂]

[✂]

As traffic continues to grow beyond 2025, it is likely that we will look to densify further (subject to budget availability). However, it will become more and more challenging to do so in urban and dense urban areas, given a lack of appropriate locations and potential interference with existing macro sites. Given this, we agree with Ofcom's view[16] that further macro cell deployments to the extent required to relieve congestion post-2025 will be infeasible.

Deploying existing spectrum holdings more widely

[✂] Deploying additional spectrum has a cost (i.e. equipment, site visit, strengthening masts, etc). It makes no technical sense to deploy our full portfolio more widely given the distribution of traffic on our network.

Once this programme is complete, we will have no further low or mid-band spectrum to deploy in high traffic areas to reduce congestion.

Upgrading technologies

We have plans to switch off our 3G network by the end of 2024. This will free up our full 29MHz of 2.1GHz spectrum to be used for more efficient technologies. [✂] Although this will help increase our spectral efficiency, we expect it to have a negligible impact on our requirement for additional spectrum post-2025.

Indoor in solutions

Ofcom has identified a number of ways in which MNOs can reduce their reliance on low frequency spectrum to serve customers in hard-to-reach locations. These are:

- WiFi.
- Femtocells.
- In-building solutions.

We agree that these solutions can be used in targeted areas. For example, some households may choose to offload traffic onto WiFi or install a repeater to boost their mobile signal. Similarly, MNOs may be able to make use of neutral hosts' offers to install in-building solutions in some traffic hotspots, such as shopping malls.

However, it will be impossible to scale these solutions to serve customers the same extent as low frequency spectrum. This is simply because these solutions suffer from the same feasibility and cost issues as small cell deployments that we have discussed above.

[16] Ofcom 2022, Mobile Networks and Spectrum: Meeting future demand for mobile data, 5.45.

4. Ofcom should allocate 600MHz and 6GHz for mobile use as soon as possible.

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Ofcom has a statutory duty to ensure the efficient use of spectrum, which includes having regard to the different needs and interests of all persons that may wish to make use of spectrum. We therefore believe that Ofcom should ensure that both the 600MHz and 6GHz bands are allocated to the highest-value use cases, which we believe to be mobile use.

The 600MHz band is currently used for Digital Terrestrial TV (DTT) services which are in long-term decline as consumers increasingly watch content online, while demand for mobile services continues to grow rapidly. We believe that this band should be allocated for mobile use as soon as possible and ask Ofcom to publish proposals to this effect.

The upper part of the 6GHz band (6425-7125MHz) currently has various uses, such as fixed links, satellite links, the MoD and PMSE. We believe that the most efficient use of this band would be to licence it for mobile use, as is the case in different countries. This spectrum strikes an ideal balance between coverage and capacity, similar to the 3.4-3.8GHz spectrum, and has large bandwidths available which could deliver significant increases in mobile capacity. We ask Ofcom to support the use of this band for mobile at the upcoming 2023 Worldwide Radiocommunications Conference, with a view to repurposing the band for mobile use as soon as possible.

Consistent with Ofcom's duty to ensure efficient spectrum use, it should consider the case for allocating 600MHz and 6GHz for mobile use

When Ofcom exercises its powers in relation to spectrum, a number of statutory duties are relevant:

- Section 3(1) of the Communications Act sets out Ofcom's principal duty to further the interests of citizens and consumers in relevant markets; and
- By virtue of Ofcom's principal duty, Ofcom is required by section 3(2) of the Communications Act to secure the optimal use for wireless telegraphy of the electromagnetic spectrum. Section 3(4)(f) also requires Ofcom, in performing its duties, to have regard to the different needs and interests, so far as the use of the electromagnetic spectrum for wireless telegraphy is concerned, of all persons who may wish to make use of it (emphasis added).

Ofcom must therefore ensure that the 600MHz and 6GHz spectrum bands are allocated to the highest-value use cases, i.e. the ones that will deliver maximum consumer benefits. We explain below our view that both bands are being used

sub-optimally and that Ofcom should carefully and fully consider the case for allocating both bands for mobile use.

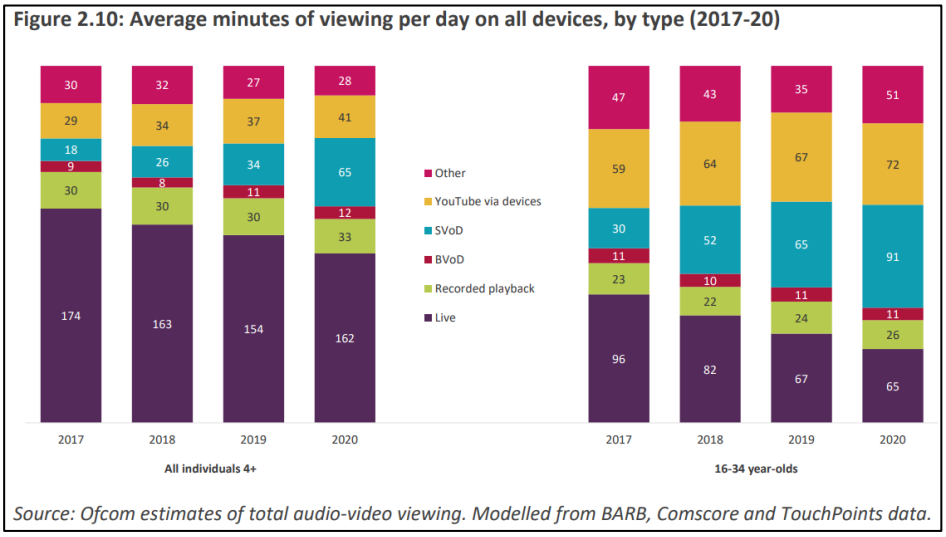
In addition, regarding the 600MHz band which is currently used for Digital Terrestrial TV (DTT), the government will ask Ofcom "*to continue to track changes to DTT viewing and to undertake an early review on market changes that may affect the future of content distribution before the end of 2025*".[17] In particular, the government notes the rise in IP TV and considers that Ofcom should consider how content should be distributed in its review.

The optimal use of the 600MHz spectrum band is for mobile

DTT Services are in long-term decline as consumers increasingly watch content online

Traditional TV viewing via DTT is in long-term decline as consumers increasingly watch TV via their internet connection, as shown below in Ofcom's Figure 2.10. The shift from traditional to online viewing is even larger for younger viewers (aged 16-34 years old).

Figure 6: Ofcom viewing minutes statistics (2017-20)



Source: Figure 2.10 from Ofcom's Media Nations: UK 2021 report

In Ofcom's Media nations: UK 2021 report[18], it discusses further the rise in IP TV and notes that the Covid-19 pandemic has accelerated the trend in watching on-demand services. Ofcom notes that:

- 65% of UK households used superfast or ultrafast services in Q1 2021 (in addition, Ofcom's 2021 Connected Nations report states that superfast broadband is available to 96% of UK households);[19]

[17] https://www.gov.uk/government/publications/up-next-the-governments-vision-for-the-broadcasting-sector/up-next-the-governments-vision-for-the-broadcasting-sector
[18] https://www.ofcom.org.uk/__data/assets/pdf_file/0023/222890/media-nations-report-2021.pdf
[19] https://www.ofcom.org.uk/__data/assets/pdf_file/0035/229688/connected-nations-2021-uk.pdf

- 74% of households used a BVoD service such as BBC iPlayer and 75% used an SVoD service such as Netflix, whereas only 42% of households used traditional TV;
- Nearly half of UK adults now consider online video services to be their main way of watching TV and film;
- There has been an increase in the number of smart TVs, with 79% of households connecting their TV to the internet; and
- Public Service Broadcasters (PSBs) are repositioning their businesses for an online-first future:
    - Channel 4 set out a new five-year plan to double viewing on All 4 and is increasing the number of series that are available in full as soon as the first episode becomes available;
    - ITV has restructured its broadcast business by positioning a new on-demand unit as its vehicle for growth, to cater for audiences that do most of their viewing online;
    - Channel 5 restructured in 2021 to combine two VoD assets into a single, new division and has been expanding the My5 content library;
    - The BBC is continuing to evolve iPlayer by making more programmes and films available for longer and ahead of broadcast schedule, among other improvements; and
    - According to reports, PSBs have discussed the development of a single, free streaming app that would aggregate all their live broadcasts and on-demand content in one place, accessible via a single sign-on.

We believe a reasonable case could be made for a mass-market switch to IP TV

In its 2014 document, The Future of Free to View TV, Ofcom considered the conditions needed for a mass-market switch to IP TV.[20] Below, we set out Ofcom's list of factors along with what Ofcom stated needed to be done for each, and we have added a column containing the latest data. We note that this is historic data and so the current position is likely an even larger switch from DTT to IP TV.

Table 1: Ofcom's view (in 2014) on the conditions required for a mass-market switch to IP TV and the latest data

	What needs to be done?	Latest evidence
Universally available superfast broadband	• 30Mb/s broadband available to 95% • Solution for remaining 5% to receive sufficient broadband for IP TV	• 96% superfast (30Mb/s) availability[21] • 0.4% (123,000) of premises can't access decent broadband (10Mb/s) but Ofcom expects this to fall to 100,000 in next year and broadband USO will

[20] Figure 5.3, https://www.ofcom.org.uk/__data/assets/pdf_file/0015/32640/Future-of-Free-to-View-TV.pdf
[21] 2021 Connected Nations, https://www.ofcom.org.uk/__data/assets/pdf_file/0035/229688/connected-nations-2021-uk.pdf

		provide connections to some of these premises[22]
High broadband take-up	• Expect at least 90% households to have broadband by mid 2020s • Potentially up to a quarter won't have superfast broadband by mid 2020s	• 86% had broadband in 2021[23] • 69% of those that can get superfast or faster broadband did so in 2021[24]
Near universal take-up of IP TV equipment	• Estimated that 27% of TV sets were connected to internet, need more IP-capable equipment in households by mid 2020s	• 79% of households connected their TV to internet as of Q1 2021[25]
Solution for those unable to receive IP TV	• Better satellite internet coverage	• 99.6% of premises can receive at least 10Mb/s (as only 0.4% cannot) which is sufficient for IP TV[26]
Broadband infrastructure capable of mass-reach IP TV	• Considers it "unlikely" that OTT services will be able to deliver reliable enough service	• As above, 99.6% of premises can receive sufficient broadband speeds to stream IP TV in HD
Sufficient protection for broadcasters against unwarranted traffic management	• Notes that existing framework could prevent significantly unwanted traffic management processes • More consideration needed as to whether further protections for broadcasters may be needed	• We are not aware of any concerns in this area and note that PSBs are investing heavily in IP TV
Commercial agreements between broadcasters and ISPs	• Relationship between ISPs as distribution platforms and broadcasters as content providers not yet tested, concern that ISPs could be gatekeepers	This concern has not been borne out (see page 22):[27] • PSBs are repositioning their businesses as online-first • Broadcasters discussing single free streaming app with single sign-on

[22] Ibid
[23] https://www.ofcom.org.uk/__data/assets/pdf_file/0020/224192/uk-home-broadband-performance-technical-report-march-2021-data.pdf
[24] 2021 Connected Nations
[25] https://www.ofcom.org.uk/__data/assets/pdf_file/0023/222890/media-nations-report-2021.pdf
[26] BBC iPlayer recommends 5Mb/s for "our best HD quality", https://www.bbc.co.uk/iplayer/help/questions/features/hd-information#:~:text=We%20recommend%20an%20internet%20connection,for%20our%20best%20HD%20quality.
[27] https://www.ofcom.org.uk/__data/assets/pdf_file/0023/222890/media-nations-report-2021.pdf

We fully expect the migration from traditional to IP TV to continue. A recent government publication (The government's vision for the broadcasting sector) explains that government is committed to ensuring that by 2025, at least 85% of premises have access to gigabit-capable networks and will seek to accelerate roll-out further to get as close to 100% as possible. It notes that at the same time, new product launches from platforms including Sky, Virgin and BT and the further development of Freeview Play-enabled devices are extending the take-up of IP TV services to a greater number of households than ever before.[28]

The government also notes that were IP TV to replace DTT over time, this could free up the spectrum for other uses, e.g. 4G, similar to when analogue TV was switched off due to migration to DTT. It notes that decisions on the future methods of distribution should be reviewed by Ofcom in its 2025 review of DTT services. We also note that government is aiming to ensure a level playing field between traditional broadcasters and providers of IP TV services, by bringing IP TV services within the scope of regulation by Ofcom, which removes a barrier to a mass-market switch to IP TV.

When Ofcom reviews DTT services in 2025, we would not be surprised if it found that a mass-market switch to IP TV was achievable, given the historic trends and the expected continuation of the move to IP TV.

600MHz spectrum used for mobile could deliver significant consumer benefits

While DTT services are in long-term decline, demand for mobile data has continued to increase rapidly and is expected to continue growing, including both in rural areas and within buildings. Ofcom has considered three scenarios for the growth in mobile data traffic, with its medium growth scenario continuing the 40% year-on-year growth seen historically. The 600MHz band is ideal for providing wide-area mobile coverage as it can penetrate into buildings and cover large rural areas.

It is therefore not surprising that the 600MHz band has been identified for mobile use in other countries: the US and Canada have auctioned 600MHz spectrum[29] and Mexico is planning an auction in 2022.[30] T-Mobile launched the first nationwide 5G network in the US using the 600MHz band, which started to drive the device ecosystem for the band.

We understand that the US uses 617-652MHz paired with 663-698MHz which is standardised by 3GPP as band B71 (4G use) and band n71 (5G use). We also understand that:

- There are 251 devices (including CPEs, MiFis and smartphones) available that support the 600MHz band, up from 19 devices in 2019; and
- There are 80 smartphones that support the 600MHz band, including Apple iPhones, Google Pixel phones and Samsung phones since 2020.

[✂]

[28] Section 5.4, https://www.gov.uk/government/publications/up-next-the-governments-vision-for-the-broadcasting-sector/up-next-the-governments-vision-for-the-broadcasting-sector
[29] https://www.gsma.com/spectrum/wp-content/uploads/2019/10/600-MHz-for-mobile-broadband.pdf
[30] https://www.mobileworldlive.com/featured-content/top-three/mexico-pencils-in-5g-spectrum-auction-for-2022

Ofcom should publish proposals to repurpose the 600MHz band for mobile use and issue licence revocations, ultimately aiming to award the band in 2028

In December 2020, the government carried out a consultation which sought views on the renewal of five national multiplexes (for DTT) which were due to expire in either 2022 or 2026. The government's decision gave Ofcom the power to carry out renewals of all five multiplexes until 2034, accompanied by a new revocation power, where revocation would require five years' notice and cannot take effect before the end of 2030.[31]

With the decline in traditional TV viewing expected to continue, the requirement for DTT services to use 600MHz spectrum (or the amount of spectrum required to achieve a given level of quality) will continue to fall. In addition, DTT multiplexes can make more efficient use of the available spectrum, which further reduces the amount of spectrum they require to maintain a given level of quality.

We recognise that Ofcom may not be convinced that the conditions for a mass-market switch to IP are satisfied and therefore may wish to retain some spectrum for DTT services. However, given the mass adoption of IP TV we believe that Ofcom should confidently be able to rule out extending the multiplex licences beyond 2030.

Consistent with government's ask, Ofcom should in 2025 issue Consultation proposals on how it could make the 600MHz spectrum available for mobile use, including on the exact frequencies to be awarded. Ofcom could then publish its Statement in late 2025 and then issue the relevant licence revocations to DTT users. Ultimately, we believe that Ofcom should seek to auction the 600MHz band for mobile use by 2028 at the latest, so that it could be deployed for mobile use at the start of 2030 (immediately after the relevant DTT licences were revoked).

Ofcom should push for the upper 6GHz band to be allocated for mobile at WRC-23

Licenced use for 5G and 6G is the highest-value use case for the upper part of the band

The 6GHz band contains two parts:

- The lower part: 5925-6425MHz, currently allocated for unlicenced use (e.g. WiFi); and
- The upper part: 6425-7125MHz, which currently has various uses (e.g. fixed links, satellite links, radio astronomy, the MoD and PMSE.

We believe the most efficient use of the upper part of the band would be to licence it for mobile spectrum from 2025 onwards. Other uses could be supported by the lower part of the band.

The 6GHz band is being planned for mobile use in different countries:[32]

- China will use both the lower and upper parts of the band for 5G;

[31] https://www.gov.uk/government/consultations/consultation-on-the-renewal-of-digital-terrestrial-television-dtt-multiplex-licences-expiring-in-2022-and-2026/outcome/consultation-on-the-renewal-of-digital-terrestrial-television-dtt-multiplex-licences-full-government-response
[32] https://www.gsma.com/spectrum/resources/6-ghz-for-5g/

- Europe is considering the upper part of the band for 5G, keeping the lower part of the band for WiFi; and
- Africa and parts of the Middle East are adopting a similar approach to Europe.

As Ofcom says in this discussion paper, the upper 6GHz band (6425-7125MHz) is being promoted by the mobile industry as a means of enabling additional 5G capacity in towns and cities, similar to 3.4-3.8GHz deployments. The GSMA is calling on governments across the world to allocate at least 6425-7125MHz (the upper part of the band) for licenced 5G.

6GHz spectrum strikes an ideal balance between coverage and capacity, in a similar way to the 3.4-3.8GHz spectrum. [✂] The upper part of the 6GHz band (6425-7125MHz) has large bandwidths available which could deliver significant increases in mobile capacity.

Huawei wireless network executive Xu Weizhong offered some interesting insight from China, where field tests carried out in the 6GHz band showed that it can provide the same outdoor coverage as 3.5GHz spectrum along with a 15% throughput gain when using 128 TRX Massive MIMO.[33]

Aside from its capacity to relieve mobile congestion, 6GHz spectrum will also be at the forefront of the next mobile technology, 6G, which Ofcom recognises in its Consultation may start to be deployed by the late 2020s.[34] A report by Nokia Bell Labs, *Extreme massive MMIMO for macro cell capacity boost in 5G-Advanced and 6G*, states that the new pioneer spectrum blocks are expected to be at 6-20GHz for outdoor cells and that using this spectrum combined with extreme MMIMO could potentially provide around 20 times more capacity compared to 5G in the 3.5GHz band.[35]

Ofcom should support the upper 6GHz band being made available for mobile use at WRC-23 and then make the spectrum available to MNOs by 2026

The 2023 World Radiocommunication Conference (WRC-23) will play an important role in determining future access to the upper 6GHz band (6425-7125MHz). It provides an opportunity to harmonise the band across large parts of the globe and to help continue development of the 6GHz ecosystem. Ofcom explains in its Consultation that it will shortly consult on preparatory considerations for WRC-23. We urge Ofcom to support preparing the upper 6GHz band for mobile use and we will engage in Ofcom's subsequent Consultation in more detail.

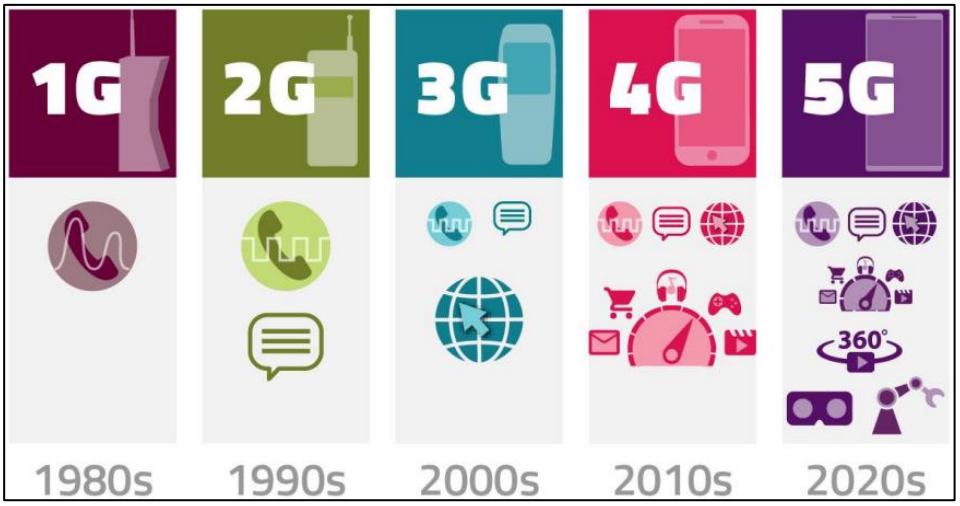
Based on progress to date and historic technology cycles, we expect 6G to be standardised by around 2028, i.e. a cycle of approximately 10 years between each major technology such as 4G, 5G and 6G. This is consistent with Figure 2 from Ofcom's Consultation, show below.

[33] https://www.mobileworldlive.com/blog/intelligence-brief-discussion-around-6ghz-heats-up-at-mwc-barcelona-2022?ID=a6g1r000000ygy8AAA&JobID=1068979&utm_source=sfmc&utm_medium=email&utm_campaign=MWL_20220322&utm_content=https%3a%2f%2fwww.mobileworldlive.com%2fblog%2fintelligence-brief-discussion-around-6ghz-heats-up-at-mwc-barcelona-2022

[34] Ofcom 2022, Mobile Networks and Spectrum: Meeting future demand for mobile data, paragraph 4.15

[35] https://d1p0gxnqcu0lvz.cloudfront.net/documents/Nokia_Bell_Labs_Extreme_massive_MIMO_for_macro_cell_capacity_white paper_EN.pdf

Figure 7: Illustration of the development of mobile phone technology



Source: Ofcom Mobile Spectrum Demand discussion paper, Figure 2

Once the spectrum has been allocated to mobile use, MNOs typically need around two years to deploy it. For example, 6GHz will require new massive MIMO units that MNOs would need to source and deploy after the auction. As a result, we believe that Ofcom needs to make the spectrum available to MNOs by 2026 so that it can be ready to use around the advent of 6G in 2028 (these timings may subsequently need to come forwards.