Virgin Media O2 response to Ofcom's consultation:

Enabling mmWave spectrum for new uses:

Making the 26 GHz and 40 GHz bands available for mobile technology

Non-confidential version

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EXECUTIVE SUMMARY

Virgin Media O2 ("VMO2") welcomes the opportunity to respond to Ofcom's consultation on enabling mmWave spectrum for new uses: "*Making the 26 GHz and 40 GHz bands available for mobile technology*"[1]. The market context for this award is very different to all previous awards of IMT spectrum in the UK. **[✂]**. Much will depend on factors outside our control, including how quickly demand for 5G data develops and the pace at which the European technology ecosystem for mmWave bands matures.

Looking ahead ten years, we anticipate that mmWave spectrum will be an important part of our network, providing additional capacity and exceptional speeds in traffic hotspots around the country. These hotspots will primarily be in urban centres **[✂]**. The most efficient spectrum solution to support this profile will be a single, contiguous block of 800MHz-1,000MHz, available on an exclusive use basis. Ideally, we would have access to the same frequencies nationwide, although clearly we do not anticipate needing or deploying mmWave in areas where customer 5G needs can be met in full using other spectrum.

Given the uncertainty regarding the business case and equipment ecosystem for 26 GHz and (even more so) 40 GHz, **the auction should be delayed until 2026-27, with exclusive licences commencing by 2028**. At this point, the usage case for mmWave spectrum should have solidified, and mobile operators will be positioned to compete for the spectrum based on firm deployment plans. The answers to many of the questions that Ofcom has posed in this consultation, for example concerning the definition of high density areas, the geographic structure of licences, and the licence duration, should by then be much clearer, enabling Ofcom to design the award process with more confidence.

VMO2 broadly accepts Ofcom's proposal to divide the country into high density and low density areas. However, the proposed boundaries for high and low density areas are not sufficiently aligned with the nascent business case for mobile deployment of mmWave spectrum. Specifically, proposed city boundaries and the arbitrary top 40 city cut-off will lead to many busy locations where we anticipate mobile mmWave deployment being unlicensed. For example, it makes no sense to us that London Gatwick Airport will be in a low density area and subject to shared use, whereas London Heathrow will be in a high density area and subject to exclusive licensing. All major airports should be assigned to high density areas.

The errors in defining high density areas are understandable given that the industry (and therefore Ofcom) does not yet have a good understanding of where and when mobile operators will deploy mmWave spectrum. We have put forward some ideas for improvement. However, we think the best solution to this uncertainty would be to delay the award. This will give Ofcom and industry the time and information needed to define sensible boundaries for high density areas.

In the meantime, **Ofcom should proceed with making available the 26 GHz and 40 GHz spectrum on a shared use basis. The demand from operators and other parties will be a leading indicator of future demand for exclusive licences.** Again, this information will enable Ofcom to make more

[1] https://www.ofcom.org.uk/__data/assets/pdf_file/0027/237258/mmwave-spectrum-condoc.pdf

evidence-based decisions when defining high density areas and determining if regional licensing is necessary.

Ofcom should also proceed directly with giving 5-year notice to all fixed link and other incumbent users to clear the 26 GHz and 40 GHz bands in or near urban areas. Regardless of where Ofcom determines the cut-off point for defining high density areas, we think fixed links should be cleared as soon as possible from all top 100+ city locations and associated traffic hot spots, including airports, university campuses and major out-of-town shopping centres. This will provide operators using both licensed and shared use spectrum with full access to spectrum in all likely deployment areas from 2028, by which time the mmWave mobile ecosystem and business case will, hopefully, be well developed.

With respect to existing licences in the 40 GHz band, VMO2 agrees with Ofcom that the best approach is Option 2: revocation of all licences, and reallocation of the entire 40 GHz band for new uses, including mobile. We strongly oppose all other options, especially options 1 and 4, which could result in long-term inefficient allocation of mmWave spectrum.

Given the possibility for sub-national operators to acquire licences on a site-by-site basis under the shared access scheme, we do not believe that Ofcom has made the case for the incremental intervention of individual citywide licensing. We are unconvinced that it is necessary for Ofcom to sell citywide licences individually, as opposed to creating a single sub-national licence that covers all high density areas. Unless Ofcom identifies evidence of meaningful regional demand, we urge it to revert to national licensing and benefit from a much simpler auction design.

VMO2 agrees with Ofcom that the clock auction is the right format for this award but the detailed rules will matter greatly. We provide our initial thoughts on lot design and auction rules, and look forward to engaging further on this topic as Ofcom's proposals mature.

Currently, we do not think that Ofcom has enough information to identify an optimal licence duration for exclusive licences. We agree that it would be premature to proceed now with indefinite licences, given the high likelihood that an auction in 2024 would not deliver a long-term efficient allocation. However, a fixed term of less than 15 years would not provide adequate time for payback of investment. The best approach would be to delay the award of exclusive licences and defer a decision on the licence term until more evidence is available.

Regardless of when Ofcom proceeds with the award, VMO2 believes there is a strong case for a precautionary cap of 1,000MHz in each of the 26 GHz and 40 GHz bands, with respect to all high density areas. Precautionary caps are necessary to eliminate the possibility that one or two operators attempt to acquire excessive holdings, e.g. to a level beyond current equipment standards, when industry demand for mmWave spectrum may be soft, in expectation of excluding rivals in the long term.

MAIN RESPONSE

AVAILABILITY OF AND DEMAND FOR MMWAVE SPECTRUM

Mobile operators worldwide are currently focused on deploying 5G networks using a mix of low-band and mid-band spectrum. For the next few years, these deployments should be sufficient to meet fast-growing market demand for speed and capacity.

mmWave spectrum is the next frontier. Unlike other 5G bands, this spectrum is not suitable for wide-area capacity, but can be deployed selectively in locations with a high density of users to provide significant increases in capacity and exceptional data speeds. The 26 GHz and 40 GHz bands promise capacity which cannot be matched at lower frequencies, owing to the more limited supply of MHz. Every mobile operator may therefore be expected to want access to mmWave spectrum in relevant locations on an exclusive basis in the medium-to-long term.

Notwithstanding the huge potential of the mmWave bands, there is presently insufficient demand for bandwidth to justify rolling out this additional capacity beyond a few traffic hot spots. The reality is that for at least the next 3-5 years, demand for 5G capacity can be almost entirely met through the roll-out of existing bands, in particular the 3.4-3.8 GHz band. This capacity may be augmented by selected local deployment of mmWave spectrum, but we anticipate that, for the next few years, MNO demand here could be met entirely through individual site authorisations.

The business case for deploying mmWave spectrum is also constrained by developments in the broader European ecosystem for handsets that can use 26 GHz or 40 GHz. To date, handset manufacturers have been reluctant to include these bands in new devices, meaning it will be some years before a critical mass of subscribers could actually access the frequencies, even if they were deployed. According to the GSA, globally there are 633 5G handsets available to consumers but only 44 of these support mmWave bands.[2] Moreover, at present there are no handsets available in European markets that use 26 GHz, and none are expected to be offered by vendors before 2023-24 at the earliest, and then only if there is broad demand from mobile operators across major European markets, which is uncertain.

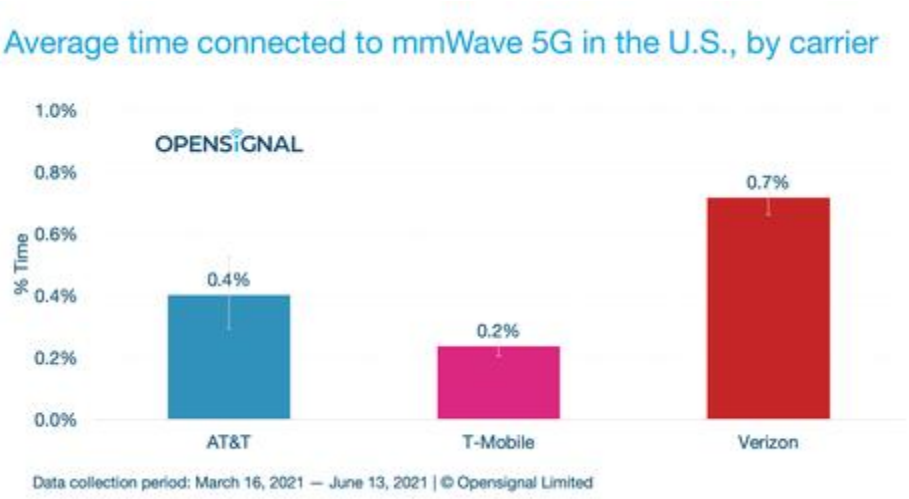
Until recently, there was some optimism that use of mmWave frequencies in Europe could take off more quickly, building on wider deployments of similar frequency bands in the United States. However, Verizon Wireless, which previously championed widespread urban deployment of mmWave spectrum, has recently downscaled its deployment plans, indicating that it will instead focus on deploying its new holdings at 3.6 GHz.[3] US handset manufacturers have responded by dropping mmWave spectrum from smartphones. Notably, Verizon has apparently decided to stock the iPhone 2022 SE, even though Apple had dropped mmWave support so as to reduce manufacturing costs and recover valuable space in the device.[4] The inclusion of new bands in handsets is a leading indicator of their expected relevance during the lifespan of the phone (typically 2-3 years), so Apple's decision to

[2] https://gsacom.com/webinar/turning-5g-mmwave-into-reality-in-asia-pacific/ and https://telecoms.com/514964/there-are-now-over-1,000-commercially-available-5g-devices/
[3] https://www.lightreading.com/5g/the-age-of-mmwave-5g-sputters-to-dusty-death/a/d-id/770838
[4] https://www.theverge.com/22968066/apple-iphone-se-5g-mmwave-verizon-uw

drop mmWave support from a key model is an indicator that mmWave expansion has stalled and they do not anticipate mmWave bands being important in the United States in the next 3 years.

Our understanding is that Verizon simply could not make the economics of widespread urban deployment of mmWave spectrum work at current levels of data demand. Deployment was exceptionally expensive, owing to poor signal propagation, and the need to deploy a dense network of sites. Resulting network quality was also patchy, with dramatic changes in network quality over distances of a few hundred yards.[5] Despite significant investment, as of mid-2021, on average, Verizon customers were connected via mmWave spectrum just 0.7% of the time, as illustrated in Figure 1. This level of connection converted to just 3.1% of data consumed, despite the high speeds and capacity where mmWave is available.[6] Now Verizon has 3.6 GHz, it makes much more sense for it to build its nationwide 5G network using lower frequencies. According to a recent article by Light Reading, "*Those buildouts* [of 3.6 GHz] *will likely divert money, time and attention away from operators' mmWave network expansions. Thus, the time users spend connected to mmWave networks, as tracked by OpenSignal, likely won't change much in the near term*."[7] This means that the proportion of data traffic carried on mmWave will likely fall, as Verizon rolls out its 3.6 GHz network.

Figure 1: Actual use of mmWave spectrum by US mobile users

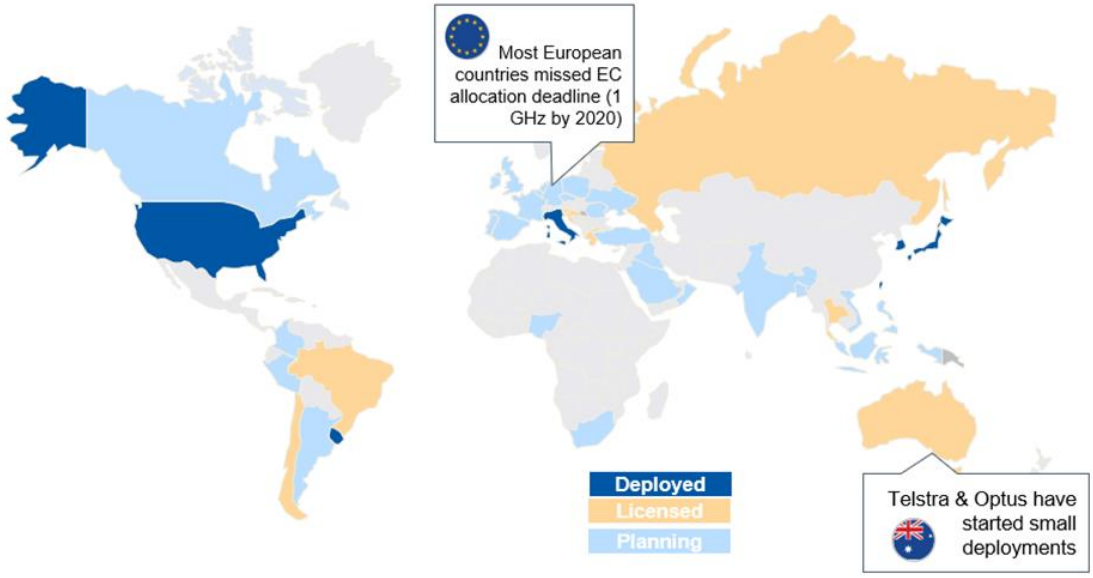


Source: OpenSignal quoted by Light Reading (https://www.lightreading.com/5g/the-age-of-mmwave-5g-sputters-to-dusty-death/a/d-id/770838)

Given the US experience, where even an exceptionally large operator and enthusiastic proponent of mmWave has not yet been able to make the spectrum work as a core network band, European operators can be expected to proceed with caution. This caution is also reflected in the slow pace of spectrum awards for 26 GHz across EU countries, despite the European Commission long identifying the 26 GHz band as one of three pioneer 5G bands, alongside 700 MHz and 3.5 GHz. As illustrated in Figure 2, international progress in releasing mmWave spectrum has been patchy, and most European regulators have still not licensed the band despite an EC allocation deadline of 2020.

[5] https://www.sdxcentral.com/articles/news/verizons-5g-mmwave-network-has-a-tree-problem/2021/12/
[6] https://www.lightreading.com/5g/atandt-scores-win-over-verizon-in-mmwave-5g/d/d-id/772230
[7] https://www.lightreading.com/5g/the-age-of-mmwave-5g-sputters-to-dusty-death/a/d-id/770838

Figure 2: Status of mmWave spectrum licensing in countries worldwide



Source: Chart based on information provided in *GSA webinar on 'Turning 5G mmWave into reality'*[8]

Our main learning from the Verizon experience is that attempts to blanket whole cities with mmWave coverage will be neither effective nor economic, for at least the current decade. Accordingly, we anticipate that roll-out plans for mmWave spectrum will be very different from those hitherto adopted for low and mid-band spectrum. In particular, roll-out decisions will be sensitive to current and forecast traffic levels for specific locations. Put differently, operators will deploy on a location not a city basis. As we explain further in the discussion below on defining high density areas, we are concerned that Ofcom's "citywide" approach is too broad, and may result in Ofcom licensing many suburban locations where there is no near-term business case for mmWave deployment, while failing to licence other busy spots where we will want to deploy mmWave before 2030.

We agree with Ofcom that 26 GHz and 40 GHz are substitutes. Both bands are suitable for offering exceptional capacity and high mobile data speeds. 40 GHz has weaker propagation: for example, AT&T found that it would need 44% - 66% more spectrum in the 39 GHz band to provide the same cell edge data rate with the same cell radius as compared to 28 GHz.[9] However, the main difference right now is the lack of ecosystem development for 40 GHz, which is even less of a priority band in Europe, relative to 26 GHz, which is identified as one of three core EU 5G bands. This situation contrasts with the United States, where Verizon and AT&T have championed the development of the 39 GHz ecosystem over 28 GHz owing to their larger spectrum holdings in the former band. This uncertainty regarding 40 GHz may be resolved in the medium term, so is a highly relevant issue for any award held in the near term for 40 GHz or any substitute.

To be clear, we do not think that this uncertainty is a reason not to award 40 GHz at the same time as 26 GHz, nor to delay clearance of 40 GHz. **[✂]**. Delaying clearance would be harmful because it would

[8] https://gsacom.com/webinar/turning-5g-mmwave-into-reality-in-asia-pacific/
[9] AT&T, Comparison of 28GHz and 39GHz Spectrum, 2016, https://web.archive.org/web/20200909183818/https://ecfsapi.fcc.gov/file/10707094413804/mmWave%20Spectrum%20Comparison%20-%20Final.pdf

diminish the scope for 40 GHz to mature to its full potential as a close substitute to 26 GHz for mobile deployment. Rather, this uncertainty is a good reason why it would be best to delay a combined auction until a time when the future relationship between the bands is better understood and the clearance deadline for incumbent users is closer to hand.

Mobile operators may ultimately want large contiguous bandwidths in mmWave bands. In order to support optimal peak and average user-experienced throughput and the full range of 5G NR capabilities, it is widely acknowledged that, where possible, operators should have the option to bid for up to 1 GHz of mmWave spectrum.

In support of this point, industry bodies and equipment manufacturers have said the following:

- *"Spectrum for 5G should ideally be made available in contiguous blocks of 80-100 MHz from the mid bands and 1 GHz of spectrum from the high mmWave bands to ensure the most effective delivery of 5G services."* (GSA)[10] [emphasis added]

- *"Regulators that get as close as possible to assigning 100 MHz per operator in 5G mid-bands and 1 GHz in millimeter wave bands will best support the very fastest 5G services."* (GSMA)[11] [emphasis added]

- *"For initial deployments, a minimum of 100 MHz of contiguous mid-band spectrum within the 3300 – 4200 MHz and 4400-5000 MHz bands (and in some countries 2600 MHz), and around 1 GHz of contiguous high-band (mmWave) spectrum within the 26 GHz, 28 GHz per licensee are needed."* (Ericsson)[12] [emphasis added]

A bandwidth of 1 GHz is also roughly in line with the largest blocks acquired by Verizon and AT&T in the 39 GHz band:

- Verizon initially targeted more than 1 GHz in this band but ultimately acquired almost 1,100MHz nationwide (on a population-weighted basis); and

- AT&T started the 39 GHz auction on around 1 GHz and subsequently dropped back to 800MHz nationwide (pop-weighted).

In practice, we do not anticipate there being the market demand in the UK to utilize 1 GHz of capacity for many years. In the short-to-medium term, in most UK locations, operators could probably get by with smaller bandwidths and site-specific licences.

We conclude from this that mmWave spectrum is not currently scarce but will become so in the future. Exclusive licences will be needed but they are not needed yet. Regardless of when these licences are awarded, Ofcom should anticipate that the spectrum will not be used much by mobile for next 3-5

[10] Global Mobile Suppliers Association (GSA), *Millimetre Wave Spectrum for 5G*, October 2019: https://gsacom.com/technology/5g/

[11] *5G Spectrum GSMA Public Policy Position*, July 2019: https://www.gsma.com/latinamerica/wp-content/uploads/2019/03/5G-Spectrum-Positions.pdf

[12] https://www.ericsson.com/en/public-policy-and-government-affairs/spectrum-awards

years, with deployment taking off only in a 5-15 year time horizon. Our subsequent comments on Ofcom's proposed award process take into consideration this realistic deployment path.

TIMING OF THE AWARD

Ofcom has tentatively proposed awarding mmWave spectrum in 2024. We think that an award this soon is premature. It would oblige operators to bid for spectrum that they anticipate deploying in the long term, but do not yet need. Bidders would have to navigate huge uncertainties, for example concerning the equipment ecosystem, the quantities of spectrum actually required to meet rapidly growing but uncertain levels of demand, the locations where mobile mmWave deployment is needed, and the potential for 40 GHz to emerge as an effective substitute for 26 GHz. Right now, operators face exceptional challenges forecasting urban capacity requirements as busy hour traffic patterns changed significantly during the pandemic, and it remains uncertain the extent to which we are in a 'new normal' with respect to the balance of work from home and office, or if old patterns will eventually return. The winners of an auction undertaken against this background would be those that are most optimistic about the long-term prospects for mmWave, who may not in fact be the most efficient long-term users once deployment cases are better understood.

The problem is compounded by the fixed term in the licence. Ofcom is currently minded to offer only a fixed term licence, potentially as short at 10 years duration. If the ecosystem is still five years away, it may be that such licences are either very hard for firms to value, or (for some citywide areas) valueless, leading to unsold spectrum. Given the costs involved in mounting an award, we believe it would be better to proceed with band clearance and site-by-site licensing today, leaving the option open to award longer term exclusive licences when the development of the ecosystem is clearer.

Our preference is for Ofcom to delay the award until 2026-27, with exclusive licences commencing by 2028. At this point, the usage case for mmWave spectrum should have solidified, and mobile operators will be positioned to compete for the spectrum based on firm deployment plans. The answers to many of the questions that Ofcom has posed in this consultation, for example concerning the geographic structure and availability of licences, and the licence duration, should by then be much clearer, enabling Ofcom to design the award process with more confidence. This will also bridge the notice period required to ensure all legacy uses are cleared from exclusive use spectrum. There would be no meaningful economic loss to society, as encumbered parts of the band could not have been used anyway and operators will still be able to deploy using site-specific licences. Even if there are select locations where demand for spectrum through site-specific licences exceeds supply in this interim period, we anticipate that Ofcom could satisfy all users by temporarily constraining the bandwidth available to individual operators, for example, limiting individual deployments to 400MHz instead of the 800MHz-1,000MHz that might later be available to individual operators in the auction.

If Ofcom does decide to delay the award of exclusive licences, it should take interim measures to ensure the spectrum can be used on a shared basis between now and the actual auction date. This will allow operators, including VMO2, to make initial deployments and test the broader use case for mobile mmWave use. Specifically, we recommend that Ofcom pushes ahead now with the shared access licence regime. For areas that could be subject to citywide licences, applicants for shared use

spectrum would need to indicate whether they envisage bidding for exclusive use licences later. If so, they could be allocated temporary assignments in frequencies that may later be subject to allocation by auction, subject to an obligation to retune if they won different spectrum later or shift activity to the lower 850MHz at 26 GHz if they did not win exclusive licences. Interest in such temporary access would also help Ofcom decide how to structure availability of citywide licences later.

[✂]

BALANCE BETWEEN SHARED ACCESS AND EXCLUSIVE USE SPECTRUM

With respect to the allocation of frequencies between shared use and exclusive use licences, we support Ofcom's proposal to allocate the majority of spectrum to exclusive use. As Ofcom says, once the use case for deployment of mmWave use as part of the mobile network grid matures, operators will need flexibility to deploy multiple micro sites in dense networks, re-using the same frequencies. This is not compatible with a shared access use regime, as the coordination requirements with multiple actors and the potential inconsistency of access to spectrum would place an undue burden on mobile operators. This would have a negative impact on incentives to roll out services and hence significantly reduce the utility and value of the spectrum. Our position here applies whether an award of exclusive licences happens in 2024 or later.

26 GHz

Ofcom proposes to divide the 26 GHz band into two parts:

i. an 850MHz block in the bottom of the band (24.25-25.1 GHz) for local licences available via the Shared Access licensing framework, granted on a first-come-first served basis; and

ii. a 2,400MHz block in the top of the band (25.1-27.5 GHz), allocated in selected urban areas for citywide licences, to be awarded by auction.

VMO2 supports the 850 MHz / 2,400MHz frequency division between shared use and exclusive use licences. Whilst our priority, as a mobile operator, is exclusive use licences, we recognise there may be demand for local area licences, and the 850MHz block is a suitable way to meet this demand. Importantly, the opportunity cost of allocating the lower part of the band to local licences is low, as Ofcom's proposed measures to protect EESS services in this part of the band make the spectrum less attractive for mobile use. Moreover, the block is sufficiently large to support multiple local area users in the same location, so it should be sufficient to meet the needs of this part of the industry for the foreseeable future. It could also allow a single operator to offer an equivalent capability at any given location to a mobile operator deploying the current maximum 800MHz carrier.

[✂]

Club model for 26 GHz

We are attracted by the concept of a club model, enabling exclusive use licensees the ability to access each other's spectrum in locations where a rival has not yet deployed. As Ofcom says, "*This approach would be likely to enable efficient use of spectrum by increasing the likelihood that all available spectrum is used, while still providing licensees with certainty that they can deploy in the specific areas licensed to them*."

The club model was originally used for mmWave spectrum in Italy, where only 1,000MHz of 26 GHz spectrum was available for award, a situation which predictably resulted in operators winning only small quantities of spectrum (200MHz each). It means that operators that lead deployment in particular locations can use larger quantities of spectrum, which may allow higher levels of service to be offered. Clearly, as Ofcom is awarding rather more spectrum at 26 GHz (2,400MHz) for exclusive use, a club model is not strictly necessary to enable operators to deploy larger quantities of spectrum. Nevertheless, the model may be helpful in easing risk for bidders who may go into the auction with considerable uncertainty about their long-term mmWave spectrum needs, given the nascent state of the technology ecosystem and uncertain demand.

Ofcom has expressed concern that the club model could be "complex to implement". However, we think the model could be adapted quite easily to shift any complexity on to the winning bidders (not Ofcom). Moreover, given that only a small number of known operators would be part of a club in any given area, we think the technical coordination would be manageable, unlike a broader shared access model.

We propose that licensees subject to the club regime would be free to use each other's spectrum provided it is otherwise unused. It would be the responsibility of club members to manage these arrangements, for example by sharing database information regarding their deployments, with appropriate 'black box' information sharing safeguards in place, such as already takes place in network sharing for the Shared Rural Network. Licensees would retain exclusive rights to their own spectrum and may invoke these rights if necessary if they cannot otherwise secure equivalent spectrum for deployment.

We anticipate that such a model could be largely self-policed, with minimum risk that Ofcom needs to be involved, given the default fallback of licensees simply reverting to their assigned holdings.

40 GHz

In the 40 GHz band, Ofcom proposes to allocate the entire 3,000MHz of spectrum in high density areas for exclusive use licences. We agree with this proposal.

If the club model is offered at 26 GHz, then we see no reason why it could not also work for 40 GHz.

WHICH AREAS SHOULD BE DESIGNATED HIGH DENSITY?

VMO2 broadly accepts Ofcom's proposal to divide the country into high density and low density areas. However, we are concerned that Ofcom's efforts to define high and low density areas fundamentally

misunderstands the mobile business case for deployment of mmWave spectrum. This has led to errors in defining city boundaries and a proposal for an arbitrary top 40 city cut-off, two actions that will lead to many busy locations where we anticipate mobile mmWave deployment being unlicensed. These errors are understandable given that the industry (and therefore Ofcom) does not yet have a good understanding of where and when mobile operators will deploy mmWave spectrum. For the reasons we outline here, we think the best approach is to delay the award of licensed spectrum until 2026-27, while proceeding temporarily with shared licence access to all frequencies. This will give Ofcom and the industry the time and information needed to define sensible boundaries for high density areas.

Ofcom definition of high and low density areas

Ofcom defines 'high density' and 'low density' areas (paragraph 4.1) as follows:

a) "***'high density areas'*** *are the major towns and cities where we expect the most widespread deployment of mmWave spectrum for new uses to occur, and*

b) ***'low density areas'*** *are the rest of the UK, outside high density areas, where we expect deployments to be sparser and more highly localised*."

We see two errors within these definitions. The first error here is to define high density areas around towns or cities. For the foreseeable future, mobile operators will not deploy mmWave at the town or city level. Instead, they will deploy mmWave spectrum in specific locations, on existing macro cell infrastructure and through deployment of dense networks of small cells. Each individual mmWave cell deployment will typically cover an area no larger than a few street blocks, owing to the poor propagation of the spectrum. Small cell deployment is expensive and involves new planning challenges. Accordingly, operators will be very selective as to when and whether they deploy mmWave spectrum. The second error is to equate low density areas with areas where deployments are "*highly localised*". All mmWave deployments in the current decade are likely to be localised. The key question is whether the spectrum in a particular location is likely to be scarce.

We urge Ofcom to consider the following alternative definitions of 'high density' and 'low density' areas:

a) **'high density areas'** are locations where there could be significant deployments of mmWave spectrum on a 5–15 year time horizon. These are areas where mmWave spectrum is potentially scarce (i.e. demand exceeding supply), where operators may require exclusive licences to support efficient deployment, and where an auction may be required to identify the highest value users.

b) **'low density areas'** are the rest of the UK, outside high density areas, where we expect deployments to be sparser and spectrum is unlikely to be scarce.

It is important to recognise that deployment of mmWave spectrum is unlikely to resemble the path mobile operators have typically followed when deploying new technologies using low and mid-band spectrum. In those situations, it has been typical for operators to commence deployment in selected major cities, with teams of network engineers that roll out the spectrum to citywide macro cell towers. Once that process is complete, the network teams move on to fully cover the next tier of cities, often

following a geographic path around the country, and it may be many years before they return to make another major deployment in that same city. With mmWave spectrum, operators will focus on deploying only to the busiest locations, starting within the larger cities. Once they have covered those locations, they will move on to the next city and set of busy locations. Later, they may return to different parts of the same cities to build out new locations that have now met the criteria for deployment. Put differently, because operators have no plans to deploy mmWave spectrum everywhere, they will focus on locations, not cities, and deployment will be more incremental.

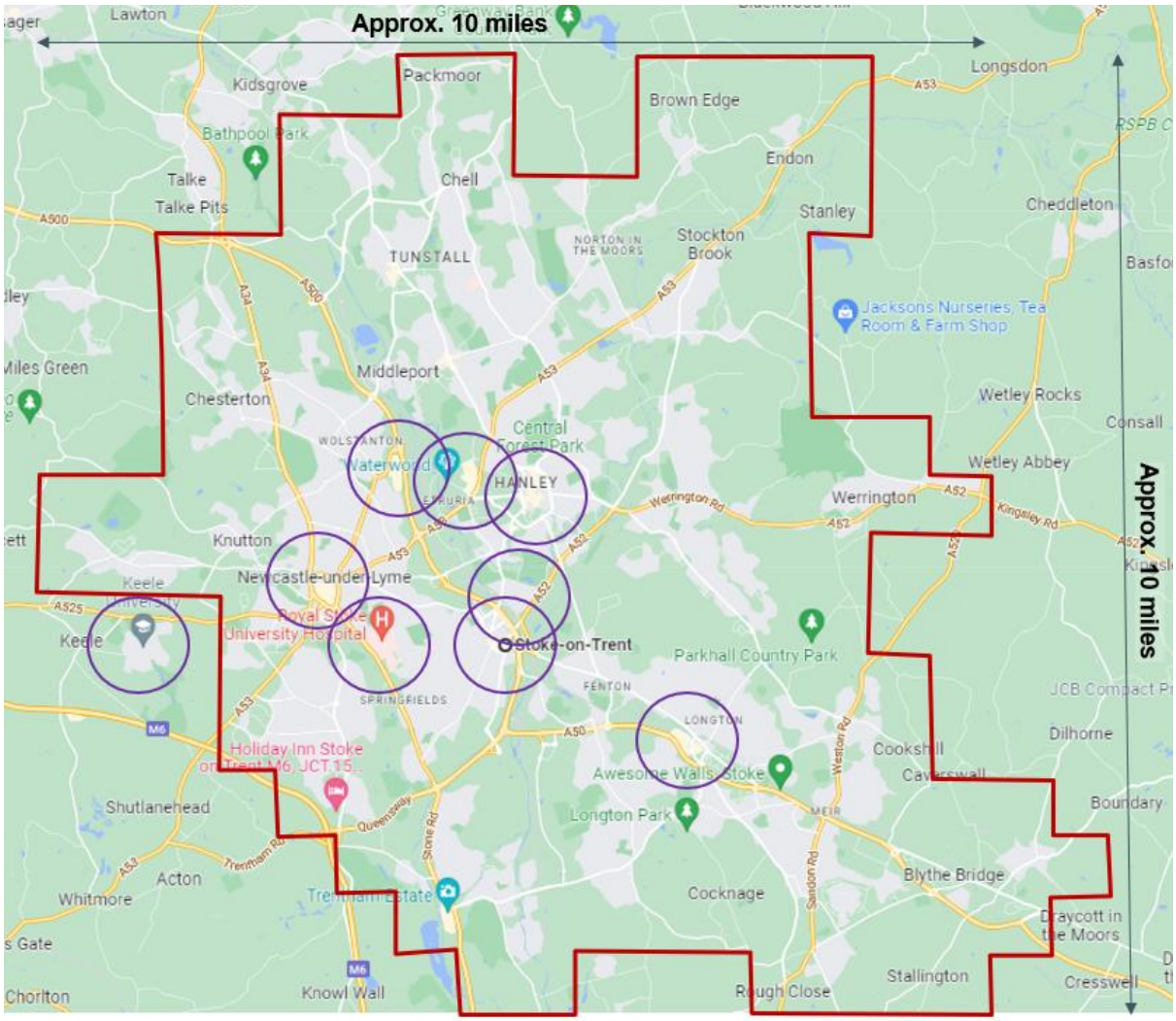
Ofcom methodology for identifying high and low density areas

Given these differences, we have significant reservations about Ofcom's methodology for identifying high density areas. In our view, the current approach is overly focused on the top cities and not local enough in its thinking. **[✂]**. At the same time, a top 40 cut off would mean not licensing traffic hotspots in other locations where all operators will likely want to deploy mmWave.

Ofcom's citywide areas cover not just city centres but also suburbs and adjoining small towns. However, it does not follow that just because an operator decides to deploy mmWave supported small cells in, say, central Reading (#12), that they will want to deploy in adjoining neighbourhoods such as, say, Woodley. It may be that all operators instead prefer to prioritise deployment in other city centres, such as Dundee (#63) or Ipswich (#73). This raises a risk that there will be local congestion in demand for shared licensed mmWave spectrum in city centres and other traffic hot spots in areas that fall outside Ofcom's citywide boundaries and outside the high density cut off point. If that does happen, Ofcom may need to move very quickly to offer exclusive licences for a broader list of locations.

As an illustration of our concerns, consider the example of Stoke-on-Trent, which Ofcom uses at paragraph 4.18 to illustrate its methodology. In Figure 3, we have superimposed Ofcom's proposed citywide boundaries on a Google map of the city. On the map we have drawn circles with approximate diameters of one mile around the main shopping centres, hospital and university campuses, areas where a mobile operator might decide to prioritise deployment of mmWave small cells.

Figure 3: Ofcom's proposed boundary for Stoke-on-Trent high density area



Source: Ofcom licence boundary and other information overlaid on image from Google Maps.

From this map, we draw two main observations:

1. Ofcom's approach is effective in capturing the major urban centres of Stoke-on-Trent and Newcastle-under-Lyme. However, it misses the adjacent campus of Keele University (where over 10,000 students study on a compact 600-acre estate) because it is outside the formal city boundaries.

2. The whole city approach captures an area approximately 10 miles wide and 10 miles long, which is large relative to locations where initial deployments of mmWave spectrum are most likely to occur. This has benefits and costs. On the benefit side, it appears that licensees in Stoke would enjoy a substantial geographic buffer around deployment hotspots, meaning that interference with (hypothetical) adjacent shared use deployments in the same frequencies is unlikely to be a concern. On the cost side, the licence boundaries capture many surrounding suburbs and villages, some of which are 3 miles or more away from urban centres, where mmWave deployment is unlikely in the foreseeable future. Many of these areas are not needed as a buffer to protect licensed use in key locations from interference from shared licence areas.

The problem of busy locations falling outside Ofcom's city-wide areas is a direct consequence of Ofcom's simplifying proposal to use town and city boundaries defined by the UK statistics agencies. While we agree with Ofcom that town and city boundaries may "*provide an appropriate starting point*" (paragraph 4.7) for defining areas, they should not be the end point. Adjustments will have to be made to address obvious errors in boundaries as they relate to actual demand for spectrum to deploy mmWave services.

As a prospective licensee, we are obviously most concerned with the risk that licence areas fail to capture potential deployment hotspots, such as university campuses, airports or out-of-town shopping centres. While we can live with Ofcom defining larger licensed areas than are strictly necessary, it is a big problem if these areas exclude busy locations.

The inadequacy of Ofcom's approach in this regard is illustrated by its own finding that the top 40 or top 80 citywide areas capture only 9 of 23 UK airports that carry over 1 million passengers per year. Airports are obvious locations for deployment of mmWave spectrum, where licensing will be necessary to address scarcity and support coordinated deployment. Consequently, it makes no sense that under Ofcom's current approach, London Heathrow, London Luton, Birmingham and Glasgow would be licensed, whereas London Gatwick, Manchester, Edinburgh, Bristol and Belfast would be unlicensed. In our view, all such airports should be in exclusive license areas, and all should be licensed in the same area as the major cities they support. This should be the case even if this requires Ofcom to define separate polygons for an airport that are not geographically contiguous with the associated city.

We are further concerned that Ofcom's approach of defining citywide licences has led it to propose an arbitrary cut-off of 40 cities, leaving many busy locations elsewhere unlicensed. As Ofcom's own measurements show, base station density and peak hour data downloads are very high for the top 15 areas, and have a relatively flat profile thereafter from the top 20 through 100 areas. From this, it may be inferred that mobile operators are likely to prioritise mmWave deployments in busy locations in the top 15 cities, and it may be some time until we have a business case to spread deployments to lower ranked cities. However, once the business case matures to the point that deployments outside the top 15 areas make commercial sense, then it may be a relatively short time between wanting to deploy in a top 40 location and a top 100 location.

Potential improvements to Ofcom's methodology

Looking forward, there are a number of actions that Ofcom could take to align high density areas more closely with likely mobile deployment scenarios:

1. **Take a closer look at citywide boundaries**

If Ofcom sticks with the approach of starting with UK statistical agency city boundaries, then it needs to take the time to examine each of the resulting areas to determine if the boundaries as proposed are actually sensible. At a minimum, boundaries will need to be extended in certain areas to ensure traffic hot spots close to each city (e.g. Manchester airport) are included. At the same time, Ofcom might identify cases where licensed areas can be shrunk, but we recognise that this may be a more difficult exercise with limited benefit.

We agree with Ofcom that high density areas should be based around population centres and traffic hotspots, and that wherever feasible, busy locations in the same city – such as shopping centres, transport hubs and major sports stadiums – should be treated as a single area. We further agree that areas immediately adjoining busy spots, even if they have lower traffic, should be in the same area, so as avoid frequency coordination challenges at the boundaries of locations where the densest mmWave deployment is likely.

It is also helpful that Ofcom has amalgamated adjoining cities into single areas. Ofcom might consider some further groupings of cities that are close together, e.g. Manchester, Wigan and Rochdale, or Leeds-Bradford and Huddersfield. We do not think it essential that all parts of an area are contiguous, as long as they make sense as an economic unit. For example, Ofcom might consider an area that combines Middleborough, Stockton-on-Tees, Teeside International Airport and Darlington, but excludes the rural areas between them.

2. **Take another look at the proposal to focus areas around traffic hot spots**

As a complement or alternative to citywide licensing, Ofcom might take another look at the data it has collected on traffic hotspots. These are the locations where mobile deployment of mmWave spectrum is most likely. From an operator perspective, the key requirement is that we can obtain a licence for a sufficiently large area around each hot spot, such that we are protected from interference. Where hot spots are closely located, it makes sense to include the gaps in a single, combined area licence.

3. **Revisit the cut-off point for defining high-density areas**

At this time, any cut-off point between exclusive and shared use licensing that Ofcom might adopt is inherently arbitrary. We simply do not know yet how 'hot' a traffic hot spot needs to be to justify deploying mmWave spectrum in the next 5-15 years. We are concerned that a decision now, based on inadequate information, could lead to congestion challenges at 26 GHz in unlicensed hot spot areas from around 2030.

If Ofcom insists on making a decision now, we urge it to take account of local factors, such as geographic representation or seasonal traffic variations when deciding the cut-off point. As an obvious point, a top 20 cut off that excludes Belfast (position 21) is unacceptable. **[✂]**.

4. **Use the experience of site-by-site licensing to improve the auction proposals**

The most efficient and likely well informed approach would be to delay the auction for a few years so more time can be given for assessing the business case for mmWave deployment in medium-sized cities. If the auction was pushed back to 2026-27, this would give Ofcom and operators another three years to develop their planning on urban deployment cases using site-by-site licensing. With this information it may be clearer where and how to define high density areas. This would allow the cut-off to have a stronger evidential basis than we currently observe.

Detailed comments on Ofcom's use of data to identify high density areas

There is a risk in using data collected in May 2021 for the Connected Nations Report, as the source of peak traffic in the high density areas calculation [Ofcom, section 4.11]. Although the UK had been

released from full lockdown by May 2021, there were still actual and de facto restrictions on movement owing to the pandemic. Therefore, the behaviour and movement of customers and the associated traffic demand profile cannot be considered 'normal'. As of mid-2022, we see that our customers are commuting less and many people have migrated away from the big cities. The situation is not static, and we are still learning and quantifying this behaviour change and dynamically reacting to it. Delaying the auction will give Ofcom time to study new, potentially more insightful data, as well as allowing operators time to understand if users return to pre-pandemic behaviour, or if we have a 'new norm'.

The Ofcom analysis also uses the 2011 census information for population data. VMO2 use this internally, but we are always mindful that the census is over 10 years old. VMO2 highly recommends refreshing any analysis with 2021 census data when released in H2 2022.

There is also a consideration with regards to 5G rollout. If the peak demand in the consultation calculations included 5G, it is likely that the cities with 5G in May 2021 will be unfairly weighted over cities that had not had 5G deployed. A delay in the auction would allow Ofcom to wait for future Connected Nations Reports data, which should be more informative regarding 5G rollout.

There is added complexity for MNOs who have an existing network sharing agreement. **[✂]**.

[✂]

[✂]

Ofcom measure peak traffic as a single hour in a single month. This is an interesting measurement but could be distorted by one-off public events with many attendees, that may not by themselves be sufficient to justify mmWave deployment. We suggest that Ofcom consider a distribution of hours where feasible, and also consider seasonal and geographic variations.

Ofcom states that the data sources used are widely available and intuitive to use [section 4.7]. VMO2 agrees and is comfortable reviewing and manipulating these boundaries files. However, there is naturally added complexity in any project when using geospatial methodologies, especially with (a) many independent users and (b) several varying sources of these datasets, as described in the consultation. VMO2 found the shapefiles that Ofcom shared supporting this consultation very useful. It will be important for our preparations for the award that any changes to them are processed and published well in advance of any auction, to allow time for us (and other prospective bidders) to study the geographies and conduct local analysis. It is likely that these files will need further iteration and versioning control as exceptions are found. This might also extend to long-term maintenance of the data, for the duration of the licenses, as cities and towns expand beyond their defined regions of today. This added complexity needs to be considered with flexibility to allow licence owners to extend their footprint when sensible.

VMO2 would be happy to work with Ofcom, at the appropriate time, to support them in improving the next iteration of this high density calculation.

REVOCATION OF EXISTING LICENCES

VMO2 supports Ofcom's proposal to clear incumbent operators from frequencies in both bands that will be subject to exclusive licensing, subject to statutory notice periods. We urge Ofcom to issue such notice as soon as practically possible.

26 GHz fixed link licences

Ofcom sets out three options for the clearance of incumbent fixed links from the 26 GHz band:

a) **Option 1**: No Ofcom-led clearance of fixed links from the 26 GHz band; new users would negotiate access to spectrum with existing users when needed.
b) **Option 2**: Clear all fixed links from the 26 GHz band, in all areas of the UK.
c) **Option 3**: Clear fixed links from the 26 GHz band in and around high density areas only.

VMO2's view is that fixed links represent a legacy use of this band and they should be cleared as soon as possible in all areas where they could impede the roll out of mobile services. As mmWave deployments outside high density areas are unlikely in the short-medium term, we recognise that it may be costless to allow some fixed link use to continue for the time being. Accordingly, we would be comfortable with either Option 2 or (subject to some additional measures, as set out below) Option 3, but we strongly oppose Option 1.

Ofcom's research clearly shows that the presence of existing fixed links reduces spectrum availability for new uses on a geographic basis. This is particularly an issue for medium power deployments, which may be the preferred approach for mobile operators in high density areas. If fixed links remained, they would undermine the value of particular frequency blocks within the band, potentially preventing licensees with smaller endowments from deploying, or preventing licensees with larger endowments from deploying larger contiguous carriers, e.g. 800MHz, thereby limiting capacity and speed. Accordingly, fixed links must be removed from areas in and around high density areas where exclusive licences are issued.

We recognise that Ofcom has an obligation to give affected users five years' notice of the revocation in line with the conditions outlined in their licences. Accordingly, we urge Ofcom to issue such revocations as soon as possible (i.e. immediately after publishing its approach in Q3 2022/23), such that clearance is complete no later than Q3 2027/2028. We expect mobile deployment in mmWave to be limited for the next 5 years, so this period of clearance should not cause significant issues. However, a delay in notification would be undesirable given that mobile investment in mmWave is likely to be on a strong upward trajectory by 2027, and enduring legacy coordination constraints on usage could start to cause real harm.

We understand that Ofcom plan to do further research regarding potential for interference between fixed links and mobile mmWave deployments, and that this will inform its approach to clearing fixed links from areas "around" (in addition to "in") high density areas. We hope that this research can be completed by the time of Ofcom's decision on the band, so that notifications of licence revocation are not delayed. We urge Ofcom to lean towards revocation in situations where the inference risk is

ambiguous. This approach will provide greater certainty for mobile licensees. We also understand that alternative spectrum is available in other bands for the fixed links.

Ofcom's provisional plan is only to revoke fixed link licences in and around the top 40 high density areas where exclusive licences will be issued. We do not think this approach is sufficient. As we explained in the previous section on defining high density areas, we think that Ofcom's proposed approach will miss many busy mobile traffic locations where there could, in due course, be high demand to deploy mmWave spectrum. If these areas are not redefined as high density, then there is a risk that availability of spectrum in these areas may be further constrained by low-value, legacy fixed links that are not cleared. This problem could be avoided if Ofcom takes action now to clear fixed links from all top 100+ city locations and associated traffic hot spots, including airports, university campuses and major out-of-town shopping centres. We urge Ofcom to issue such notice as soon as practically possible.

At this point in time, we would be comfortable with Ofcom not yet giving notice to fixed links that do not interfere with the top 100+ city locations and associated traffic hot spots. However, the situation will evolve and, by the early 2030s, it may be that mobile operators will need mmWave spectrum across a much broader range of geography, creating conflict with a new set of fixed links. We therefore request that Ofcom regularly review the status of remaining fixed link licences, so that it is ready to issue further 5-year revocation notices well in advance of mobile-industry need.

Other incumbent uses of 26 GHz

We agree with Ofcom's proposed approaches to manage coexistence between new 5G users and the other existing users in the 26 GHz band. We support the proposals to limit future satellite earth stations in this band to low density areas only. We understand that Ofcom may consider new applications outside high density areas, but request that Ofcom take into account whether the new location could be redesignated as a high density area later. In particular, we would not support new applications being granted in any top 100+ area, even if exclusive licensing is initially limited to top 40 areas. We support the proposal to end access to the entire band for PMSE users with five years' notice.

40 GHz incumbent licences

There are three main incumbent users in the 40 GHz band, each with rights to operate fixed links: MLL, H3G and MBNL (owned by BT and H3G). However, only MBNL is making substantive use of its holdings, with 4,500 links across two blocks of 250MHz. In contrast, the next largest user, H3G, is deploying a mere 60 links across two blocks of 1,000MHz. It is clear from this that the band is not being well used and, with the possible exception of the MBNL spectrum, should be repurposed for 5G mobile.

In the consultation, Ofcom puts forward four options for repurposing the band:

a) **Option 1** – Variation of all licences to enable existing licensees to deploy new uses in the band, including mobile.

b) **Option 2** – Revocation of all licences, and reallocation of the entire band (3,000MHz) for new uses, including mobile.

c) **Option 3** – Partial revocation of licences, revoking H3G and MLL's licences, but not MBNL's licence.

d) **Option 4** – Partial variation and partial revocation of licences, by varying H3G and MLL's licences to enable new uses, but only in relation to some of their existing frequencies.

VMO2 strongly agrees with Ofcom that the best approach is Option 2, which will allow for the clearance and reallocation of the whole band. This approach offers multiple benefits:

- It is most likely to produce an efficient, pro-competitive allocation, as all potential users will have an opportunity to compete for the spectrum on a level playing field. In contrast, any approach that leaves spectrum in the hands of the incumbent users risks entrenching an existing allocation that is unlikely to represent an efficient allocation of 5G spectrum, as it was formed through primary and secondary transactions before the 5G era.

- It removes the risk of secondary market failure, which might otherwise occur owing to high transaction costs or because legacy licensees are reluctant to trade with rival operators. As Ofcom points out, if licences are allocated on a local area basis and multiple licensees win different quantities of spectrum in different markets, the combination of trades necessary to address legacy allocative inefficiencies could be particularly complex.

- **[✂]**

- It will maximise opportunities for innovation and investment in new uses of mmWave spectrum by all operators as a whole. As Ofcom says, "*Both existing licensees and other prospective users would be able to access all mmWave spectrum simultaneously to acquire the spectrum they might need to provide quality services*."

- The costs involved in reallocating fixed links are not large compared with the potential long-term value creation from reallocating the band. Although the existing licences will be revoked, incumbent users will have five years notice to replan their fixed links in high density areas. As per the proposed 26 GHz regime, links outside (current or future) high density areas may remain.

The current situation in the 3400-3800 MHz band is unfortunately a good example of the failure of the secondary market to efficiently reallocate legacy spectrum when this depends on trading between incumbent operators. In that band, Ofcom opted to repurpose UKB's legacy licences for mobile use, enabling H3G to secure 120MHz of spectrum, which it enlarged to 140MHz through auction. At the time, we warned Ofcom that this was almost certainly not an efficient allocation, and that the position of H3G's two spectrum blocks would form a barrier to other operators securing contiguous spectrum. Subsequently, no other operator was able to secure a preferred 100MHz assignment and all three ended up with discontiguous blocks of 80MHz-90MHz. Through trading with Vodafone, O2 was ultimately able to secure a contiguous 80MHz block, but BT and Vodafone's holdings remain fragmented. Whatever the reasons why trading has not yet happened, it is clear the current situation is not an efficient allocation. It could have been avoided if Ofcom had taken a less generous approach to the incumbent licensee in that band. To avoid a similar situation emerging at 40 GHz, Ofcom should adopt Option 2 and not Option 1.

The next best option and only other credible approach is Option 3. MBNL has a relatively modest allocation and is making substantial use of it, unlike the other incumbents. If, uniquely, its allocation was maintained, this would have a much smaller impact on future efficiency of mmWave deployment. However, we consider this a less attractive option for several reasons. First, the legal basis for rolling over some licences and not others may be questionable, notwithstanding differences in live deployments. Second, the owners of MBNL are well capable of buying the spectrum back if they want to continue the fixed link use, so revocation should not raise any continuity concerns. Thirdly, the current spectrum configuration in two discontiguous blocks is not compatible with replanning the band for mobile use, so revocation is a better option for replanning purposes.

Furthermore, MBNL is owned by BT and H3G. It is opaque to other bidders in the auction what shareholder / commercial arrangements exist or will exist between the parties to repurpose this spectrum once the band is liberalised for mobile use. If the licence is not revoked now, the only solution would appear to be a requirement that this spectrum remains for fixed links only until surrender. Participants in the auction would have a legitimate expectation that Ofcom would not deviate from this going forward.

The existing incumbents will require five years notice of revocation. As with 26 GHz fixed link licensees, we urge Ofcom to provide such notice as soon as possible. In the interim period, there will be severe constraints on the ability of new licensees to use their spectrum. This is unlikely to be an issue for the next 3-5 years, given the limited business case for mobile use of the band, but that should change as the mobile ecosystem develops, so a longer delay could be value destructive.

AUCTION FORMAT AND RULES

VMO2 agrees with Ofcom that the clock auction is the right format for this award but the detailed rules will matter greatly. We explain our position here and provide some initial comments on geographic licensing, lot categories at 26 GHz, and the potential rules for the Principal Stage and Assignment Stage.

Geographic licensing

VMO2 operates a nationwide mobile network. We aim to offer the best possible experience for our customers in all parts of the UK. **[✂]**. Accordingly, our interests are best served by national licences. Nevertheless, we stand ready to compete to aggregate regional licences if Ofcom concludes this is the appropriate licence structure to meet the needs of all potential winning bidders.

Given the possibility for sub-national operators to acquire licences on a site-by-site basis under the shared access scheme, we do not believe that Ofcom has made the case for the incremental intervention of individual citywide licensing as well. We are unconvinced that it is necessary for Ofcom to sell citywide licences individually, as opposed to creating a single sub-national licence that covers all high density areas. Given the added complexity of local licensing, Ofcom needs to properly examine whether fragmentation of the lots in the award will likely give rise to diverse geographic ownership. We recall the experience of the 3.5 GHz award run by the Radiocommunications Agency in 2003,

where considerable effort was put into the design of regional licences, but ultimately all the spectrum ended up in the hands of a single operator.[13]

For a national operator, geographic licensing is, at best, an inconvenience and, at worst, a potential source of spectrum fragmentation and network holes that would create engineering problems for our network teams for many years to come. No evidence is provided as to whether local bidders for citywide licences really exist and, if they do, whether their demand could be otherwise addressed in full through the 850MHz of national shared use spectrum in the 26 GHz band. If there is no such evidence or if such demand could be met with the lower 850MHz, then there is no case for regional licensing.

At paragraph 9.13(c), Ofcom suggests that it might use a pre-auction evaluation round to determine if there is any regional demand, and might opt to amalgamate lots where there was no such demand. This is an interesting idea but we are concerned it could mean that bidders going into the auction face uncertainty over the lot structure until very late in the process. We also have concerns that a lot category structure that mixes a single large sub-national block and many small local areas may create barriers to switching between categories and bands in the auction. We therefore reserve our opinion on this idea, pending more information about the broader auction rules.

Again, a later auction, but with an immediate availability of shared access in the bands would provide the evidence that Ofcom needs to divert from its historical regulatory practice of nationwide licensing (or in this case, a single urban area licence). Experience of site-by-site licensing might provide clear evidence of meaningful regional demand, and in that circumstance we accept that regional licensing might be a fair way to proceed. If there is no such evidence, then we urge Ofcom to revert to national licensing and benefit from a much simpler auction design.

26 GHz lot categories

Regarding the 26 GHz band, we strongly prefer there being only one category for the entire 2400MHz range. This approach ensures that each operator will secure the same contiguous spectrum for the duration of the licence term, which is preferable for network planning purposes. Although spectrum encumbered by fixed links will have lower value, this constraint is limited to the first 5 years, when mobile deployment is likely to be limited in most locations. Therefore, we conclude that the value losses associated with fixed links incumbency is not so great as to necessitate having an extra lot category and the associated complexity for auction design and bidders that this would introduce.

Further, two categories of lot could create problems for bidders whereby:

- a winning bidder has demand split across the two categories which is not contiguous; and
- **[✂]**

[13] There were 15 regional licences covering the entire United Kingdom. In the auction, PoundRadio (UKB) won 13 licences, Red Spectrum won 1 licence and Public Hub won 1 licence (https://www.itu.int/osg/spu/ni/spectrum/UK-RSM.pdf). Subsequently, in 2004, UKB bought the Red Spectrum and Public Hub regional licences, so as to create a single nationwide licence (https://rethinkresearch.biz/articles/pccw-lifts-the-veil-on-uk-broadband-wireless-plans/).

We note that these problems disappear if Ofcom proceeds with our proposal for awarding site-specific licences now, with the launch of exclusive licences delayed until incumbent uses have been cleared.

Auction format

VMO2 agrees that the clock auction format is the appropriate format to implement this award. We support this format irrespective of whether Ofcom adopts sub-national or geographic lot categories.

A clock auction design is the right approach for the following reasons:

1. It is a multi-round auction design that will facilitate price discovery. This is important given the significant degree of common value uncertainty that mobile operators must manage when developing their valuations for the mmWave spectrum. Accordingly, a sealed bid format should not be adopted.

2. We do not think combinatorial bidding is necessary for this award. There are several reasons for this. Firstly, we agree with Ofcom that the aggregation and substitution risks that bidders will face are not large enough to require package bidding to mitigate them. Secondly, if geographic licensing is adopted, there could be 80+ categories of lots, and this would be too complex a setting for bidders to make combinatorial bidding work effectively. Finally, we have deep reservations about the effectiveness of the combinatorial clock auction format in general, given its association with high and/or asymmetric price and allocation outcomes for 4G awards, and persistent concerns about the incentives the format creates for price driving.

3. The clock format facilitates a faster and simpler auction design than the SMRA. If 100MHz blocks are adopted (see below), there could be either 12 or 24 lots in the 26 GHz band and 15 or 30 lots in the 40 GHz band. With a high bid mechanism and modest excess demand, the auction could move incredibly slowly if an SMRA format is adopted. Accordingly, we consider a standard SMRA format to be impractical. We recognise that there are hybrids of the clock and SMRA which are faster than the standard SMRA but we see no benefit to using them here versus a clock format.

If Ofcom proceeds with a clock auction, it will face a number of key decisions with respect to the activity rules governing switching between geographic categories and between bands, and conditions under which demand may be retained. We provide some initial comments on activity rules below and look forward to participating in the next stage of consultation on the detailed auction rules, in due course. We also provide some initial comments below on other key rules, namely lot sizes, reserve prices and bid increments.

Lot size

With a clock auction format, there is no trade-off between the number of lots in a category and speed of the bidding process. However, larger lots may still be relevant in mitigating aggregation risks, especially if Ofcom applies lot retention rules. Accordingly, Ofcom should select a lot size that corresponds the base unit of demand which bidders for exclusive licences will use to assemble larger blocks, but no smaller than this. Our provisional view is that 100MHz lots are the appropriate units for the 5G mobile business case. We are concerned that 50MHz lots may be too small relative to 100

MHz units that appear favoured in the emerging ecosystem, whereas 200MHz lots may not allow enough flexibility for bidders.

Activity rules

We support having both 26 GHz and 40 GHz in the same auction, as the bands are both substitutable (as options for local area high speed capacity) and complements (both offering large incremental capacity). Therefore, it makes sense that bidders should be allowed to take advantage of the price mechanism in an auction to identify the best available portfolio for them across the two bands.

Uncertainty regarding the development of the separate but related equipment ecosystems for the two bands will be a source of great uncertainty for mobile operators as we build our business cases to acquire spectrum in one or both bands. This uncertainty can only be eased through the passage of time, which is why we advocate a delay in the award of exclusive use licences, while pushing ahead with making the bands available on a shared use base. The earlier the auction happens, the greater the challenge for Ofcom in designing the activity rules for the auction, given the uncertain structure of bidder demands.

If the auction is held as soon as 2024, the format will need to be sufficiently flexible to cope with bidders having the following potential conflicts in their demand within and across bands:

a) Bidders that prioritise keeping network costs low and therefore only want spectrum in one band or the other, but not both; vs bidders that prioritise long-term access to capacity, and may therefore be willing to buy spectrum in both bands.

   The first category of bidders would value switching rules that allow a bidder to cleanly transfer demand between 26 GHz and 40 GHz in response to changes in relative prices. Such bidders may want to shift their entire demand in all regions in a single round. The second category of bidder may be content to be maintained on a subset of its demand in one band, provided it can still buy a critical mass of spectrum in both bands.

b) Bidders that are targeting the same quantity of spectrum in either band; vs bidders that may be interested in 40 GHz only if they can buy a larger quantity of spectrum, so as to offset concerns about weaker propagation and delayed ecosystem development.

   For the first category of bidder, it would be acceptable to have a 1:1 eligibility points ratio across the 26 GHz and 40 GHz bands. However, the second category of bidder would need to be able to switch to larger quantities at 40 GHz, so would prefer a larger ratio. A compromise approach might be to adopt uniform eligibility ratios, but allow bidders to bid some superset of the eligibility when active at 40 GHz.

We conclude from this that Ofcom should be wary of imposing demand retention rules that unduly restrict switching across bands. It may also need to explore innovative rules with respect to bidders changing demand levels when switching demand across bands.

For national bidders, switching between bands would obviously be much easier with a single sub-national lot rather than many regional lots. Therefore, Ofcom should not take the decision to embrace regional bidding lightly.

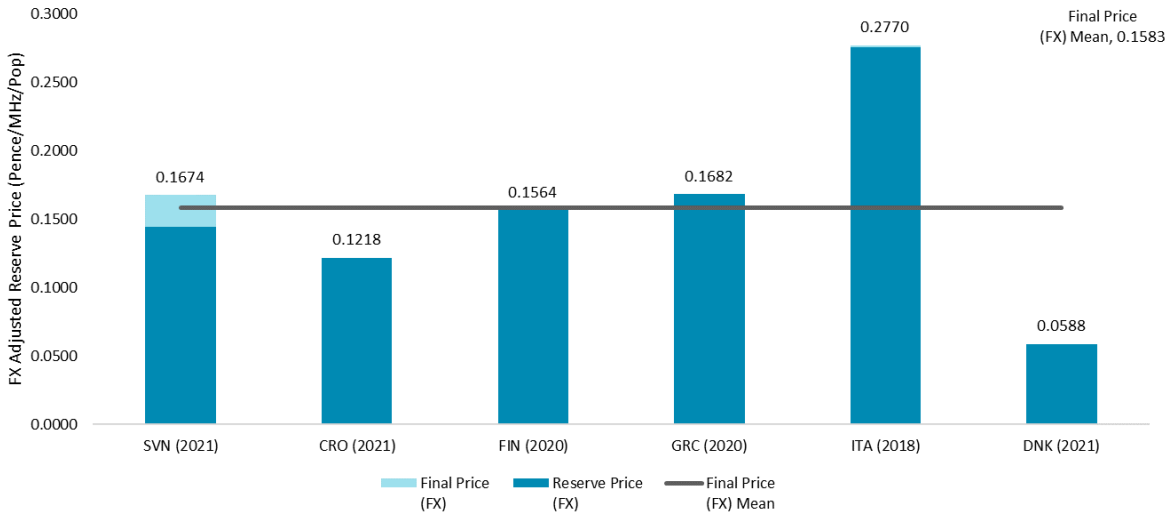
Reserve prices

Stakeholders worldwide face considerable uncertainty over the value of mmWave spectrum. This is particularly true in Europe and the UK, where a limited number of awards have taken place and devices capable of supporting the 26 GHz and 40 GHz bands are not yet available. The UK award will also feature significantly more spectrum than earlier European awards, owing to the award of the full 40 GHz band alongside the full 26 GHz band. Accordingly, Ofcom should adopt a policy of setting modest, conservative reserve prices for these bands, so as to encourage participation, minimise the risk of spectrum inefficiently going unsold and to allow room for meaningful price discovery in the auction.

Ofcom will presumably consider international benchmarks when setting reserve prices. To date, very few mmWave auctions in Europe have featured meaningful price discovery owing to low demand, despite less spectrum being available than in the UK: 26 GHz spectrum sold at reserve price in Croatia, Finland and Greece, and sold to within 1% of reserve price in Italy. Our provisional view, therefore, is that Ofcom should adopt a reserve price for 26 GHz that is well below the European average of £0.00158 per MHz/pop, as shown in Figure 4. Furthermore, the reserve price for 40 GHz should be set at a lower level (e.g. 50% of the 26 GHz price), given its weaker propagation and less developed ecosystem.

This approach of setting modest prices for bands with uncertain ecosystems and uncertain demand would be consistent with past auctions, e.g. the 700 MHz SDL band in the 2021 auction.

Figure 4: 2G GHz benchmark prices for European awards to date



Bid increments

For the auction of 700 MHz and 3.6-3.8 GHz, Ofcom introduced a new rule capping the absolute size of bid increments in GBP, so as to avoid a situation where the use of fixed percentage increments leads to ever larger absolute increments. This reform was much appreciated and made it easier for bidders to predict the path of prices in any given bidding day and manage their projected bid exposure.

This rule was introduced as a measure to ease governance challenges for bidders in the context of the COVID emergency. However, we think the benefits are just as relevant to an auction that takes place in more normal times, and we urge Ofcom to introduce a similar rule for this award.

Compared to the 700 MHz FDD and 3.6-3.8 GHz bands, the value of this spectrum is much lower and much less certain. We recognise that reserve prices are likely to be modest and it may be that the auction would have to continue for some time before any serious governance concerns could emerge owing to large bid increments. Nevertheless, we urge Ofcom to consider the possibility of a long auction, and adopt appropriate constraints on the GBP size of bid increments in any individual band.

Assignment Stage

The priority in the Assignment Stage should be to ensure that bidders that win multiple lots in the same band and same geographic area receive the corresponding spectrum in the form of contiguous spectrum. The priority here is frequency contiguity within each area. Contiguity across areas is nice to have but much less important.

At paragraph 9.13b, Ofcom proposes combining areas for assignment purposes if all bidders have won the same geographic location. We broadly agree with this approach, but Ofcom should also consider the geographic location of the relevant lots and those that cannot be assigned together. In general, if the allocation is identical **and** the areas are geographically close, then combining is desirable. We urge Ofcom to study past auctions in Australia and Canada, where there are well established rules for combining regions and sequencing assignment rounds, starting with more valuable (larger) regions.

A potential complication in the Assignment Stage is the reduced value of some frequency placements owing to incumbent fixed links that could continue for 5 years. We note that some of the potential bidders in this auction are also incumbent fixed links operators in the 26 GHz and/or 40 GHz bands. Subject to preserving contiguity of assignment for all bidders, these operators should be directly assigned to the spectrum that they themselves are impairing. This would prevent an unacceptable situation where one operator is pushing ahead with deployment in a major city while simultaneously drawing out the life of a fixed link so as to block a rival from deploying competing infrastructure.

DURATION OF LICENCES

VMO2 strongly supports Ofcom's approach to licence duration for low-band and mid-band mobile spectrum, which is to sell licences with an initial 20-year term that are then subject to 5-years rolling renewal. However, we recognise that there may be a case for a different approach for mmWave licences given the uncertainty over how the business case will evolve. Given that the secondary market for spectrum in the UK is not fully liquid, we agree there is a risk that an auction now could lock in an allocation that turns out not to be fully efficient. For the mmWave bands, there is a trade-off between longer licence terms, which promote investment certainty for licensees, and shorter licences, that provide a guaranteed future opportunity for market reallocation of a scarce resource.

As a compromise, Ofcom says that it is minded to grant licences for a fixed term of 10-15 years. However, we are concerned that 10 years is simply too short, especially if the auction happens in 2024.

There is a significant risk that there is little investment in the first few years (and deployment may also be constrained by legacy fixed links), and then subsequently, when the market timing is right for operators to commit fully to the band, the remaining term will be so short that operators will be deterred from ramping up that investment. If licences are issued in 2024, they should be for a period of not less than 15 years. A duration of 15 years would also be in line with most other countries that have issued mmWave licences to date, as illustrated in Table 1.

Table 1: Licence durations for mmWave spectrum by countries worldwide

Country	Award year	Spectrum	Licence duration
Korea	2018	2,400MHz @ 28GHz	5 years
Italy	2018	1,000MHz @ 26GHz	19 years
USA	2019 - 2020	4,296MHz @ 24, 28, 39 & 47 GHz	Indefinite
Hong Kong	2019	4,100MHz @ 26 & 28GHz	15 years
Japan	2019	1,600MHz @ 28GHz	15 years
Taiwan	2020	2,500MHz @ 28GHz	20 years
Thailand	2020	2,600MHz @ 26GHz	15 years
Finland	2020	2,400MHz @ 26GHz	14 years
Brazil	2021	1,200MHz @ 26GHz	20 & 10 years
Australia	2021	2,400MHz @ 26 GHz	15 years
Croatia	2021	1,000MHz @ 26 GHz	15 years
Denmark	2021	2,400MHz @ 26 GHz	15 years

If the auction takes place in 2024, we support adopting a fixed term, given the high uncertainty over business cases and potential for the auction not to deliver a long-term efficient allocation. However, rather than adopt a 15-year licence now, we urge Ofcom to consider delaying the auction of exclusive licences for a few years (i.e. to 2026-27). This will give Ofcom and the industry more time to assess the business case, and to experiment with limited deployments under the shared access regime. In a few years' time, the best approach in terms of licence duration and renewal may be more obvious. For example, it may be that 15 years is appropriate for the minimum term of an indefinite licence.

One concern we have with renewable spectrum rights in the 26GHz and 40 GHz bands is that this approach may not allow for efficient replanning of the band, if the allocations across operators change at the time of re-award. Ideally, at this point, the band should be reorganised so all new licence holders have contiguous spectrum. However, if there are incumbent operators whose allocations are renewed, they may have incentives to block replanning. This has been a problem in the UK 3.5 GHz band, where BT and Vodafone have to date, been unable to broker a deal with H3G to defragment the band. Therefore, regardless of whether Ofcom adopts fixed term licences or renewable licences, we urge Ofcom to make clear that the band may be subject to replanning at the end of the initial term,

and that this may require incumbent licensees to change frequencies, so as to accommodate other users. Given that modern equipment is frequency agile within the same mmWave band, this approach should not impose any meaningful costs on incumbent operators, while making it easier for new and expanding players to secure contiguous spectrum.

COMPETITION MEASURES

In the consultation document, Ofcom develops a line of thinking that suggests that precautionary caps are only necessary if one party enters the auction with an incumbency advantage. **[✂]**. Given the nascent state of the mmWave industry, we agree with Ofcom that this probably would not raise any competition concerns in the short-to-medium-term. However, we also agree with Ofcom that such an outcome could create long-term competition concerns, as other operators may find themselves excluded from a key category of spectrum, with no good options to compete with H3G in the provision of ultra-high speed and capacity in high density areas.

Accordingly, VMO2 believes there is a strong case for a precautionary cap of 1,000MHz in each of the 26 GHz and 40 GHz bands, with respect to high density exclusive licences. Thus, each bidder would be limited to acquiring at most 2,000MHz in total, a maximum of 1,000MHz at 26 GHz and a maximum of 1,000MHz at 40 GHz.

Turning to Options 2 and 3, H3G would have no such advantage going into the auction, because all or most of its spectrum rights would have been revoked. On this basis, Ofcom concludes that precautionary caps are not required:

> "*Our provisional view is that a competition concern would be unlikely to arise in this situation, as there would be a large quantity of spectrum available and none of the MNOs would start out with holdings of mmWave spectrum which could potentially be suitable for mobile use. Therefore, our provisional view is that it is unlikely that competition measures would be required under this option*."

While we agree with Ofcom's first point that competition concerns are much less likely to arise under these options, we disagree with Ofcom's conclusion that this means it can safely take no action. To the contrary, if there is a case for precautionary caps to stop any single bidder buying excessive quantities of mmWave spectrum, then this case applies irrespective of whether particular bidders enter the auction with a spectrum holdings advantage.

As we have pointed out, the business case for mobile deployment of mmWave spectrum is very uncertain, especially with respect to the timing of when operators will need to deploy. If Ofcom proceeds with an auction at this time, there is a material risk that spectrum is won not by those parties with the best long-term business case but those who are most optimistic right now or, worse, a bidder (or bidders) that is willing to take a chance on buying excessive quantities of mmWave spectrum in the hope of cornering the market later. To limit the scope for such scenarios, Ofcom should adopt precautionary caps, set at a level that will not preclude any realistic business case but will stop excessive accumulations of spectrum.

We think it is self-evident that 1,000MHz per band is a sensible level for a precautionary cap, for the following reasons:

- This level of cap will ensure that there are at least three winners in each band, eliminating the possibility that just one or two players could build a dominant holding.

- Every bidder has an option to pursue contiguous blocks of up to 1,000MHz of mmWave spectrum, which manufacturers and industry bodies have identified as a sufficient quantity "*to support the very fastest 5G services*".[14]

A cap of 1,000 MHz would be in line with the international norm for precautionary caps adopted by other countries that have released mmWave spectrum. Excepting the United States, which did not apply any caps, and countries where the supply of mmWave spectrum was severely constrained (such as in Italy, Greece and Croatia), regulators have typically set band specific caps of 800-1,000 MHz. This is illustrated in Table 2.

Table 2: Spectrum caps adopted for 26 GHz 5G spectrum awards

Country	Total amount of spectrum (MHz)	Cap (MHz)	% of total
South Korea	2,400	1,000	42%
Italy*	1,000	400	40%
Finland	2,400	800	33%
Greece	1,000	400	40%
Taiwan	2,400	800	33%
Denmark	2,850	1,650	58%
Thailand	2,700	1,100	41%
Slovenia	1,000	800	80%
Croatia	1,000	400	40%
Brazil (national)	1,000	1,000	100%
Australia	2,400	1,000	42%

*Under the club model, licensees can access up to 1,000MHz in areas where other licensees are not using the spectrum.

Given that competition concerns relate to long-term access to mmWave spectrum, not short-and-medium-term access, the application of a precautionary cap becomes increasingly relevant:

- the longer the duration of the licence: for example, a 15-year licence would reach further into the long term than a 10-year licence;

- the later the award takes place: for example, if the award happens in 2028 rather than 2024, then it is more likely that the licence term will include a period when competitive benefits of exclusionary behaviour become relevant; and

- if the licences are indefinite rather than for a fixed term, for similar reasons.

As a general point, we anticipate that there is likely to be more demand for mmWave spectrum if these licences are longer and start later. If this is right, then the risk of competition concerns is also greater, and the case for precautionary caps is even stronger.

[14] Quote from GSMA. See footnote 11 for full reference. See also footnotes 10 and 12 for similar quotes from GSA and Ericsson.

CONCLUSION

VMO2 is a potential buyer of exclusive use spectrum licences in the band and so we have assessed our likelihood of purchasing the spectrum on Ofcom's current preferred terms, as set out in the consultation. **[✂]**.

[✂] it is very important to us that if Ofcom decides to adopt a fixed term licence, that 'fixed means fixed', i.e. that Ofcom commits upfront that the spectrum will be available in a competitive award open to all parties where the initial licence term expires. The importance of maintaining a regulatory contract once entered into is a point that we have emphasised both in this response and previous responses on related topics **[✂]**.

[✂]. We strongly believe that in this case, the shared access regime will provide useful insight to inform the design of exclusive licences, allow the ecosystem to develop and provide the right approach to address uncertain demand in the short term.

ANNEX: RESPONSE TO SPECIFIC QUESTIONS

Question 1: (Section 2) Do you have any comments on our assessment of potential use cases, demand and deployment strategies for new uses of mmWave spectrum?

We are excited about the long-term potential to augment our 5G network using selective deployment of mmWave spectrum. However, for mobile operators, mmWave spectrum is not currently a priority band for delivering 5G, as growing demand for high-speed data can best be met by deploying low and mid-band spectrum, including 700 MHz and 3.4-3.6 GHz. The business case and equipment ecosystem for mmWave spectrum is uncertain, and it is likely to be many years before 26 GHz and 40 GHz become a mainstream component of 5G network provision.

We conclude from this that mmWave spectrum is not currently scarce but will become so in future. Exclusive licences will be needed to cover busy traffic locations but they are not needed yet. Regardless of when these licences are awarded, Ofcom should anticipate that the spectrum will not be used much by mobile for the next 3-5 years, with deployment taking off in a 5-15 year time horizon.

Our full comments are set out in our Main Response under the heading "AVAILABILITY OF AND DEMAND FOR MMWAVE SPECTRUM".

Question 2: (Section 2) Do you have any comments on our proposed overall approach to mmWave spectrum (including our aim to make the 26 GHz and 40 GHz bands available for new uses on the same or similar timeframe)?

Ofcom has tentatively proposed awarding mmWave spectrum in 2024. We think an award this soon is premature. It would oblige operators to bid for spectrum that they anticipate deploying in the long term, but do not yet need. Bidders would have to navigate huge uncertainties, for example concerning the equipment ecosystem, the quantities of spectrum actually required to meet rapidly growing but uncertain levels of demand, the locations where mobile mmWave deployment is needed, and the potential for 40 GHz to emerge as an *effective* substitute for 26 GHz. The winners of an auction undertaken against this background would be those that are most optimistic about the long-term prospects for mmWave, who may not in fact be the most efficient long-term users once deployment cases are better understood.

Our preference is for Ofcom to delay the award until 2026-27, with exclusive licences commencing by 2028. At this point, the usage case for mmWave spectrum should have solidified, and mobile operators will be positioned to compete for the spectrum based on firm deployment plans. The answers to many of the questions that Ofcom has posed in this consultation, for example concerning the geographic structure and availability of licences, and the licence duration, should by then be much clearer, enabling Ofcom to design the award process with more confidence. This will also bridge the notice period required to ensure all legacy uses are cleared from exclusive use spectrum.

For further explanation, please see the section of our Main Response entitled "TIMING OF THE AWARD".

We agree that 26 GHz and 40 GHz should be made available on the same timeframe, and that exclusive licences for these two bands should be auctioned together. Please see the section on "AVAILABILITY OF AND DEMAND FOR MMWAVE SPECTRUM" for discussion of this point.

Question 3: (Section 3) Do you agree with our approach of specifying high and low density areas in the UK, and authorising new uses differently in those areas?

VMO2 broadly accepts Ofcom's proposal to divide the country into high density and low density areas. However, we are concerned that Ofcom's efforts to define high and low density areas fundamentally misunderstands the mobile business case for deployment of mmWave spectrum. This has led to errors in defining city boundaries and a proposal for an arbitrary top 40 city cut-off, two actions that will lead to many busy locations where we anticipate mobile mmWave deployment being unlicensed. These errors are understandable given that the industry (and therefore Ofcom) does not yet have a good understanding of where and when mobile operators will deploy mmWave spectrum. For the reasons we outline under the heading "WHICH AREAS SHOULD BE DESIGNATED HIGH DENSITY?", we think the best approach would be to delay the award of licensed spectrum until 2026-27, while proceeding temporarily with shared licensing. This will give Ofcom and the industry the time and information needed to define sensible boundaries for high density areas.

Question 4: (Section 3) Do you agree with our overall authorisation approach in high density areas for the 26 GHz band (i.e. to grant Shared Access licences on a first come, first served basis for the bottom 850 MHz of the 26 GHz band, (24.25-25.1 GHz), and to auction citywide licences for the rest of the 26 GHz band (25.1-27.5 GHz))?

VMO2 supports the 850MHz / 2,400MHz frequency division between shared use and exclusive use licences. Whilst our priority, as a mobile operator, is exclusive use licences, we recognise there may be demand for local area licences, and the 850MHz block is a suitable way to meet that demand.

We agree that high density areas should be auctioned. We are attracted by the concept of a club model for high density spectrum, enabling exclusive use licensees the ability to access each other's spectrum in locations where a rival has not yet deployed. Ofcom has expressed concern that the club model could be "*complex to implement*". However, we think the model could be adapted quite easily to shift any complexity on to the winning bidders (not Ofcom).

Please see the section of our Main Response entitled "BALANCE BETWEEN SHARED ACCESS AND EXCLUSIVE USE SPECTRUM" for further explanation of our position.

Question 5: (Section 3) Do you agree with our overall authorisation approach in low density areas for the 26 GHz band (i.e. to grant Shared Access licences on a first come, first served basis)?

Yes, we support this approach for low density areas, subject to Ofcom correctly defining low density as areas outside high density areas, where we expect deployments to be sparser and spectrum is unlikely to be scarce. Please see our answer to Question 7 where we identify concerns that Ofcom's current approach is incorrectly identifying some high traffic locations as low density areas.

Question 6: (Section 3) Do you agree with adopting a similar approach to authorising the 40 GHz band as our proposals for the 26 GHz band, if we were to decide to re-allocate the 40 GHz band?

Yes, we agree that Ofcom should adopt a similar approach to authorising the 40 GHz band as for the 26 GHz band. This point is also addressed in the section of our Main Response entitled "BALANCE BETWEEN SHARED ACCESS AND EXCLUSIVE USE SPECTRUM".

Question 7: (Section 4) Do you agree with our proposed methodology for identifying and defining high density areas?

VMO2 broadly accepts Ofcom's proposal to divide the country into high density and low density areas. However, we are concerned that Ofcom's efforts to define high and low density areas fundamentally misunderstands the mobile business case for deployment of mmWave spectrum. This has led to errors in defining city boundaries and a proposal for an arbitrary top 40 city cut-off, two actions that will lead to many busy locations where we anticipate mobile mmWave deployment being unlicensed. For example, it makes no sense that under Ofcom's current approach, London Heathrow, London Luton, Birmingham and Glasgow airports would be licensed, whereas London Gatwick, Manchester, Edinburgh, Bristol and Belfast airports would be unlicensed. In our view, all such airports should in exclusive license areas, and all should be licensed in the same area as the major cities they support.

These errors are understandable given that the industry (and therefore Ofcom) does not yet have a good understanding of where and when mobile operators will deploy mmWave spectrum. We think the best solution to this uncertainty would be to delay the award of licensed spectrum until 2026-27, while proceeding temporarily with shared licensing. This will give Ofcom and the industry the time and information needed to define sensible boundaries for high density areas.

For further explanation of our position, please see our Main Response under the heading "WHICH AREAS SHOULD BE DESIGNATED HIGH DENSITY?".

Question 8: (Section 4) Do you agree with our proposed cut-off point of 40 high density areas?

No, we are not comfortable with the proposed cut-off point of 40 high density areas. We think this cut off point is inherently arbitrary, lacks supporting evidence, and is not sufficiently correlated with the actual location of traffic hotspots where mmWave spectrum will (eventually) be deployed. **[✂]**. At the same time, a top 40 cut off would mean not licensing traffic hotspots in many urban centres, airports, university campuses and other locations where all operators will likely want to deploy mmWave and spectrum will, in due course, become scarce.

For further explanation of our position, please see our Main Response under the heading "WHICH AREAS SHOULD BE DESIGNATED HIGH DENSITY?".

Question 9: (Section 5) Do you agree with our proposal to clear the fixed links in and around high density areas from the 26 GHz band?

VMO2 supports Ofcom's proposal to clear incumbent operators from frequencies in both bands that will be subject to exclusive licensing, subject to statutory notice periods. Regardless of where Ofcom determines the cut-off point for defining high density areas, we think fixed links should be cleared as soon as possible from all top 100+ city locations and associated traffic hot spots, including airports, university campuses and major out-of-town shopping centres. We urge Ofcom to issue such notice as soon as practically possible.

Our full comments are set out in our Main Response under the heading "REVOCATION OF EXISTING LICENCES".

Question 10: (Section 5, Annex 8) Do you agree with our estimates of the cost of migrating fixed links into alternative spectrum bands?

We support migration of existing fixed links in the 26 GHz band as soon as practically possible, subject to following rules regarding statutory notice to vacate the frequencies. Our understanding is that the costs associated with clearing are small relative to the potential medium-to-long-term benefits to society from making the spectrum available for 5G. We have no opinion at this time on the specific estimates of the costs of migrating the fixed links.

Question 11: (Section 6) Do you agree with the proposed approaches we have outlined to manage coexistence between new 5G users and the different existing users in the 26 GHz band? In particular, do you have any views on our proposals to limit future satellite earth stations in this band to low density areas only, and to end access to this band for PMSE users with five years' notice?

The positioning of satellite earth stations away from high density areas where spectrum is highly used is acceptable and is consistent with the approach to this in other bands. We agree that PMSE should be removed from the band.

Question 12:(Section 7) Do you agree with our initial assessment on which option for enabling the 40 GHz band for new uses would best achieve our objectives?

VMO2 agrees with Ofcom that the best approach is Option 2: revocation of all licences, and reallocation of the entire 40 GHz band for new uses, including mobile. We strongly oppose all other options, especially options 1 and 4, which could result in long-term inefficient allocation of mmWave spectrum. Our reasoning is set out in our Main Response in the subsection entitled "40 GHz incumbent licences" under the heading "REVOCATION OF EXISTING LICENCES".

Question 13: (Section 7, Annex 8) Do you agree with our analysis of the impact on existing 40 GHz licensees, including our estimates of the cost of moving fixed links under the options involving revocation (options 2, 3 and 4)?

We support migration of existing fixed links in the 40 GHz band as soon as practically possible, subject to following rules regarding statutory notice to vacate the frequencies. Our understanding is that the costs associated with clearing are small relative to the potential medium-to-long-term benefits to

society from making the spectrum available for 5G. We have no opinion at this time on the specific estimates of the costs of migrating the fixed links.

Question 14: (Section 8) Do you have any comments on our high-level Shared Access proposals (including technical and non-technical licence conditions and proposed approach to setting fees)?

We agree that using the existing framework would be suitable and would allow these bands to operate under a common licensing approach with other mobile bands. As that framework develops, spectrum users (whether primary licensees or incoming sharers) will be presented with a uniform approach across a wide range of frequencies.

Question 15: (Section 8) Do you agree with the overall approach we have set out to coordination and coexistence between new Shared Access users in the 26 GHz band and existing users?

Yes, we are broadly comfortable with the approach proposed by Ofcom. We have not had time to study the technical parameters in detail. However, our general understanding is that the measures proposed by Ofcom will give adequate protection from interference to operators using licenced spectrum in high density areas. If that is the case, then we are content with the proposals for high density areas.

One area of potential concern is the continued access of fixed links in the 26 GHz and 40 GHz bands to areas not specifically identified as high density. As set out in our answers to Questions 7 and 8 above, we think that Ofcom's existing approach to defining high density areas is missing many busy mobile traffic locations where there could (eventually) be high demand to deploy mmWave spectrum. If these areas are not redefined as high density, then there is a risk that availability of spectrum in these areas may be further constrained by low-value, legacy fixed links that are not cleared. As we stated in our answer to Question 9, the problem could be avoided if Ofcom takes action to clear fixed links from all top 100+ city locations and associated traffic hot spots, including airports, university campuses and major out-of-town shopping centres.

Question 16: (Section 9) Do you have any comments on our initial thinking in relation to auction design?

Given the possibility for sub-national operators to acquire licences on a site-by-site basis under the shared access scheme, we do not believe that Ofcom has made the case for the incremental intervention of individual citywide licensing as well. We are unconvinced that it is necessary for Ofcom to sell citywide licences individually, as opposed to creating a single sub-national licence that covers all high density areas. Unless Ofcom identifies evidence of meaningful regional demand, we urge it to revert to national licensing and benefit from a much simpler auction design.

Regarding the 26 GHz band, we strongly prefer there being only one category for the entire 2400MHz range. This approach ensures that each operator will secure the same contiguous spectrum for the duration of the licence term, which is preferable for network planning purposes.

VMO2 agrees with Ofcom that the clock auction is the right format for this award but the detailed rules will matter greatly.

In our Main Response, under the heading “AUCTION FORMAT AND RULES”, we explain our position on lot design and provide some initial comments on the potential rules for the Principal Stage and Assignment Stage.

Question 17: (Section 10) Do you have any comments on the licence duration options we have considered in this section for new licences for the 26 GHz and 40 GHz bands that we would auction?

VMO2 strongly supports Ofcom’s approach to licence duration for low-band and mid-band mobile spectrum, which is to sell licences with an initial 20-year term that are then subject to 5-years rolling renewal. However, we recognise that there may be a case for a different approach for mmWave licences given the uncertainty over how the business case will evolve. Right now, we do not think that Ofcom has enough information to identify an optimal licence term for exclusive licences. The best approach would be to delay the award of exclusive licences until 2026-27, and defer a decision on the licence term until nearer that time when more evidence will be available.

If licences are issued in 2024, they should be for a fixed period of not less than 15 years. Terms shorter than 15 years do not allow adequate time for payback of investment, especially given mmWave frequencies are likely to be little used for the next 3-5 years. It would be premature to proceed now with indefinite licences, given the high likelihood that an auction in 2004 would not deliver a long-term efficient allocation.

For further explanation, please see our Main Response, under the heading “DURATION OF LICENCES”.

Question 18: (Section 11) Do you agree with our assessment of potential competition concerns and that it may be appropriate to impose a competition measure such as a ‘precautionary cap?

VMO2 believes there is a strong case for a precautionary cap of 1,000MHz in each of the 26 GHz and 40 GHz bands, with respect to all high density areas. Thus, each bidder would be limited to acquiring at most 2,000MHz in total, a maximum of 1,000MHz at 26 GHz and a maximum of 1,000MHz at 40 GHz. Precautionary caps are necessary to eliminate the possibility of one or two operators attempt to acquire over-large holdings now, when industry demand for mmWave spectrum may be soft, in expectation of excluding rivals in the long term. We agree that this risk is greatest if Ofcom does not revoke 40 GHz licences, but the risk remains even if Ofcom does revoke. Our further reasoning is set out in our Main Response, under the heading “COMPETITION MEASURES”.