Non-Confidential

Enabling mmWave for new uses

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

BT's response to the consultation document published on 9 May 2022

Issue: v1.1

Date: 18 July 2022

Contents

Executive summary

1. Availability of mmWave spectrum is essential for the UK to benefit from the full range of capabilities that public mobile networks can deliver and to do so in an economically viable way at locations where traffic densities are highest or where service requirements are very high. We therefore welcome Ofcom's proposals to move ahead with authorisation of use of mmWave spectrum for mobile communication by 2024.
2. We support the principle of auctioning rights to use 26 GHz frequencies for mobile. Our preference would be that the full 26 GHz band is awarded on a national basis. We consider that would secure optimal use of spectrum when combined with trading and leasing on commercial terms. Local Access licences from Ofcom would also be an alternative to access awarded spectrum while and where it is not yet used.
3. If Ofcom sticks to its proposal to manage mmWave spectrum outside of high density areas using its shared spectrum access framework, this must be available rapidly on demand also to holders of auction licences. In the high density areas, sub-national licences should be offered and the area covered by these extended to better align to high traffic areas. Concerning the bottom 850 MHz of the 26 GHz band in high traffic density areas, we consider it more likely to secure optimal use of spectrum if Ofcom includes it in the auction for standard power use, rather than limiting it to low power shared access licences managed by Ofcom thereby reducing average bandwidth available to auction winners.
4. We agree that 26 GHz licences should be revoked where these conflict with higher value mobile use. In contrast to 40 GHz, the use of the band for 5G has been long anticipated and market mechanisms alone may not be suitable to facilitate change to mobile use due to the nature of the existing licenced use. Ofcom should consider grants to facilitate early migration of existing links to achieve most efficient use of the spectrum.
5. We agree that the 40 GHz band should be made available for mobile in 2024, at the same time as the 26 GHz band, although in practice they may not be used in the same timeframe (due to the less mature ecosystem and MBNL's existing use of part of the 40 GHz band). Liberalising the 40 GHz licences to allow migration to mobile according to market demand, and reliance on market mechanisms of trading and leasing, with a safeguard cap on total mmWave holdings in the 26GHz auction (dependent on total mmWave holdings), is the best route to securing optimal and efficient use of 40 GHz mmWave spectrum. Forcing a premature migration to mobile by licence revocation where spectrum is efficiently used (e.g. MBNL's use of fixed links) undermines market-based spectrum management principles. If Ofcom believes a revocation would secure more optimal use of the 40 GHz band, a grant for spectrum efficiency is justified to cover the costs that we estimate could exceed £20m.
6. We agree either a clock or simultaneous multiple round ascending style auction could be appropriate for award of 26 GHz licences, with an assignment round based on a second price sealed bid if generic lots are awarded. We do however reserve our position on auction design until the detailed proposals for the auction are made available. We consider that separate lots for each high traffic location are an unnecessary and unwelcome complication, but we can support two different categories of lots to reflect different constraints on different parts of the band. Competition measures for the 26 GHz award are essential if H3G's existing 40 GHz licence is varied to allow mobile and not revoked.
7. Finally, we advocate indefinite tradable licences and reliance on market mechanisms to achieve optimal use of spectrum, not the proposed fixed term licences of 10 or 15 years, as these would not create the best conditions for investment in mmWave networks.

1 Introduction

We welcome Ofcom's proposals[1] for making the 26 GHz and 40 GHz bands available for mobile technology (the "Consultation Document").

Our response reflects the chapters of the Consultation Document. We provided our views and addressed the Consultation questions in sections 2 to 11 below.

In section 12 we comment on the next steps and look forward to engaging constructively with Ofcom to take forward its important work to make mmWave spectrum available for mobile.

2 Our mmWave requirements for mobile

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

Summary

We are in broad agreement with Ofcom's assessment of potential use cases, demand and deployment strategies for new uses of mmWave spectrum, and provide our own detailed perspective on these matters and highlight any areas of divergence below.

Demand for use cases needing mmWave and their associated data requirements

The availability of large spectrum bandwidth at mmWave band should enable provision of very high data rates where traffic demand is growing. In addition to the typical mobile use cases there will be new use cases where traffic might be localised, e.g. sport stadiums and other venues with high concentration of devices using ultra-high-definition video, industrial settings, smart cities etc.. Most of these new use cases require support of data rates close to 1 Gbps and/or ultra-low latency. We have identified (see Table 2-1) a variety of use cases for mmWave, some are "vertical" specific, whilst others are generic and we expect more use cases to emerge as the technology matures.

The developments and announcements around augmented reality (AR)/ virtual reality (VR) are making high future data demand less speculative. The advent of Metaverse and the trend of VR/AR applications have started to change the future data demand profiles. The discussion of Metaverse is driving hype and investment around AR/VR and we have started seeing increases of AR/VR connected devices , with IDC reporting 11.2 million worldwide shipments in 2021 and predicting 50 million units shipped through 2026[2]. There are several AR/VR recent announcements and expectation for future mobile networks to support them. Examples include: Nreal Air AR glasses in UK launched by EE; AR/VR fitness service launched by Vodafone Germany; EE demo AR shopping at Wembley store; EE green planet AR experience; Audi Holoride VR entertainment launch in 2022; and the Sony and Niantic plans to add AR features to headphones.

The current AR headsets add at least 50 Mbps Downlink throughput requirement per user and low latency requirements and we are expecting the requirement to increase to 100 Mbps to 500 Mbps per user as technology is improving and screen mirroring is maturing (e.g., screen mirror using car windscreen, windows, advertisement panel display etc.) and as a result resolution is increasing.

We expect that the timeframe for this data demand and consequently the demand for mmWave is not too far in the future, if there is device and network ecosystem support.

As the use cases mature and adoption is increases, we expect AR/VR use cases to become more consumer targeted. Initially we expect mmWave use cases to be location specific driven by

[1] https://www.ofcom.org.uk/__data/assets/pdf_file/0027/237258/mmwave-spectrum-condoc.pdf
[2] IDC - AR & VR Headsets Market Share

Enterprise demand but as time progresses and Metaverse vision matures, we expect to see more mobile demand.

Demand outside urban areas

We have already seen technology developments where mmWave range can be extended up to 7km[3] in line of sight scenarios and we consider that in the next few years mmWave technology will be able to support use cases outside of the dense urban environment. FWA is one of those use cases. We have already seen several implementations related to FWA in Europe[4] and US[5]. Use in Science and Business parks is another example.

The mmWave developments in other markets, in particular around FWA, suggest that mmWave is not only concentrated in densely populated areas, but also in remote locations lacking fast fixed connectivity, where FWA can be used as an alternative high bandwidth solution. Deployments in Italy with external customer premises equipment (CPE) antennas suggest that such scenarios are feasible. Although fibre to the premise (FTTP) deployment is growing rapidly in UK, with BT Group committed to reach 25 million premises by 2026, there will still be locations outside of the urban environment where FWA will be used as substitution. In those scenarios mmWave can offer a reliable fast connection to support data demand in locations with low or no fixed broadband connectivity. If the area of interest for FWA is included in the auction licences and it is not the auction winner that wishes to operate FWA, commercial arrangements or local access licences could facilitate shared access by another party.

[✂

]

We also expect mmWave to support non-FWA use cases outside dense urban environments. Automotive use cases are one example: Audi and other car manufacturers have released ideas for car entertainment systems that use VR technology for passengers. Audi announced commercial release in June 2022[6,7,8]. Proposed UK legislation will allow people using self-driving cars to watch television on built-in screens.[9,10] In the next few years a car's passenger windows (and long term even the windscreen) are expected to function as displays for passengers of autonomous vehicles to find information, watch videos or play games.

All these developments – current and future - will require mobile networks to support high throughput data services outside dense urban environments, such as motorways, roads and across rural areas. Currently assigned spectrum is not enough to provide experiences required by future VR/AR/xR (Extended Reality) use cases and mmWave could have an important role to play in support of such use cases.

[3] https://www.ericsson.com/490025/assets/local/reports-papers/further-insights/doc/leveraging-the-potential-of-5g-millimeter-wave.pdf
[4] https://www.qualcomm.com/news/releases/2022/02/fastweb-and-qualcomm-announce-collaboration-commercialize-5g-standalone
[5] https://www.mobileworldlive.com/featured-content/top-three/uscellular-lights-mmwave-5g-fwa-service
[6] https://media.audiusa.com/en-us/releases/513
[7] https://www.audi.com/content/dam/gbp2/experience-audi/mobility-and-trends/digitalization/2019/holoride/holoride-virtual-reality-immersion-video.mp4
[8] https://www.audi.com/en/innovation/development/holoride-virtual-reality-meets-the-real-world.html
[9] https://www.frontiersin.org/articles/10.3389/ffutr.2022.810698/full
[10] https://www.youtube.com/watch?v=0dlia553wVU

Licence arrangements for mmWave should therefore consider future use cases including roads (especially motorways), rail and rural locations (see section 4). mmWave is a strong complement to existing national mobile spectrum licences.

Spectrum bandwidth requirements

Initially the data demand will not be very high, but as adoption and use cases increase demand will grow. Ofcom mentions that early engagement with MNOs suggested a requirement of 400 MHz to 800 MHz per operator.

[✂

[11]

]

[✂

]

Figure 2-1 shows the modelled dependency of the number of small cells in the area on data demand with various minimum available bandwidths per MNO. Assuming a cell range of 100 metres for mmWave coverage in dense area, in one km^2 a minimum of 100 small cells would be needed, assuming the traffic is uniformly distributed. This is still a high number, but for simplicity let's assume this is the minimum required to cover the area. [✂ [12]

]

[11] [✂

]

[12] [✂

]

Figure 2-1: Illustration of number of cells required under certain demand and available bandwidth

[✂

]. Therefore, we partially agree with Ofcom's suggestion that 800 MHz per MNO will be sufficient.

Integrated access and backhaul (IAB)

3GPP has defined IAB as a mechanism for providing in-band or out-of-band backhaul connectivity for cellular base station connectivity. IAB is defined for use with FR1 and FR2[13]. However, it is the mm-wave FR2 bands which offer the greatest opportunities for practical implementation. IAB is designed to support a range of topologies, which will include point to point, point to multipoint and multipoint to multipoint (mesh). This broad range of options offers significant flexibility and may, along with fibre points of presence (PoPs) and D-band[14] radio systems, enable the flexible and cost-effective deployment of small cells to support network densification.

While support for IAB varies considerably between equipment vendors, we are keen to ensure that any future spectrum regulations enable this use case. To facilitate this, it will be necessary to allow above the horizon transmissions in the same manner as that implemented today for point to point links in the 26 GHz and 40 GHz bands.

Wider bandwidths make for more cost-effective deployments

Current equipment supports up to 800 MHz bandwidth at mmWave. [✂

]

Figure 2-2 below shows modelled cost saving with mmWave in capacity provision for a high density area compared to using currently assigned frequencies to deliver additional capacity with conventional small cells.[15]

[✂

]

[13] FR1 and FR2 are terms used in the 3GPP forum for bands below 7.125 GHz and above 24.25 GHz respectively.

[14] D band is the frequency range 110 – 170 GHz.

[15] Modelling has assumed a 20 years period. The area modelled is 1 sq. km dense urban environment as explained earlier. We have assumed that the cost of mmWave is 1/3 of the small cells. We assumed we start seeing mmWave demand from 2025 onwards and deployment is following demand profile i.e., the more mmWave device penetration we have the faster we deploy mmWave small cells.

Figure 2-2: mmWave bandwidth requirements – indicative

Summary of mmWave Use cases

A summary of potential mmWave use cases that we have identified, indicating the timeframe and its likely deployment scenario (i.e. Location specific or Network Wide), is shown in Table 2-1 below.

Table 2-1: Use cases that require mmWave spectrum

Type	Vertical	Use case	Time frame S: 2-3y M: 3-5y L: 5y+	Deployment L: Location specific W: Network Wide	Example of locations
eMBB	Generic	Typical Hotspots scenarios/ including wifi hotspots	S/M	L/W	Typical city hot spot locations e.g., train stations, tourist locations, around entertainment venues etc.. and anywhere else depending on demand
eMBB	Generic	FWA	S/M	W	Locations with no or limited fixed broadband
eMBB	Entertainment	Live events enhanced with AR experience- Stadiums/arenas/venue specific	S/M	L/W	Wembley & Glastonbury
eMBB	Entertainment	VR/AR to mobilise live entertainment view (watch the boxing fight in the car/pub)	S/M	W	Anywhere depending on demand
eMBB	Entertainment/ TV	Media broadcast/Multicast and media delivery eg Uplink link to transmit contents/video footage to cloud and redistribute	S/M	L/W	Wembley, Glastonbury and anywhere depending on demand
eMBB	Tourist/Education /Entertainment	VR for e.g., tourist/education entertainment etc.	S/M	L	Tourist places such as Bath, York, Cambridge / University campuses, Stone Henge and other venues
URLCC/ eMBB	Generic	Cloud gaming	S/M	L/W	Anywhere depending on demand
eMBB	Automotive	Infotainment	S/M	W	Anywhere including main roads depending on demand
eMBB	Generic	SW download	S	W	Everywhere depending on demand
URLLC	Automotive	CAV	M/L	W	Roads
eMBB	Automotive: Bus and Trains	Generic eMBB service support	S/M	L/W	Roads and trains
URLLC	Manufacturing	Robotics and automation	M/L	L	Factories, business & science parks, heavy industry ports, airports
mMTC	Generic	Asset management and supply chain	S/M	L	Affects all industries. Can be implemented anywhere where customers from different verticals want
mMTC	Smart cities	Sensors	S/M	L	Cities
eMBB	Medical	Remote diagnostic	S/M	W/L	Remote areas and hospitals- Depending on demand
mMTC	Generic	Sensors monitoring for utilities, footfall monitoring, security etc…	M	L	Buildings
URLLC	Public safety	Sensors and video footage transmission	L	W	Anywhere depending on demand
URLCC	Drones	Public safety/Deliveries/Monitoring	L	W	In line of sight situations and deployment can be anywhere- subject to demand
eMBB/URLCC	Fronthaul/ backhaul	IAB	L	W	Subject to demand and equipment support
eMBB/ URLLC	Gaming	In the car[16]	S/M/L	W	Roads
eMBB/ URLLC	Gaming	In other automotive – bus trains	M/L	W	Roads / Rail
eMBB/mMTC	Security	Mobile security devices	M/L	W/L	Anywhere depending on demand
eMBB /URLLC	Generic	Metaverse/AR/VR/xR	M/L	W/L	Anywhere, depending on demand Typical mobile application

Question 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)?

Availability of bands and timescales

As explained in response to Question 1, we see demand for mmWave in the near term and potentially sooner than Ofcom may envisage. We have already seen trends for high data use cases that suggest mmWave will be required, but agree that for practical reasons Ofcom should aim to have the authorisation process completed for the 26 GHz band by 2024. This will allow sufficient time for the ecosystem to develop in the European 26 GHz mmWave frequency range and for demand for use cases to mature.

There is a long-term requirement for at least 4 GHz of mmWave spectrum in the UK. Ofcom's approach to authorise both 26 GHz and 40 GHz for mobile at the same time is reasonable - although equipment might not be available in exactly the same timeframe due to differences in the maturity of the ecosystems. As we explain in section 7.3, liberalising 40 GHz for mobile use at the same time as 26 GHz is awarded, will allow the market mechanisms to deliver sufficient spectrum for mobile when it may be required.

3 Ofcom's authorisation proposals

Question 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?

Summary

We support the principle of auctioning rights to use 26 GHz frequencies for mobile. Our preference would be that the full 26 GHz band is awarded on a national basis. We consider that would secure optimal use of spectrum when combined with trading and leasing on commercial terms. Local Access licences from Ofcom would also be an alternative to access awarded spectrum while and where it is not yet used.

If Ofcom sticks to its proposal to manage mmWave spectrum outside of high density areas using its shared spectrum access framework, this must be available rapidly on demand also to holders of auction licences. In the high density areas, sub-national licences should be offered and the area covered by these extended.

Our preference for national licences

We support the principle of auctioning rights to access the 26 GHz frequencies and see this as the most appropriate method of assigning this band for mobile use. We would ideally prefer these frequencies to be awarded as national licences, with the ability to trade and lease the frequencies to others on commercial terms. We consider that would secure efficient and optimal use of this spectrum and is consistent with a market-based approach to spectrum management. This would allow us to provide services that rely on mmWave anywhere our customers want (but not necessarily everywhere, noting in some scenarios other spectrum solutions may be sufficient).

Where we may want to roll out mmWave coverage in the future depends on demand, which is uncertain and liable to change (e.g. in particular businesses move, demographics change), and we need to be able to respond to demand. Further, a range of applications are envisaged which may not all be in the high-density areas that Ofcom has identified, for example sections of roads, rail, airports, entertainment venues, tourist places etc. We want to be able to claim that we launch our services everywhere in UK and for this we need first to secure a licence everywhere a service

could be available. Potential lack of a national licence will limit our ability to market our products. In Table 2-1 we give some examples of use cases that will require a wider deployment area.

National licences would give us the greatest confidence to commit investment in new mmWave technology and applications, knowing that the spectrum would immediately be available where and when demand arises.

The national licensees could take into account existing services deployed in the band, such as fixed links, and it would be for the national licence holder to agree any new such use or to manage early removal of existing use inside any notice period on commercial terms.

Sub-national licences

Whilst our preference is to secure national licences, if Ofcom adopts its proposal to auction spectrum licences that cover pre-defined high-density areas, we advocate sub-national licences that encompass all high-density areas combined (not separate licences for each town/city).

We do not support separate awards for every high-density area as this represents unnecessary and unwanted complexity in the auction and would be incompatible with our requirements to be able to deploy mmWave capability in any location, especially all high traffic areas. Given that Ofcom proposes to keep back 850 MHz for shared access licences and the possibility for sub-national spectrum licensees to trade or share spectrum, or for Ofcom to issue Local Access licences where it is not being used, we do not see the justification for separate award of individual high density areas and downsides in terms of auction winners, potentially holding different bandwidths and frequencies across the UK.

Ofcom has not explicitly stated that the proposed auction licences will contain a provision allowing leasing as well as trading. We assume they would but invite Ofcom to confirm that.

Shared access licences in low density areas (and bottom 850 MHz of 26 GHz in high density areas)

The proposed hybrid authorisation process with auction of spectrum (except lowest 850 MHz of 26 GHz) in high density areas and issuing individual shared access licences in the low density areas, will be complicated for Ofcom. It will be necessary to manage the interference between low- and high density areas as well as between the new users and between new users and existing services. It may also lead to buffer zones where the spectrum can't be used.

We acknowledge that some parties may find it convenient to apply for shared access licences from Ofcom rather than securing a commercial agreement with a national licensee for leasing/trading, or obtaining a Local Access licence[17], to gain access to spectrum that has been auctioned. However, the level of demand for access to mmWave by users other than national MNOs seems unclear, with little demand for the existing 26 GHz indoor licence that has been available for 2 years.

In other lower bands, such as 3.8 - 4.2 GHz, demand for shared access licences has been very modest so far. This is supported by experience in other countries. For example, in Germany some spectrum that had been reserved for verticals is now being accessed by national MNOs. It is not clear to us that the benefits of the shared access licensing arrangements outweigh the benefits that would arise if the spectrum were instead assigned on a national basis and made available to others via market mechanisms.

In low-density areas, the holders of auction licences must also be given access to the spectrum if the same services are to be available from these licensees at locations outside of high density

[17] Ofcom issues "Local Access licences" in bands assigned nationally to MNOs where in a particular location a portion of the assigned spectrum is not yet in use by the MNO and there are no plans for the MNO to use it within 3 years. After 3 years (or the period agreed) the licence might be extended for a further period.

areas. It would be important that licences for low density areas can be obtained simply and rapidly and with the same technical conditions as high density when required so that spectrum availability is not a barrier to network deployment.

Question 4: 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))?

Summary

Concerning the bottom 850 MHz of the 26 GHz band in high traffic density areas, we consider it more likely to secure optimal use of spectrum if Ofcom includes it in the auction, rather than limiting it to low power shared access licences managed by Ofcom.

Frequencies to be included in auction licences

Excluding the bottom 850 MHz of the 26 GHz band from the auction of spectrum in high density areas, to facilitate access by parties who do not win auction licences, will affect the auction outcome: it is likely to lead to higher prices and/or smaller per operator assignments, which in turn may affect the extent to which the mmWave technology is deployed and the benefits to consumers. With 2400 MHz available and 4 national MNOs, this averages 600 MHz per operator if all 4 national MNOs win spectrum. With 3250 MHz available, all 4 MNOs could secure an average of 800 MHz each. Whilst there are benefits of keeping some shared spectrum available for other users in the high density areas, there is a risk is that it will not be used, or will be lightly used, in which case it would be more efficient to include it in the auction. We note that the 26 GHz indoor licences that Ofcom makes available today, have not been taken up to date.

The fact that winners of the auction spectrum could also seek access to the shared spectrum managed by Ofcom mitigates this to some extent, however the shared licences are proposed to be restricted to low power.

Whilst there are certain constraints due to sharing with satellites in the bottom portion of the 26 GHz band, they would still be suitable for auctioning (perhaps as a specific lot category).

We propose that all of the 26 GHz band frequencies should be made available in the auction in the high-density areas.

We also note that 60GHz is available for low power licence-exempt applications if there is demand for low power shared spectrum use.

Question 5: 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)?

As explained in Question 3 above, we prefer a national licence.

However, if Ofcom does not auction national licences, then we agree with the authorisation approach it proposes in low density areas.

Question 6: 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?

If 40 GHz licences are revoked, and Ofcom does not award the spectrum as national licences, then a similar approach to that used in the 26 GHz band could be appropriate.

4 Definition of high density areas

4.1 Limitations of the present proposal

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

Summary

We have several concerns with Ofcom's methodology for identifying and defining high density areas.

We are concerned that the methodology used, together with the cut-off used for the number of town/cities to be included, does not align sufficiently with the places where we are most likely to deploy mmWave technology in the future. There are a number of deficiencies that we believe Ofcom should address before it concludes on the definition of the areas to be included in auction licences.

Below is a summary of our concerns supported with our analysis shown in Annex A: Additional places for inclusion with auction licences; and Annex B (Example high traffic areas not included in Ofcom's top 40 and 80 areas).

Missing important locations

Some important locations are not included in the 40 (and 80) high density areas, for example large UK airports, locations with seasonal traffic, roads etc. This may be a consequence of the methodology being weighted more towards dense areas based on population than areas based on data traffic. Although the Top 80 list includes more of such venues, there are, for example, still 13 airports excluded and 57 sporting venues. Please see Table 4-1 below for a summary of venue coverage.

Table 4-1: Analysis of venue coverage of the proposed High Density areas

SECTOR	Total UK Venue Count	Top 20 Covered Count	Top 20 Covered %	Top 40 Covered Count	Top 40 Covered %	Top 80 Covered Count	Top 80 Covered %
EXHIBITION_CENTRE	48	33	69%	40	83%	43	90%
SHOPPING_CENTRE	42	28	67%	32	76%	37	88%
AIRPORT	27	12	44%	14	52%	14	52%
UNIVERSITY_CAMPUS	223	95	43%	121	54%	167	75%
SPORTING_VENUE	186	78	42%	103	55%	129	69%
BUSINESS_PARK	221	71	32%	87	39%	112	51%

Missing existing high data traffic demand areas

A further analysis shows that a significant proportion of high traffic demand sites is excluded from the top 40 and top 80 areas. We analysed the top 2000 busiest sites, ranked based on the busiest hour traffic demand during March 2022. Those sites carry 34% of the total Network traffic. Table 4-2 below shows how many sites from those 2000 are included in the top 20/40/80 areas Ofcom identifies. Even the top 80 group does not cover all busy sites in the network.

Table 4-2: Analysis of our top 2000 busiest base station sites

Top 2000 sites based on Busy hour traffic demand	Top 20 Covered sites Count	Sites % included in top 20	Top 40 Covered sites Count	Sites % included in top 40	Top 80 Covered sites Count	Sites % included in top 80
0-2000[18]	1232	62%	1371	69%	1533	77%

This diversion between our and Ofcom's analysis is primarily because Ofcom's methodology puts most weight on the population density. Our analysis shows that areas with high traffic demand, such as historical town centres, airports, tourist places, are not included in Ofcom's top 20/40/80 areas (see examples in Annex B). This will create several material challenges for MNOs aiming to launch services in those locations as discussed below.

Both the irregularity in borders and the weighting primarily on population density result in excluding some important areas with high traffic demand from Ofcom's top high density areas.

Busiest sites not always correlated with highest population density

The busiest sites in the network are in some cases not correlated with areas of highest population density. As an example, Gloucester (bottom left of the charts) is in the top 40 areas (see right hand chart), Cheltenham (top right area of charts) is busier than Gloucester (see left hand chart) but is not included in the Ofcom's high density area categorisation (right hand chart).

[✂

]

Figure 4-1 : Cheltenham & Gloucester

Our analysis shows that the top 40 areas does not include many sites within our top 2000 busiest sites. For example, Figure 4-2 below shows some of the busiest sites (shown as orange/purple dots in the left chart) in Middlesbrough in the Teeside area which are not included in Ofcom's top 40 high density areas but are amongst the sites included in the top 80 (shown as Green on the right chart). However, there are few of these sites not included in the top 80 either (shown as Blue). We have observed similar results for a number of locations such as historical towns (e.g., York, Oxford, Cambridge and Bath).

[18] Top 2000 sites ranked based on busy hour demand during March 2022. The top 2000 carries 34% of the total traffic in the network.

[✂

]

Figure 4-2: Teesside Top 80- site locations

Locations with busy sites outside Ofcom's top 80 high density areas

We have identified a number of locations where we have top 2000 busiest sites but these are not captured in Ofcom's top 40/80 locations. For example, Figure 4-3 below shows many of our busiest base stations being around Milton Keynes and Bedford, but Milton Keynes is only in Ofcom's top 80 areas and Bedford is not in the top 80 areas.

[✂

]

Figure 4-3: Milton Keynes & Bedford

Other similar examples are South Wales valleys, Torquay and Paignton, Burton and Swadlincote, Edinburgh Airport, Aberdeen Airport, Gatwick airport.

Complexity in border definition for the top 20/40/80 areas

Ofcom's methodology to select the top 20/40/80 sites results in a complicated map, and very complicated operational challenges in managing interference in the border area.

For example, the map below shows the parts of Leeds/Bradford area that are included in the top 40 and top 80 high density areas. The blue shapes are the areas where Ofcom considers the high density mmWave licence will be applicable, whilst the areas outside are those where Ofcom envisages the "shared access" licence regime is envisaged to apply. However, the borders are very irregular and it will be challenging for both MNOs and Ofcom to ensure interference mitigation in the border area. This may lead to less efficient use of spectrum than if the "gaps" between these clustered high density areas had just been assigned as part of a single larger high density area.

Combining the cluster of high density areas to be part of a larger contiguous and regular shaped area would avoid wasted buffer zones around the irregular high density areas, where shared

access licences could not be possible because of the need to protect any existing or future deployments in the blue high density areas.

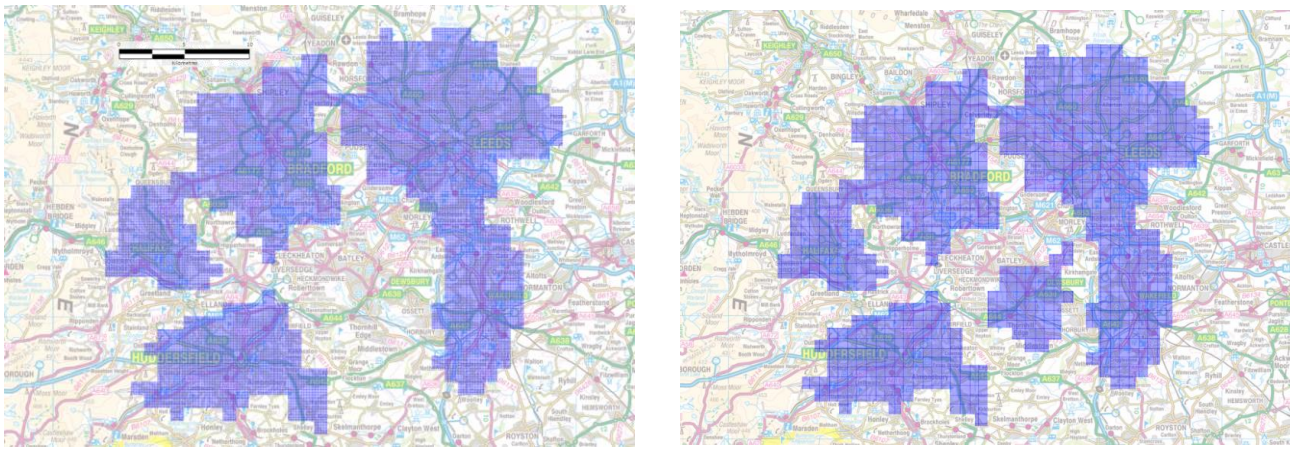


Figure 4-4: Leeds/Bradford area, Top 40 areas (left) Top 80 areas (right)

4.2 Potential solutions for definition of auction areas

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

Summary

We do not agree with the cut-off point of 40 high density areas as explained based on the results of analysis we have undertaken to look at what proportion of certain types of venues are covered by Ofcom's high density areas. We have several recommendations to improve the methodology if full national licences are not awarded.

In summary, if Ofcom proceeds with auctioning high density areas, then our recommendation is to:

- Group the high density areas (top 80) in clusters contained within larger regular areas or parallelogram shapes to reduce complexity, improve spectrum efficiency and include more high traffic areas.
- Include additional high density locations with high traffic: airports, historical towns, stadiums, main roads (M and A roads in UK) and train stations, University campuses, Business Parks. All these as per the detailed list provided in Annex A.
- Allocate sub-national licences (all the high density areas combined together as a single auction lot) to ensure MNOs can deliver services to customers across all areas they operate. This is to (a) avoid inconsistent messages related to service delivery and support; (b) support investment at scale based on demand in mmWave infrastructure; (c) ensure ability to deliver services anywhere customers require where it is commercially viable and (d) allow market mechanisms to enable smaller players to access spectrum if licence is owned by MNO.

Methods to improve the defined high density areas

We suggest the methodology should be weighted more to high traffic areas; a larger number of high density areas than 40 should be the starting point; and a larger resolution than 1km should be used for the boundary of high density areas, so closely spaced high density areas instead form one larger area (reducing the number of distinct licence areas). Specific details follow below.

Top 80 or a larger groups

Our analysis has shown that a significant number of venues and high demand areas are excluded from the top 40 and even top 80 areas. We therefore suggest to have larger number of high density areas or, if Ofcom prefers to stay with the definition of 20/40/80, we recommend to use at least the top 80 as a starting point with some modifications as set out below.

Regular borders

As explained earlier, the proposed borders are currently irregular and would create several operational complexities. We suggest making the borders a more regular shape, for example, regular square of sufficient size to embrace all high density areas in a cluster. An example of a rectangular (shown as yellow) for Leeds/Bradford area in the top 80 is shown below.

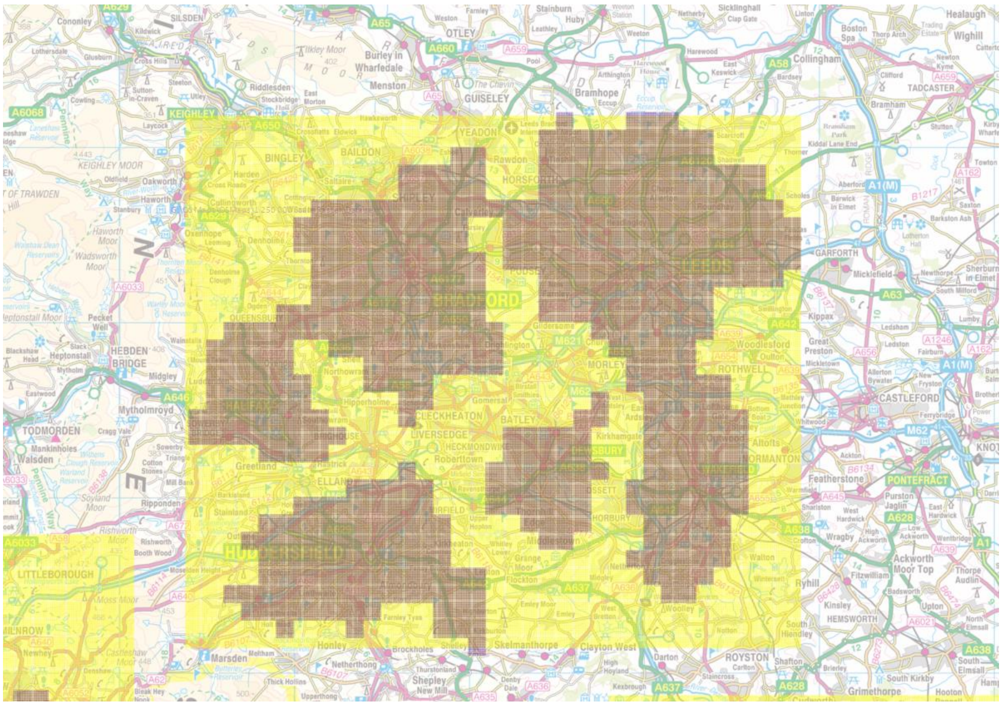


Figure 4-5: Suggested methodology approach

The minimum distance between high density areas before they are brought together as part of one cluster could consider the minimum separation distance that Ofcom will allow when coordinating deployments outside the high density areas to protect any existing or future permitted use in those high density areas, according to the rights under the high density area licenses.

Using this approach the top 80 map will be as in the following figure (reduced to *c.* 48 distinct rectangular areas that could be aggregated into one sub-national licence).

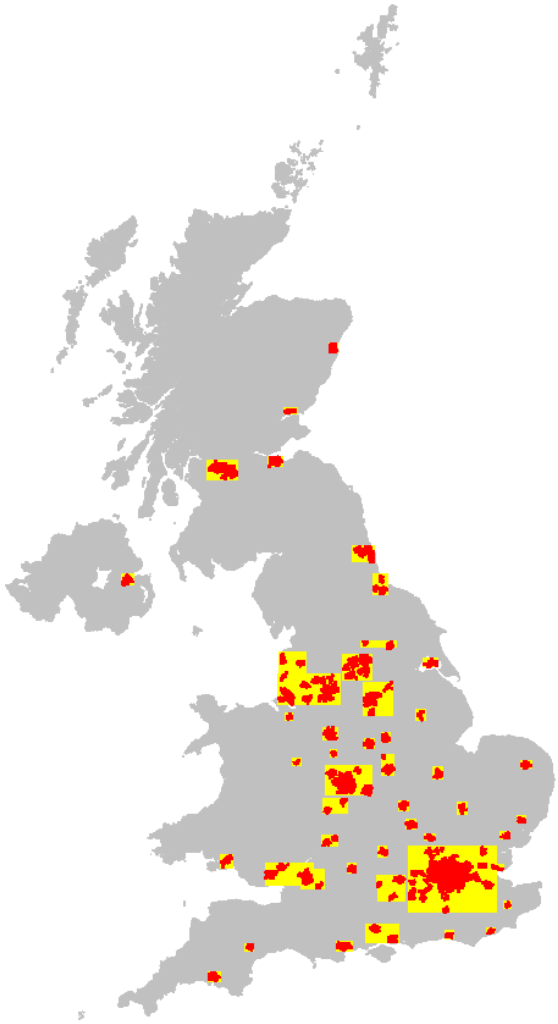


Figure 4-6: Top 80 using regular boarders (Yellow: BT proposal; Red: Current Ofcom top 80 areas)

BT's above proposal will capture a much larger proportion of important venues compared to Ofcom's top 40 proposal as shown in Table 4-3 below.

Table 4-3: Increased venue coverage with BT's proposal

		Ofcom Top 80 dense area coverage		BT proposal - top 80 squared areas	
SECTOR	Total UK Venue Count	Top 80 Covered Count	Top 80 Covered %	BT proposal Covered Count	BT proposal Covered Count
EXHIBITION_CENTRE	48	43	90%	44	92%
SHOPPING_CENTRE	42	37	88%	39	93%
AIRPORT	27	14	52%	21	78%
UNIVERSITY_CAMPUS	223	167	75%	180	81%
SPORTING_VENUE	186	129	69%	138	74%
BUSINESS_PARK	221	112	51%	134	61%

Weight towards traffic

We recommend higher weight towards traffic, including seasonal traffic and inclusion of locations such as historical towns (e.g., York, Oxford, Cambridge and Bath) and tourist locations (e,g., Torquay and Paignton, South Wales). If such locations are not captured in the larger 80 high density areas and the coarser rectangular squares that would aggregate clusters together, then a larger number than 80 high density areas should be considered.

Include additional key venues and locations

As mentioned in previous analysis, there are some large and important airports excluded from the top 40 and top 80 high density areas, such as Gatwick , Aberdeen and Edinburgh, and many venues that could be candidate places for mmWave such as business parks, Universities, and sports stadiums,– see detailed list in Annex A.

We recommend that Ofcom licenses 26 GHz on a national basis and if not combines all high density areas into a single subnational licence and adds to it additional high traffic locations.

Shared licences outside auction areas

There are additional places where our customers may benefit from mmWave:

- Enterprises that require specific use cases where mmWave is the best available option to deliver reliable service in all of their premises, that are scattered across the UK, in multiple localised outdoor and indoor environments, for example, industrial customers, logistics and councils (e.g., deploying CAV (Connected and Autonomous Vehicles)).
- Consumers will want access to services that require mmWave outside the defined high density areas and it will be more difficult to provide and market a service where there is uncertainty of rapid access to spectrum in locations were mmWave deployment may be commercially viable.
- Major road and rail routes are also of interest as places where the traffic density may not be highest today but could be important areas for mmWave coverage in the future to support some of the use cases listed earlier.

It is preferable to include as many high traffic locations as possible in the auction licence and if it is not a national licence then the shared access licences from Ofcom would need to be issued very rapidly on demand and cater for bulk requirements, such as along a major road or rail route.

5 Sharing with 26 GHz fixed links

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

Summary

We agree that 26 GHz licences should be revoked where these conflict with higher value mobile use. The use of the band for 5G has been long anticipated and market mechanisms alone may not be suitable to facilitate change to mobile use due to the nature of the existing licenced use. Ofcom should consider grants to facilitate early migration of existing links to achieve most efficient use of the spectrum

Clearing 26 GHz fixed links from high density areas

As Ofcom has illustrated, the 26 GHz fixed links have been steadily declining in number for several years. Ofcom has given many years' notice of the migration of the band to 5G and new assignments have not been made for some time. Other bands are available that could accommodate these fixed link requirements.

We agree the fixed links should be cleared around high density areas as they would be incompatible with use of mobile over a large proportion of these areas due to interference risks. We agree that outside of these areas the existing links could remain, but no new links should be introduced, given the likely lower and less certain level and timing of demand for mobile.

Revocation of 26 GHz licences

We consider that in the specific situation of the 26 GHz band, revocation of existing fixed links licences in/near urban areas is justified on spectrum management grounds. This is due to: (i) the large benefits that mobile will deliver compared to the benefits of existing use (these benefits are likely to be delivered significantly sooner than is the case for the 40GHz band); and (ii) existing benefits can be delivered using other spectrum bands at a far lower additional cost than the revenue that an auction is likely to generate. The fact that the band has been closed to new licences, and Ofcom has warned for many years that mobile is to be introduced, are important distinguishing factors compared to the situation of the 40 GHz band.

A further important difference is that at 26 GHz it is not feasible to use the market mechanism of trading/leasing to enable introduction of higher value mobile use. The 26 GHz fixed links licences are point to point transmission rights between two specific sites, rather than a spectrum access licence covering an area.

Grants to encourage earlier clearance of 26 GHz fixed links

Removing the links sooner than 5 years' notice is likely to generate additional benefits from earlier mobile use. Ofcom should consider exercising its discretion to provide grants to licensees to compensate for the costs, if links are removed sooner than 5 years' notice, via grants for spectrum efficiency as is provided for under the WT Act[19].

The revenue from the auction would be higher if there was prospect of earlier unencumbered access to the 26 GHz band for mobile as the value of the spectrum to winners would be increased. If that forecast higher auction revenue exceeds the grants that may be issued to encourage earlier clearance of the links, it would be illogical for HM Treasury not to consent to a request from Ofcom to make grants available for earlier cancellation of 26 GHz fixed links licences than the 5 years' notice period.

Question 10: Do you agree with our estimates of the cost of migrating fixed links into alternative spectrum bands?

Costs of clearing 26 GHz links

The projected costs of c. £1m to clear the 26 GHz fixed links from high density areas seems, based on our initial assessment, is too low. We understand from Annex 8 of the Consultation Document that this is an estimate of the additional capex costs of replacing some equipment sooner than its expected lifetime (i.e. if its lifetime extends beyond the 5 years notice period) and moving it to an equivalent spectrum band. It assumes that other equipment is moved to another band at the end of its lifetime with no additional costs. Ofcom's assumptions about equipment lifetimes relative to the 5-year period, costs of new equipment and other factors will no doubt vary amongst the licensees.

In the case of BT/EE we are concerned that in some cases 26 GHz was used because other bands were not available at the location and hence finding replacement fixed link frequencies may not be straightforward. In practice, even where a new band is available, the swap will cause service

[19] Wireless Telegraphy Act 2006 section 1(5)

disruptions as each link swap will take about one week[20] to remove an old link, replace equipment and re-pan the antenna. Given the density of links and the fact that in some locations fibre is not available in the area this could trigger financial penalties in service contracts.

One significant cost that Ofcom may have overlooked is the additional manpower effort that will be required to plan for and manage a process of decommissioning the 26 GHz fixed links and moving to a new band. The migration of links will require additional manpower effort in areas such as procurement, programme/project management, legal/regulatory, network planning and so forth[21]. Aggregated across the 12 affected 26 GHz licensees, these manpower costs alone could significantly exceed the c. £1m total cost that Ofcom has estimated for clearing the links. If Ofcom proceeds with clearing 26 GHz links, it should allow more time for affected parties to assess related costs and consider the case for compensation considering those costs.

6 Sharing with other users in 26 GHz

Question 11: 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?

Yes, BT supports Ofcom's proposed approaches to handling co-existence between 5G users and the different existing users in the 26 GHz band as set out in the Consultation Document.

7 Enabling optimal use of 40 GHz

7.1 Current use of the 40 GHz band

The current 40 GHz band assignments[22] are illustrated in the Figure 7-1 below. From the Consultation Document, it appears two thirds of the band (assigned to H3G) is presently lightly used, one sixth (assigned to MLL) is unused and one sixth (assigned to MBNL) is intensively used. So, the efficiency of present use varies considerably across the band.

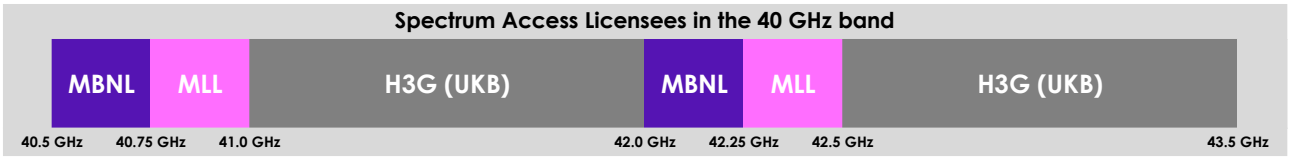


Figure 7-1: Current 40 GHz band assignments

MBNL, the joint venture between H3G and EE, has over 4,000 links deployed in its 2 x 250 MHz assignment. These links are used for mobile base station backhaul.

If Ofcom were to give 5 years' notice of revocation of these licences, then the current licensees would, during that period, still be entitled to continue to deploy new links in the band in any

[20] This does not include new equipment order lead time and planning process.

[21] The internal BT team that deals with microwave link planning estimates that the additional engineering cost alone of changing each fixed link could be approximately 4x FTE for a week, plus to prevent possible delays an additional 2 days of FTE engineering effort to preconfigure and arrange transport of equipment for each replacement fixed link. These costs are on top of the costs of replacing equipment that would otherwise continue in use for a number of years and the other professional services costs mentioned above.

[22] In the consultation document the illustration of the assignments in the 40 GHz band (figure 7.1) is not drawn to a consistent scale and so the relevant proportion of the intensively used spectrum by MBNL relative to the very lightly used spectrum by H3G and the unused spectrum held by MLL is to an extent distorted.

location. This would represent uncertainty for both the new winners of the auctioned licences in high density areas and the existing licensees. In effect, for 5 years Ofcom would be simultaneously licensing the same spectrum usage rights to two parties.

Ofcom may charge annual fees for existing 40 GHz licences from February 2023. It says it intends to consult on these after it has decided on the future of these licences. We don't see a justification to charge any more than Ofcom's administrative costs, which should be low given the band is managed by the licensees. ALFs are not necessary to secure efficient use of this tradable and leasable spectrum and could be a barrier to spectrum trading and investment or more efficient use.

7.2 Revocation vs liberalisation of 40 GHz licences

Revocation of licences on spectrum management grounds

We were surprised by the proposal to revoke these licences on spectrum management grounds. We can find no precedent for doing so for spectrum that was assigned by auction, nor any explanation of what exactly is meant by the term "spectrum management grounds".

We can see only two reasons why Ofcom might consider a licence revocation on "spectrum management grounds":

- Tradable spectrum isn't traded, despite it being valued more highly by another licensee, because there are strategic reasons why incumbents don't want to sell it (e.g. because if someone else had it even if they valued it more highly it would detract from other valuable objectives the seller has); and/or
- the spectrum in its existing use generates less economic benefits to the existing licensee than in an alternative use, e.g., because the existing licensee cannot or will not change its use for some reason).

We don't think either apply at present, although as Ofcom recognises (and we agree) the 40GHz band will in due course be valuable and needed for mobile use and should therefore be authorised for it.

Market based principles could secure optimal use of 40 GHz band

The existing 40 GHz licences are both tradable and leasable. If the principles of technology and service neutrality are applied and the licence conditions are liberalised to allow mobile use, and excessive and unnecessary annual licence fees are avoided, then market mechanisms could determine the appropriate use and users of this spectrum. Such an approach would avoid many of the complications associated with licence revocation. However, given the asymmetry of current 40 GHz spectrum holdings, competition concerns would need to be addressed in the design of the 26 GHz band auction.

Potential Grounds for revoking 40 GHz licences

We would welcome additional evidence from Ofcom to support the conclusion that licence revocation would be an appropriate solution. Presently, and noting the two possible reasons for revocation above, we don't see how it could be justified for Ofcom to revoke a previously auctioned licence, or for that matter on the basis of revoking an efficiently used licence on the basis that it might prevent more efficient use of the band as a whole. Other options Ofcom have include liberalising all licences, so they can be used for mobile, or revoking all of them and ensuring that users are compensated at opportunity cost. There seem to be no other options consistent with efficient spectrum management and market mechanisms. For those licences that are currently efficiently used, compensation is particularly important in this context as opportunity cost of losing current use is higher than for those not efficiently used.

Compensation for additional costs to existing 40GHz licensees

It would seem to us that the appropriate course for Ofcom to take in the current situation, if Ofcom were to revoke the licences, would be to use its discretion to make use of the provisions in the Wireless Telegraphy Act relating to making grants for spectrum efficiency and spectrum management purposes[23]. Such a grant could cover the costs of clearing existing links, perhaps some of them sooner than the 5 years' notice and on condition of stopping new deployments in the band.

We note that in the past, grants have been made to displaced PMSE users. Also, where mobile was seen to represent a higher value use than broadcasting, the costs of clearing the 800 MHz (and later 700MHz) bands were paid for by Government[24, 25].

Other structured options for compensation for removing existing fixed links could also be envisaged, such as an "auction winners fund". Such a fund would entail all auction participants to committing to contributing to a "clearance fund" should they win an encumbered lot, and equally existing licence holders would need to agree (prior to the auction) to accepting to sell at that pre-agreed price list.

The price list would need to be firmly set before the auction, depending on how the winners of a particular encumbered lot would need to pay to obtain unencumbered spectrum after 5, 4, 3, 2, or 1 year(s), respectively. The price would be set at a level reflecting the opportunity cost of clearing the spectrum at that point in time.

The advantage of such a fund would be that it would facilitate an efficient auction (because all bidders would be able to factor the cost of obtaining unencumbered spectrum into their bids), while incumbent users of the 40GHz band could obtain compensation at opportunity cost. It would also minimise aggregation risk, because the entire band could be auctioned in one lot category reducing complexity. We note the precondition for such a fund to produce the intended benefits would be that all incumbent users of the 40GHz band would need to legally commit to trade their rights to the winners of the lots under the conditions (price list and timings for clearance) agreed upfront (including any penalties for delay etc).

We consider that licence revocation, especially without compensation and where it is efficiently used, undermines the potential for spectrum trading, which is a right contained within the existing licences. More generally, it sends a signal to the market that Ofcom is potentially moving away from its established market-based spectrum management principles recently confirmed in Ofcom's Spectrum strategy Statement[26].

7.3 BT's view on Ofcom's options for the 40 GHz band

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

Summary

We agree that the 40 GHz band should be made available for mobile in 2024, at the same time as the 26 GHz band, although in practice they may not be used in the same timeframe (due to the less mature ecosystem and MBNL's existing use of part of the 40 GHz band.

[23] Wireless Telegraphy Act 2006 section 1(5)

[24] In relation to TV spectrum clearance see https://commonslibrary.parliament.uk/research-briefings/cdp-2016-0211/

[25] In relation to funding PMSE clearance see https://www.ofcom.org.uk/__data/assets/pdf_file/0022/118831/PMSE-700-MHz-statement-and-consultation.pdf

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

Liberalising the 40 GHz licences to allow migration to mobile according to market demand, and reliance on market mechanisms of trading and leasing, with a safeguard cap on total mmWave holdings in the 26GHz auction (dependent on total mmWave holdings), is the best route to securing optimal and efficient use of 40 GHz mmWave spectrum.

Forcing a premature migration to mobile by licence revocation where spectrum is efficiently used (e.g. MBNL's use of fixed links) undermines market-based spectrum management principles. If Ofcom believes a revocation would secure more optimal use of the 40 GHz band, a grant for spectrum efficiency is justified.

We set out our more detailed views with comments on each of Ofcom's four options below.

Option 1 (Liberalise all 40 GHz licences)

BT could support this option on the condition that an appropriate cap on H3G's ability to acquire 26 GHz spectrum is included in that auction.

This option would be most consistent with the market-based spectrum management regime that Ofcom has operated over the past two decades. It would enable industry to determine the best use of the spectrum and the timing of any changes to the use of the 40 GHz spectrum. The trading and leasing provisions in the licences would provide a means to enable changes in the ownership of assignments or who can access different portions of the band in given areas (providing Ofcom does not impose inappropriate annual fees that are not set conservatively and could impede trading).

Under this option the existing licence conditions would need to be updated to also enable mobile use.

A further benefit of this option is that the licences are national and so would allow the existing licensees to deploy mobile mmWave anywhere. This contrasts with other options for 40 GHz and the proposal for the 26 GHz band, where the auctioned rights are proposed to be limited only to defined "high density" areas of the UK.

Competition measures for 26 GHz award

Please refer to section 11 of this response for our views on the necessary competition measures for the 26 GHz award if Ofcom were to implement Option 1.

Existing 40 GHz licences are national whereas the proposed 26 GHz band auction licences are only sub-national. This is a relevant factor to be weighed when setting the necessary competition measures in relation to the 26 GHz auction under the 40 GHz Option 1 scenario.

Option 2 (revoke all 40GHz licences).

This is not BT's preferred option. Given the significant and efficient use of the band by MBNL today, we are concerned that revocation of the MBNL licence would not be a proportionate measure or a fair measure given that MBNL would encounter substantial additional costs whereas other existing licensees would not. In the circumstances we believe Ofcom should consider exercising its discretion to provide a grant to MBNL to cover the costs of clearing the band from its present highly efficient and optimal use. We address the additional costs that MBNL might encounter in section 7.4 below.

BT's estimate of the costs of revoking existing link licences are higher than Ofcom's baseline figure of c. £4m. Even if they were c.£4m, there is no reason not to compensate for them. We suggest it would be relevant to:

- Firstly look at whether removing the links with 5 years' notice generates greater benefits (net of costs) than leaving current use or removing them at some later point in time. This would help assess whether revocation on spectrum management grounds could be justified at all.
- Secondly, if there is a clear benefit of revoking the licence, consider compensating the affected parties given that the benefits will accrue to others whereas the costs will not. This is particularly relevant where one party (MBNL) faces substantial costs of clearance that BT understands may not be faced by others.
- Consider the benefits that would arise if the removal of the links were compensated for via a grant compared to if they were not. For example, if a grant would enable earlier clearance of the fixed links than would otherwise be the case, the benefits that this would unlock in terms of earlier unencumbered access to the spectrum for mobile, potentially reflected in higher auction prices, should also be considered to determine whether a grant would be appropriate (and the level of such grant).

To revoke an efficiently used licence without receiving a grant to compensate and incentivise clearance would surely undermine confidence in the market-based spectrum management regime in the UK, including spectrum trading as the value of efficiently used spectrum assets becomes uncertain. This could discourage investment and competition.

We question what evidence Ofcom has as to the extent of demand to use 40 GHz for mobile (although agree it should be allowed by liberalising the licence terms). Although this consultation may provide some relevant evidence of future demand, the fact that much of the spectrum is presently unused and none of it has changed hands via trading (or to our knowledge has been leased) suggests that demand to access it by parties that do not hold a licence is low or non-existent at present. It is not clear to us why revoking the existing licences and re-auctioning the band in high density areas and managing shared access to it by Ofcom elsewhere, would promote more optimal and efficient use of spectrum than leaving it as it assigned at present and liberalising it to allow mobile use in the timescale licensees may require.

Even with 5 years' notice of revocation, the existing licensees could newly deploy in the spectrum, under their existing licence, in the high density areas after the auction and before the end of the 5 years notice period. Ofcom would need to specify how such use would be coordinated and, in the event of conflicting requirements and rights to deploy, how the matter would be resolved.

Option 3 (revoke H3G and MLL licences, MBNL licence unchanged[27])

BT does not favour this option. It would result in MBNL having different rights to those of the auction winners, as the MBNL licence would not be liberalised to allow an option for future mobile use and would require future Ofcom agreement to vary the licence for mobile.

It is unclear on what basis Ofcom would set the annual fees for the MBNL licence under this option. For example, if based on opportunity cost Ofcom might argue for a fee based on auction prices even though the licence, unless liberalised, would only allow fixed links use.

This option would leave a degree of fragmentation due to the retained MBNL licence and the auction of other remaining 40 GHz spectrum. That remaining spectrum would comprise two separated blocks of 1250 MHz, each of which does not neatly divide into 200MHz lots without leaving or awarding an odd 50MHz of each block.

[27] Footnote 194 of the consultation document states "under this option, we would not vary MBNL's licence"

Option 4 (revoke half and liberalise half of MLL and H3G licences, MBNL licence unchanged[28])

BT does not support this option. It raises similar issues to Option 3 in terms of the limitation to future use of the MBNL licence for mobile, and more so given 50% of the H3G and MLL licences would be liberalised for mobile use whereas MBNL's licence would not. Although some differential in annual fees for the liberalised retained spectrum of H3G and MLL relative to the retained existing spectrum licence of MBNL could address this issue, we regard this option as sub-optimal. This option would release 1250 MHz of spectrum, again with an odd 50 MHz, that is contiguous and would support at least one additional MNO in addition to H3G that would retain 1 GHz of existing spectrum. However, given the low use or lack of any use of the H3G and MLL spectrum respectively, it is unclear what the advantage is of Option 4 over Option 3.

7.4 Costs of clearing 40GHz fixed links

Question 13: 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)?

Summary

The total costs of clearing 40 GHz links from in and around the high density areas are much greater than the estimate of c. £4m that Ofcom has assumed. This is firstly because the cost to prematurely replace each link, when taking into account all relevant costs, is much greater than just the remaining depreciation of the cost of the equipment. Secondly, many of the links would in the absence of licence revocation have continued to be operated well beyond the period that the asset is nominally depreciated over for accounting purposes and licence revocation therefore results in additional costs that would otherwise not be encountered.

On the other hand, many of the existing 40 GHz links would anyway potentially be replaced by fibre within the 5 year revocation period, or would need to have a capacity upgrade in the same band or move to another band, therefore reducing or eliminating some of the costs of revocation that need to be considered.

Our internal analysis of the total additional costs to prematurely clear those links that would not otherwise have been replaced/upgraded is up to[29] [✂] with 40 high density areas to be avoided and assuming a 25km buffer zone is required around each. For a higher number of high density areas (for example, 80 areas rather than 40 areas) and if required buffer zones are greater than the 25km we have assumed, the cost will be higher – potentially approaching the estimate of [✂] cost if every link had to be removed.

If Ofcom does revoke the 40 GHz MBNL licence, then we believe that Ofcom should use its discretion to (subject to required HM Treasury approval) compensate MBNL with a grant for spectrum efficiency. Furthermore, in view of the additional benefits if the links could be cleared in a shorter timescale than 5 years, the grant should be structured to encourage accelerated clearance of the band and commitment not to deploy more links in the revocation notice period.

[28] Footnote 196 of the consultation document states "Under this option, we would be unlikely to revoke MBNL's licence or vary it".

[29] Our calculations only considered EE's unilateral capacity requirements (i.e. BT/EE only, rather than BT/EE + Three) when determining how many links would have anyway been upgraded, whereas in practice MBNL might be more likely to upgrade a larger number of links to meet combined capacity requirements (i.e. BT/EE + Three) which would result in a lower estimated lower cost of revocation.

We also note that other options to compensate for the costs of removing links might be considered as part of the auction process.

Ofcom's baseline under-estimates the costs of clearing the existing 40 GHz links

BT is not itself a 40 GHz licensee, but we would be directly impacted by Ofcom's decision on the future arrangements for 40 GHz in view of our stake in MBNL. We are therefore interested to understand the additional costs of prematurely having to replace a large proportion of the existing c. 4000 MBNL 40 GHz fixed links that are used for backhaul (if Ofcom were to go down the path of revoking the current licence rather than liberating it to provide a future option to use it also for mobile).

We have examined Ofcom's cost modelling for determining the incremental costs faced by MBNL if the existing fixed links in, or near, high density areas had to be moved within 5 years to another frequency band, as set out in Annex 8 of the Consultation Document. We have considered the key assumptions that underpin Ofcom's analysis and made enquiries of MBNL. Some important points have emerged. We summarise these points in the Table 7-1 below.

Table 7-1: Key assumptions for determining cost of revoking MBNL's 40 GHz licence

Factor used in cost model	Ofcom's assumption	BT's comments	Impact
Capex of replacing a fixed link	£7k + 50% for install	We estimate the total costs to replace each 40GHz link would be £15k.	Increases the costs compared to Ofcom's assumption.
Usual operating lifespan of new links before routine replacement	7 years	Typically, many 40 GHz links will have an operating lifespan far in excess of 7 years, some up to 15-20 years.	Increases the costs compared to Ofcom's baseline assumption.
Distribution of link lifespan before scheduled replacement	Uniform distribution over 7 years.	Links were mostly deployed all around the same time when MBNL backhaul networks moved to a hub rather than mesh-based architecture. The mode of the distribution of link ages is 8 years.	Reduces the costs as a smaller proportion of links would have remaining asset value at the 5 year revocation point.
Extra manpower costs of managing the migration of 40GHz links to another band	Not included	These costs are significant and included in our assumed £15k per link cost above.	Increases to costs compared to Ofcom's assumptions
Counter-factual replacement policy assumption	Like for like fixed link replacement every 7 years	Replacement links may be at higher capacity in other bands (e/g/ E-band, 32GHz or fibre.	Lowers the costs compared to Ofcom's assumptions

As indicated in the table, the impact of using BT's assumptions for the various key factors in the modelling will in some cases increase the projected costs and in other cases reduce them, and it is the net effect of the revised assumptions that will be important to understand. We have therefore prepared our own cost estimates to understand the net impact of these factors when applied to the existing 40GHz band links and our expectations of how our use would change in the counterfactual scenario of the licence not being revoked.

BT's estimate of the additional costs of clearing the 40GHz links with 5 years' notice relative to the counter factual of the 40GHz band remaining available

Overview of BT/EE's mobile backhaul strategy

[✂

]

Impact of MBNL 40GHz licence revocation from BT's perspective

The proposed changes to the 40GHz band will have a significant impact on our current strategy and while we are supportive of the longer-term approach to this band – and agree with the need for more millimetre wave spectrum for 5G NR – we will be significantly impacted by any formal band clearance notification. Microwave radio systems are written down over an 8 year period however in many cases, the link will be suitable for the demand and therefore the operational life will be extended, in some cases the links would be operational for 15 years. [✂

].

Methodology to estimate financial impact of revocation of MBNL 40GHz licence

To understand the commercial implications of Ofcom's proposal we have analysed the 40 GHz installed base and planned upgrades to confirm the number of links which would need to be replaced with equivalent capabilities in other bands. The implementation of such a plan will incur costs to facilitate; network planning activities, site acquisition activities as new links will, in many cases, need to be installed in parallel in the first instance to minimise service outages on EE's customers, including the Emergency Services Network. New equipment will need to be purchased in alternative frequency bands, this will include spares holdings, the new links will need to be installed, commissioned and integrated into the network and then 40 GHz links will be decommissioned, deinstalled and pass through the process of managed disposal. We next set out our estimate of the costs of this process.

Details of estimated costs of MBNL 40GHz licence revocation from BT/EE's perspective

Our starting point is to individually consider each one of the existing (or already planned) 40GHz microwave links from BT/EE's own commercial perspective to determine how it should be categorised in terms of its current status and likely future evolution (e.g. existing 40 GHz link with plan to upgrade capacity in 40GHz; existing 40 GHz link with plan to upgrade capacity in another band; existing link with plan to replace by fibre; existing link with no plan to replace or upgrade; link planned to be decommissioned; new planned 40 GHz link etc).

We next consider various future scenarios relative to the scenario A of the 40 GHz licence not being revoked. The most relevant scenario for BT/EE is a Scenario B where we need to account only for costs related to a subset of the existing links that are either:

(i) planned 40 GHz links that can't go ahead as planned;

(ii) live links 40 GHz that have no plan to change configuration

(iii) live links that would be capacity upgraded in 40GHz

We exclude from the cost analysis links that are already expected to be migrated to fibre, or to another band. This leaves [✂] links that would potentially incur some additional costs.

We have estimated how many of these links that are relevant to the calculation of additional costs are actually in or within a certain distance of the 40 proposed high density areas and therefore affected by the proposed licence revocation. We don't know what separation distance will be required but for illustrative purposes we have assumed 25km and this would mean that about 70% of the links would be in scope. If 80 high density areas are relevant then the percent of links will be much higher (we did not specifically calculate this, but it will of course be somewhere between 70% and 100%).

The estimated additional costs attributable to 40 GHz licence revocation (compared to the scenario of the licence remaining unchanged) is summarised in the Table 7-2 below.

Table 7-2: Additional costs due to 40 GHz licence revocation

Cost element	Top 40 high density areas with 25km buffer	All GB & NI
Premature write-off costs	[✂]	[✂]
Pull forward of like for like replacement costs	[✂]	[✂]
Total additional costs of 40GHz revocation	[✂]	[✂]

It should be noted that the above cost estimates that we have provided assume that all of the existing links that would need to be moved to other fixed links spectrum bands can actually be accommodated within those other bands. If this proves not to be feasible, the costs will be higher as additional hops or fibre solutions might be required. Ofcom should consider investigating how many of the existing links could in fact be successfully coordinated in the nearby bands that they manage, including 38 GHz and E-band and advise MBNL (EE/Three) accordingly so that this can be taken into account when looking at other options available (e.g. 32 GHz).

Finally, in addition to the direct financial costs that could arise if Ofcom were to revoke the existing 40 GHz licences, there are other relevant considerations that we believe Ofcom should also take into account in coming to its decision on whether or not to revoke 40 GHz licences. These include:

- The impact that requiring 40 GHz links to be cleared will have on MBNL scare resources that are already stretched to cover other Government led initiatives (i.e. the High Risk Vendor swap) and the costs and impracticality of upscaling resources to deal with unplanned removal of 40 GHz links.
- The potential disruption to important services that rely on 40 GHz backhaul when links are being swapped out, or the costs of temporary parallel working to mitigate this (e.g. Emergency Services Network)
- The difficulty in sourcing new radio equipment in the volumes and timescales required, especially given the global shortage of chips and other components that we are already seeing as a barrier to our procurement requirements for microwave radio equipment

- The undesirable environmental impact of creating extra waste by the premature removal of and disposal of equipment that is working perfectly, as well as the environmental impact of the associated travel of engineering teams deployed to effect the changeover.

8 Extending shared access licences to 26GHz

Question 14: 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)?

One concern we have with the incorporation of low density areas in the existing shared access licence framework rather than including these in the auctioned licences are the timescales to obtain licences and the potential need to obtain these simultaneously over large areas, for example if coverage of a road or railway was to be planned. An automated licensing system would be essential. We agree that the fees should be based on costs of managing the spectrum.

Question 15: 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?]

We agree with the proposed coordination arrangements between Shared Access users in 26 GHz and existing users that Ofcom has outlined.

9 Auction design

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

Summary

We agree a clock or simultaneous multiple round ascending style auction is appropriate for award of 26 GHz licences, with an assignment round based on a second price sealed bid if generic lots are awarded. We do however reserve our position on auction design until the detailed proposals for the auction are made available.

We consider that separate lots for each high traffic location is an unnecessary and unwelcome complication but can support two different categories of frequency lots to reflect different constraints on different parts of the band. We also support a second assignment round (Ofcom's option "(c)") to ensure contiguous assignments after 26 GHz fixed links clearance.

Ofcom's proposal

Separate lot categories by geography

Ofcom proposes to auction the spectrum in each high density area as a separate lot category but welcomes views on how high density areas may be aggregated. Its rationale is that the potential benefits in terms of enabling entry and a more efficient allocation are likely to outweigh the costs to consumers.

Separate categories of lots for sub-bands

Ofcom proposes separate lot types for sub-bands within the 26 GHz band which are likely to have different value to bidders (i.e. the bottom portion of the band (25.1- 26.5 GHz) vs the top portion of the band (26.5-27.5 GHz) which is unencumbered by fixed links, so usable immediately).

Preferred auction format

Ofcom proposes a Clock auction (although it is open to SMRA as an alternative). Ofcom's rationale is that the Clock format allows for a faster and simpler auction design because it removes the

standing high bid mechanism, which is used in the SMRA. Ofcom proposes to award generic lots within two categories in the principal stage, followed by an assignment round, and possibly a 2nd assignment stage for a rearrangement after 5 years to achieve contiguity.

BT's high level requirements

Because there are a number of auction designs (and combinations of the above proposals) that could potentially deliver on BT's key requirements, we summarise these here, before commenting on each of the proposals above.

- **Bidders must be able to secure access to** [✂] **of the band if they wish**
- **A price that is as predictable as possible** i.e., price discovery at the principal stage largely determines final price of a lot (normally a feature when generic lots in the principal round are close substitutes).
- **Ofcom must minimise the risk of winning non-contiguous spectrum (by both geography and frequency).** Ofcom's proposals seek to cater for this but we think there may be pragmatic solutions to some types of challenges: for example, if there was only one split winner after the principal round, in a Clock auction Ofcom could put their assignments at the boundary of the two Lot types, or if a winner has contiguous spectrum positioned at the top or bottom of the 26 GHz band they should not be required to move in a proposed second assignment round for the band rearrangement after 5 years. Ofcom should consider pragmatic solutions. Bidders also should not have to run the risk of winning different bandwidths across different high density areas because it would be unnecessarily costly and complex. Ofcom could prevent this by awarding national or subnational (as opposed to individual high density area) licences.

Views on the auction format

Principal stage

We agree with Ofcom that a combinatorial clock auction (CCA) is not appropriate for the 26 GHz award (or 40 GHz if that is awarded). It would represent unnecessary and unwanted complexity and has no material benefits over other auction formats that are simpler and adequate for this award, especially if sub-national rather than individual licences in each high traffic area are awarded.

A suitably designed simultaneous multiple round ascending auction (SMRA) or clock auction format could be appropriate for this award. We have no strong preference as to which of these formats is used and will be more concerned with the exact details of the design, which we understand Ofcom is to consult on at a later stage. On balance we suggest an SMRA type auction would be the most suitable. This format is familiar to likely bidders given other recent UK auctions and we don't see benefits from the intra round bids (or potentially fewer rounds) that a clock auction provides, especially as some ability to vary increments can be included in the SMRA. We acknowledge that an SMRA should include a guaranteed minimum spectrum requirement mechanism (to avoid licensees being stranded with lots where the value of the bids sums to more than their combined value) whereas a clock auction can be designed to avoid this (but can leave unsold spectrum).

Assignment stage

We have no objection to a second price sealed bid auction being used for the assignment stage where generic lots are awarded. We will provide our views on this aspect when Ofcom brings forward its consultation proposals for the detailed auction design.

We have some general concerns with the assignment stage that would follow if Ofcom does not award sub-national channels.

We welcome Ofcom's proposal for a second assignment round to defragment the band beyond the 5 year period where fixed links may constrain use of the auctioned licences, although will be concerned with the details of how the proposal would work.

Views on lot categories

Frequency dimension

Ofcom is right to call out that – in an SMRA or clock auction –

- frequencies in one single lot category should be of similar value if auctioned as generic lots in the principal stage; and that this is unlikely to be the case for the upper and lower 26 GHz band given encumbrance of the lower part of the band by fixed links.
- the main trade-off between having one lot category and two lot categories is between awarding contiguous spectrum and enabling bidders to express their preferences over encumbered and unencumbered spectrum during the principal stage.

However, Ofcom should consider more carefully the factors that will allow it to determine:

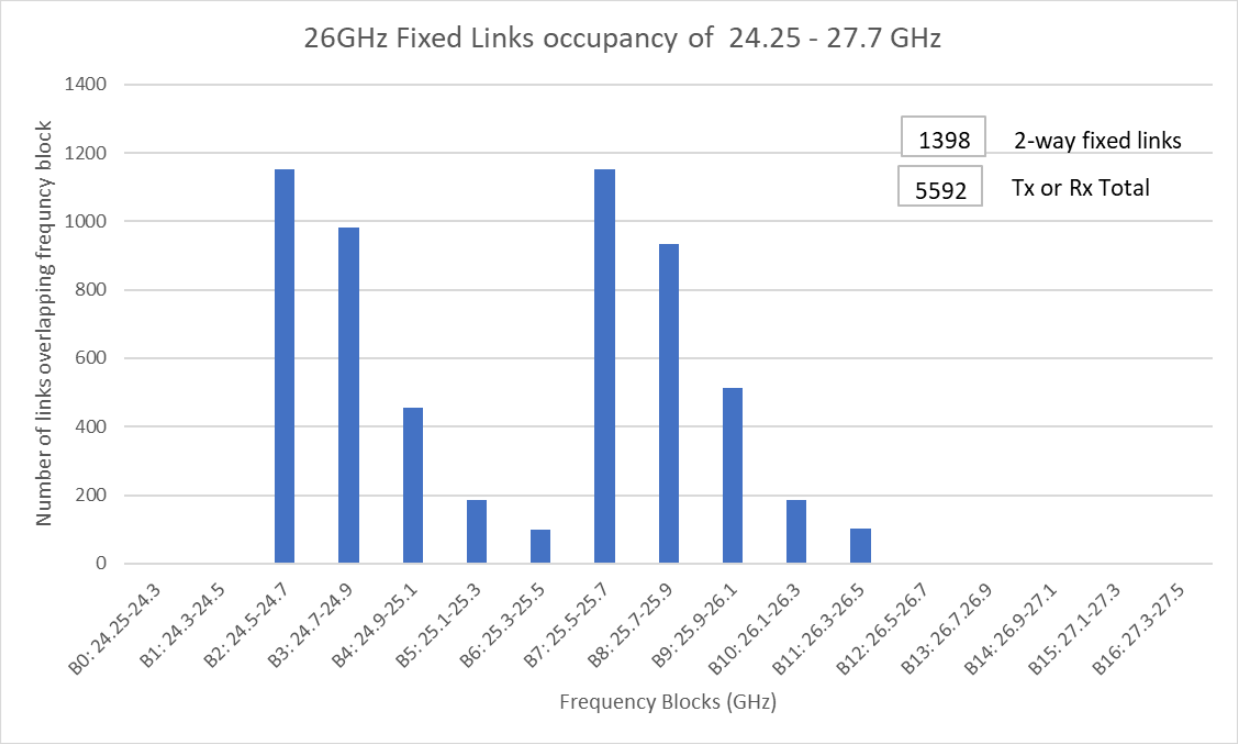
- If, in practice, valuations are likely to differ between the upper and lower frequency bands in practice, and how this may even vary within the lower part of the 26GHz band, as we illustrate in Figure 9-1.
- the likely effectiveness of the assignment stage in resolving differences in value which were not resolved in the principal stage. In our view the assignment stage is less likely to be effective in achieving this if differences in value between generic lots is large.

Further, there are other mechanisms Ofcom should consider that could enable efficient assignment post auction, including: (i) allowing for trading and leasing of spectrum in the licence; (ii) creating a longer term (indefinite or 20-year licence), as otherwise it will not be worth making use of the possibility;[30] (iii) adopting pragmatic solutions (e.g., if there is only one winner who is split between the two lot categories, commit to assign them adjacent lots spanning the lot category boundary); (iv) should shorter licence terms be adopted (which we believe would come with significant drawbacks, see section 10 below) signal that Ofcom will review its approach to Annual Licence fees so they do not become an obstacle to trading.

Based on our initial analysis, in view of the constraints on part of the band caused by fixed links, we consider that the value of the lower and upper part of the 26 GHz band is sufficiently different to warrant two separate lot categories. However, to obtain a lot at the lower portion of the 26GHz band with lots broadly consistent in value, we consider it essential that Ofcom offer grants to accelerate removal of 26 GHz links, high enough for them to be taken up (Ofcom could also consider a 'winners fund' as described in 7.2 above for the 26 GHz band). This would help reduce difference in value between different parts of the lower portion of the band and allow the benefits of an assignment round (in terms of overall auction efficiency) to be realised rather than by needing to consider whether perhaps the differences are actually significant enough to warrant further lot categories within the lower part of the band.

Figure 9-1 provides the number of fixed link channels falling within each 200 MHz slot of the 26 GHz band. This shows that even within Ofcom's proposed Lot category 1 (the sub-band affected by fixed links), the number of links varies considerably across the various 200 MHz slots. If the links affecting mobile use in urban areas are not removed quickly this could have significant impact on values of different parts of the band.

[30] Should e.g. innovative uses arise say 5 years down the line of the initial licence term, then the prospect of uncertain regulatory intervention shortly after a new service has been commercialised could increase risk of deployment to such an extent that it could scupper any such initiative even before it is attempted.



Source: BT analysis of Ofcom WTR

Figure 9-1: Analysis of number of fixed link channels falling within each 200 MHz of the 26 GHz band

We agree that it would be worthwhile to provide a mechanism within the auction to ensure assignments are made contiguous in the longer term after fixed links are removed. The option (c) (second assignment round to "defragment" the band after 5 years when fixed links have been cleared) is something we could in principle support. However, the second assignment round would need careful design and there might be circumstances where winners would be exempted from taking part, for example if in the initial auction assignment phase a winner has a single assignment that is located at the very top or very bottom of the band it may be appropriate not to require them to participate in a second assignment round as they are not an obstacle to other parties with split assignments being made contiguous.

Lot size

Lots of 200 MHz bandwidth for 26 GHz and 40 GHz, as Ofcom has illustrated in the Consultation Document, would be appropriate, but there should be a mechanism for a guarantee of not winning less than a total of 400 MHz. In practice much larger bandwidths are likely to be required by operators in order for mmWave deployments to be most viable, i.e. [✂] MHz per operator, which would be compatible with the 200 MHz lot size.

Geographic dimension

Ofcom does not propose national (or sub-national) licences: it proposes a highly localised approach instead. We think the costs of more localised approaches are likely to be higher than the potential benefits because:

- **We question the consumer benefits of auctioning mmWave spectrum by geography.** Demand for services is likely to evolve location by location over time, and an auction can be expected to result in allocations that will be out of date relatively quickly. Irrespective of whether licences are

auctioned nationally, sub-nationally or locally, there would need to be trading or leasing to enable localised demand to meet supply as it changes over time. Localised auctions would likely result in spuriously accurate valuations, at costs that are likely to be incommensurate with the consumer benefits.

- **Differential demand for specific localities may, in particular for areas of low demand, signal low economic value.** This could lead to unhelpful snow-ball effects: businesses may use this as a measure of revealed demand, and in turn discard thoughts of setting up in areas perceived to be as low value in the auction. This could be unhelpful from a levelling up point of view. Instead, national or sub-national licenses would ensure that the cost of spectrum in areas of lower value are effectively subsidised by areas with higher value, and where demand evolves over time, leasing and trading should be facilitated.
- **Trading/leasing of spectrum by winners of sub-national licences.** Localised entry even by firms who end up without any spectrum allocations after the auction would not be prohibited or discouraged by national or subnational licenses, if it was possible for licence winners to lease or sell localised "sub-licences" with ease. This would be most consistent with a least administratively complex approach to ensuring optimal use of spectrum as demand evolves. It would also enable auction winners to partner with e.g., industry verticals or other providers of localised services, in bringing innovative uses cases to market locally. With multiple holders of sub-national licences in a high density area, there would be competition and choice as to which sub-national licence holder to trade/lease spectrum with. If current practice in other mobile bands is followed, Ofcom also could issue Local Access licences where spectrum is unused and not planned to be used within 3 years by the national/sub-national licence holder. This is a further route to getting access to spectrum in the high density areas if leasing, trading, or shared access licence options are not suitable.
- **Shared Access Licences are proposed to be available** in the bottom 850 MHz of the 26 GHz band in the high density areas for all-comers, so firms that do not win a sub-national licence would not be excluded from accessing a high density location that might be of interest to them even if access via leasing or trading with a holder of the subnational licence in the area is not possible.
- **Localised licences may impose costs or make it impossible for MNOs to (credibly) launch services nationally.** When launching a new service reliant on mmWave spectrum, MNOs would have to communicate to customers that a certain service is available in one region of the UK and will not become available in another (just because the auction did not allow spectrum to be won in an aggregated fashion across the country). This would introduce significant uncertainty in MNOs product portfolio management and product launches often associated with a relatively high fixed upfront investment (not just locally in terms of mmWave spectrum and equipment, but also in terms of developing the service proposition which – to cost in – should be designed to be repeatable at least across different UK geographies). Further, introducing services in a piecemeal fashion tends to cause additional costs, as it prevents the deployment of standardised services for the mass market and key industry verticals. It is also unlikely to be desirable from a policy point of view (see above on levelling up).
- **Localised licences are complex to administer**, with potentially different bandwidth, frequencies and gaps in coverage depending on what a bidder secures in the auction.

If Ofcom were minded to go ahead with its preference for localised licences, then we consider it is crucial that:

- **Ofcom has hard evidence of real value in a localised approach.** For example, to ensure that potential bidders have to reveal their true preferences, Ofcom might consider a deposit commitment requirement (subject to a proposed detailed auction design). Then, if deposit commitments for particular geographic lots or lot categories fall below a certain threshold,

Ofcom could signal it would then consolidate the relevant geographic lots where deposits did not exceed a certain threshold.

  - Experience from elsewhere in the world demonstrates that where cities are auctioned separately this has not been taken up by the market. A good illustration of this the 2021 Australian 26 GHz auction, where there were 360 lots available: 12 x 200 MHz lots across 24 areas and 24 x 100 MHz lots across 3 areas. Existing mobile operators won 352 lots with new users winning 6 lots (with a maximum of 200 MHz in four local areas): Two lots were unsold. These auction results suggest relatively low demand for 26 GHz from new users. If this demand was read across to the UK, this would support national or sub-national geographic licences for 11 x 200 MHz (for mobile operators) and individual city lots (or combinations) for 1 x 200 MHz (for niche players).[31].

- **Ofcom aggregates high density areas to form the minimum possible number of separate geographic lots** to maximise consumer benefits and minimise the costs we have set out above. If this is done then the assignment stages as envisaged by Ofcom (i.e., so that the same frequency lots are consolidated into a single assignment round across geographies) are more likely to result in consistent frequency assignments across geographies, in turn enabling the hoped for consumer benefits (including minimising the cost of serving them).

Overall, should Ofcom decide to not offer national licences, then we prefer that Ofcom includes all high density areas in a single sub-national licence (covering the aggregate of all the high density areas), rather than having to bid separately for each high density area. Separate auctions to acquire different bandwidths in each high density area represents unnecessary complexity. [✂

]. If there were parties interested in only getting licences in some cities or different amounts of spectrum in different cities (which we think unlikely) then Ofcom's Shared Access Licences or Local Access Licences or commercial trades/leases could accommodate that requirement.

10 Duration of licences

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?

Summary

In summary, we would advocate indefinite licences that are tradable and leasable for this band, with an initial term of 20 years before they can be revoked on spectrum management grounds. This would be consistent with a market-based approach to spectrum management. We do not think that the alternative of a fixed duration licence of 10-15 years is more likely to secure optimal and efficient use of spectrum, certainly where there is no presumption that the licence would automatically be extended if the spectrum is being efficiently used.

Licence duration and investment cycles

In Figure 10-1 below we illustrate the three options for licence duration that are set out in section 10 of the Consultation Document, including Ofcom's proposal to use a fixed duration licence of 10-15 years. We have also illustrated the 5 year notice period before fixed links will be cleared from in or near the auction areas and shown an example time frame for deployment of equipment and a period over which the equipment might be expected to operate. Even if the example is varied, it is

[31] See Auction summary – 26 GHz band (2021) https://www.acma.gov.au/auction-summary-26-ghz-band-2021 and Q&A at https://www.acma.gov.au/sites/default/files/2022-02/FAQs%2026%20GHz%20band%20auction.pdf

clear from this illustration that a 10-15 year fixed licence duration would not be compatible with any practical network deployment and investment cycles and would therefore not secure optimal use of the spectrum.

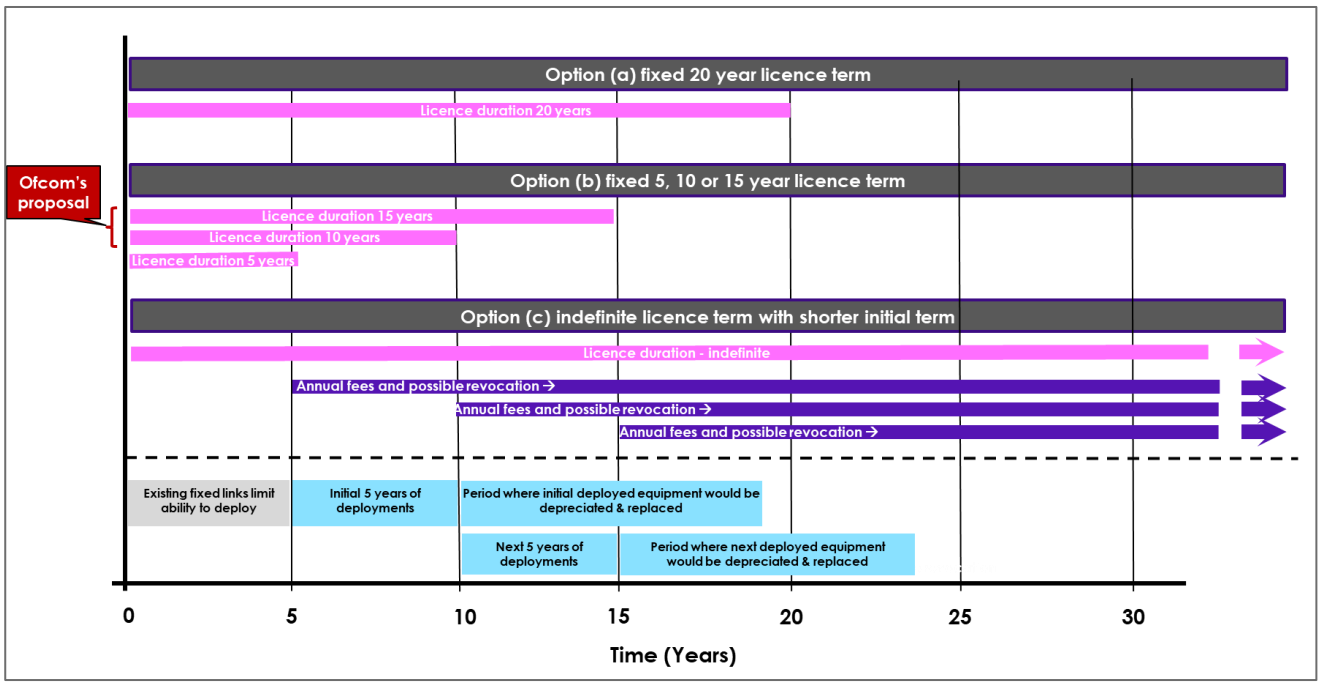


Figure 10-1: Illustration of Ofcom's options and proposal for licence duration and relationship to practical deployment and investment scenarios

An indefinite licence with an initial term of 20 years, as is Ofcom's past practice for auctioned mobile spectrum, is more likely to be compatible with mobile network investments in mmWave bands. It would also support market-based spectrum management in which trading (and leasing) would provide a means of securing optimal use of spectrum, together with the possibility of Ofcom to issue Local Access licences where trading is not seen as an effective solution.

In order to invest in mmWave, we would want certainty in the availability of the spectrum and it's cost for the longer term, e.g., at least 20 years.

Ofcom's concerns with indefinite licences are unfounded

Ofcom justifies its proposal to offer fixed duration licences of 10-15 years on the basis that the uses of mmWave spectrum are emerging and there is a risk that the initial allocation of spectrum will become inefficient over time, and that trading will not be sufficient to address this concern. We disagree with this assessment and consider that the risks to investment that would arise if fixed duration licences of 10-15 years are used, are more serious than the risks from indefinite licences. The mmWave technology ecosystem needs certainty that there will be a market to justify investments in product development, short term licenses with the risk of revocation will deter investment by operators and the supporting ecosystem. The fact that Ofcom can issue Local Access licences anyway, significantly mitigates any risks of relying on trading. Spectrum Access Licences represent another route for other users to gain access to the mmWave spectrum in the auction licence areas.

The European Electronic Communications Code (EECC) recognises the importance of long licence durations

The importance of long licence durations for mobile networks is enshrined in the European Electronic Communications Code (EECC) [32] where at Article 49 (2) a minimum duration of 15 years is specified for harmonised spectrum. Article 49 (2) says:

Member States "*shall ensure regulatory predictability for the holders of the rights over a period of* ***at least 20 years*** *regarding conditions for investment in infrastructure which relies on the use of such radio spectrum*" (emphasis added).

The UK Government considered how to implement the EECC in UK legislation

When the Government consulted on implementation of the EECC into UK law[33], in relation to Article 49, it concluded that Ofcom's practice of indefinite duration licences was sufficient.

The Government consulted on the following options:

- "Option 1 (preferred approach): this would maintain the existing approach - under current UK legislation, Ofcom issues licences **on an indefinite basis** through its spectrum award process, with the exception of certain types of licences requiring shorter durations (in practice, existing arrangements are consistent with the requirements of regulatory predictability)
- Option 2 (alternative approach): we would expressly transpose the European Electronic Communications Code requirement for member states to grant individual rights of use for 'wireless broadband services' for a **minimum duration of 15 years with rights of extension** to ensure regulatory predictability for 20 years for harmonised spectrum" (emphasis added).

The Government decided to adopt Option 1.

Therefore, the existing UK legislation retains Ofcom's power to issue unlimited licences.[34] The Government noted responses from industry which supported the current regime, in particular on the grounds that:

- UK legislation already provided for the requirements for regulatory predictability introduced by Article 49 of the EECC; and
- The imposition of licence terms would create uncertainty and undermine incentives to invest towards the end of the licence term.

The Government's response to the consultation expressly confirmed its preference to maintain the existing regime: "*In line with the majority of respondents to this question, we have decided to maintain our preferred approach as outlined in the consultation document to not specify minimum durations in UK legislation on the basis that, in practice, existing arrangements are consistent with the European Electronic Communications Code requirements of regulatory predictability.*"

Even the second option that the Government considered and rejected (minimum 15 years with the right to extend once) is better than Ofcom's current proposal. Therefore, Ofcom should implement indefinite licences in line with the unchanged legislation and Government's expressed preference or, at the minimum, limit the duration to 15 years with a right to extend to 20 (in line with the Government's option 2). There is no justification for a 10 year licence AS proposed here.

[32] Directive (EU) 2018/1972 of the European parliament and the council of 11 December 2018 establishing the European Electronic Communications Code https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L1972

[33] See Section 4.5 of https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/902879/Government_response_EECC.pdf

[34] See Wireless Telegraphy Act 2006, Part 2 and, in particular, sections 8-20.

Examples from other European countries

We note that recent practice in other European countries that have auctioned mmWave spectrum is to award licences of longer duration than the 10-15 years Ofcom proposes. For example:

- In Finland 14 year licences for 26 GHz spectrum were awarded in 2020.
- In Italy 19 year licences were awarded in 2018.

Consistency between 26 GHz and existing 40 GHz licences

We draw Ofcom's attention to the inconsistency of 10-15 year licence in 26 GHz, if Ofcom adopts Options 1 or 4 (liberalise exiting indefinite licences) for making the 40 GHz band available for mobile.

11 Potential competition measures

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?

Summary

We agree with Ofcom's proposal to address competition concerns resulting from H3G's existing holdings in the 40 GHz band in the Option 1 scenario by using a precautionary cap on spectrum that can be acquired in the 26 GHz auction[35].

Given H3G's current holdings of 40 GHz, taking all relevant factors into account, including the rights of the 40GHz licences compared to the 26GHz licences, the timescales in which the spectrum may become equally useable, and the importance of 26GHz to compete at the wholesale and retail level, we support a precautionary cap of 37% to be applied to H3G's aggregate mmWave holdings.[36]

Under this approach H3G would therefore be able to acquire 26 GHz spectrum in the auction, but only if it relinquishes equivalent holdings of 40 GHz spectrum (e.g., if H3G wishes to acquire 400 MHz of 26 GHz it would need to relinquish 400 MHz of 40 GHz).

Mobile spectrum holdings in current bands and future mmWave bands

Current mobile spectrum holdings in sub mmWave bands (under 6 GHz) alongside the 26GHz and 40 GHz bands that are under consideration for mobile use are shown below in Figure 11-1. The total amount of sub-6GHz mobile spectrum currently assigned is **1,152 MHz.** Spectrum shares in sub mmWave bands are fairly balanced with BT/EE: 32%, VM/O2: 22%, Vodafone 24% and H3G: 22%.

Ofcom is proposing to make 26 GHz and 40 GHz available for mobile use. This will increase the available mobile spectrum by **5,400 MHz** to a total of **6,552 MHz** (roughly a fivefold increase in available mobile spectrum bandwidth).

[35] See Paras 7.64 and 11.4 of the Consultation Document.
[36] This implies 26 GHz and 40 GHz spectrum holdings are broadly additive for the purpose of setting the cap.

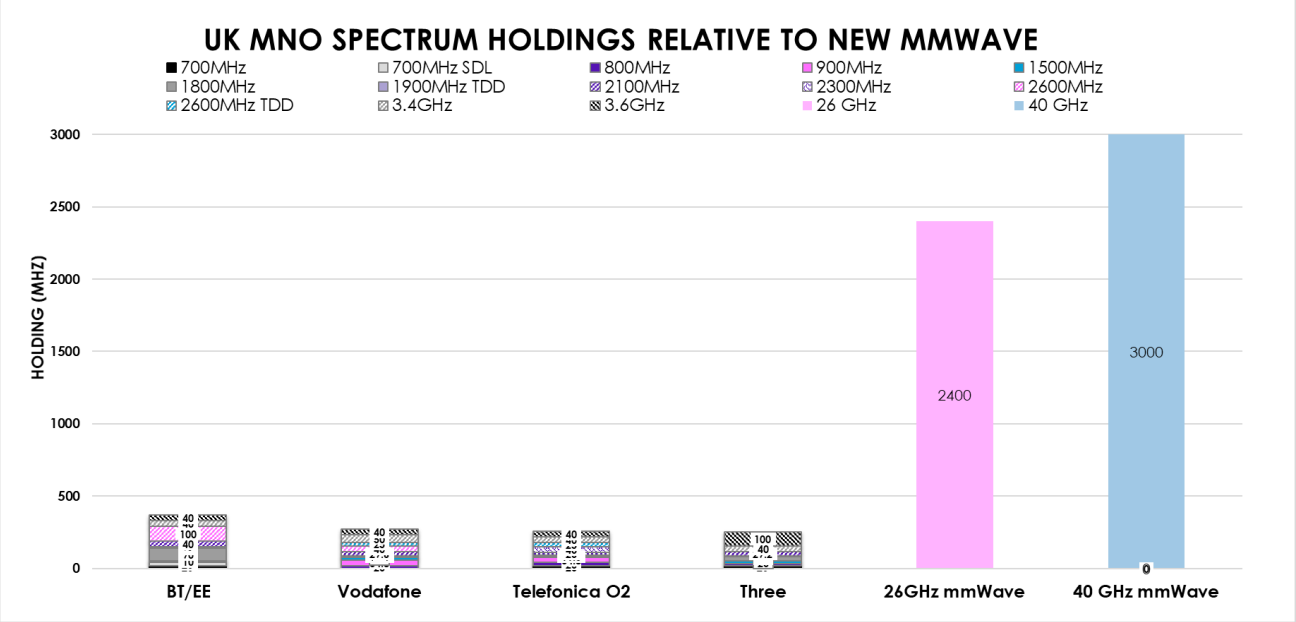


Figure 11-1: Current UK mobile spectrum assignments compared to mmWave (in MHz)

mmWave spectrum should be considered separately to sub-6GHz spectrum

As we set out below, we consider that mmWave is very different to sub-6GHz mobile spectrum that is assigned today. As Figure 11-1 above shows, the volume of mmWave spectrum completely dwarfs that volume of sub-6GHz spectrum and the scenarios within which the different categories of spectrum would be used and the capabilities they can support are distinct.

Any competition assessment should therefore focus on mmWave. It makes sense to distinguish 26 GHz as immediately available for mobile use, and 40 GHz as future usable mobile spectrum (once the equipment and device ecosystem develops). Because existing 40 GHz licences are currently assigned nationally whereas Ofcom proposes local licences for 26 GHz, there are measurement issues related to estimating combined mmWave spectrum shares for users as well as any precautionary cap on mmWave holdings.

Spectrum assignments under the four options for 40 GHz band

In Table 11-1 below we illustrate the share of the 40 GHz and the 40GHz and 26 GHz spectrum combined[37] that each of the existing 40 GHz licensees would hold going in to the auction under each of the four Options for 40 GHz that Ofcom has set out in the Consultation Document.

[37] Aggregating spectrum holdings and shares across 26 GHz and 40 GHz assumes 26 GHz licences are issued on a national basis (same as 40 GHz) when in fact Ofcom proposes to issue the 26 GHz licences on a local basis. We discuss this and other measurement issues when aggregating spectrum holdings and shares across mmWave bands later in this section.

Table 11-1: Analysis of share of 40 GHz and share of combined 40 GHz & 26 GHz spectrum held by 40 GHz licensees going into the auction(s) under the four Options set out by Ofcom

MNO	Option 1 (Liberalise)		Option 2 (Revoke all)		Option 3 (leave MBNL)		Option 4 (Revoke half, except MBNL)	
	40 GHz	26 GHz + 40 GHz	40 GHz	26 GHz + 40 GHz	40 GHz	26 GHz + 40 GHz	40 GHz	26 GHz + 40 GHz
H3G	67%	37%					33%	19%
MLL	17%	9%					8%	5%
MBNL	17%	9%			17%	9%	17%	9%

We further note that H3G also has an indirect interest in the 500 MHz of spectrum held by MBNL[38]. If the MBNL licence is varied to allow mobile use as we propose, the existing fixed links use would preclude significant use for mobile for several years and would therefore not need to be considered in the auction cap calculation[39]

Competition concerns

There is a significant risk that H3G gains an unmatchable advantage in serving high traffic areas and hotspots under Option 1

We have in the past argued that no caps are needed on total spectrum holdings and that market mechanisms can be relied on to arrive at the appropriate distribution of mobile spectrum among MNOs, given trading, future auctions and the high costs to acquire a very disproportionate share of spectrum in an auction. However, in the instance of the mmWave, where H3G already holds some 67% of the currently assigned 40 GHz spectrum, as well as significant amounts of 28 GHz spectrum (albeit Ofcom says it does not envisage allowing 28 GHz to be used for mobile), some competition measure is necessary. Under Option 1, there is a risk that H3G could, given its substantial existing holdings of 40 GHz, gain an unmatchable advantage in relation to the provision of mobile services in key locations where very high density of mobile traffic occurs. If other competitors are not able to replicate this level of service, then this could lead to a reduction in competition, thereby harming consumer welfare.

Potential unmatchable advantages that could arise over the duration of the mmWave licences absent a precautionary cap would likely include the following:

- Inability of competitors to replicate H3G's service levels to meet consumers' local peak data traffic requirements (e.g. simultaneously high speeds for all customers) at sporting and special events, concerts, shopping centres and airports
- Inability of competitors to replicate H3G service levels to meet commercial and industrial customers' local peak data traffic to support high-speed data services (e.g. tech parks, industrial sites, hospital, ports).

In addition, we are concerned with the fragmentation of that band caused by the present assignments, which may need negotiations with multiple parties to trade; as well as the likelihood

[38] MBNL is a network sharing joint venture and is owned by BT/EE and H3G. Were the MBNL agreement not renegotiated upon expiry in 2031, spectrum shares could be traded back to the two shareholders with the percentage holdings of 40 GHz of EE and Three depending on how that were organised. MLL is a provider of managed network services.

[39] What proportion of the 40 GHz spectrum each of the JV partners might have access to and potentially use for mobile when/where not used for fixed links in the future could in theory vary between 0 and 500 MHz.

that, given Ofcom proposes to not include 850 MHz in the 26 GHz auction, if H3G acquires significant 26 GHz spectrum other MNOs cannot all acquire the 800 - 1000 MHz the GSMA recommends is needed per operator.

Competition measures should focus on the combination of 26 GHz and 40 GHz holdings

We agree with Ofcom that 26 GHz and 40 GHz could in principle be functionally substitutable, although we would acknowledge that in the near term, due to differences in the timing and maturity of ecosystem developments, the 40 GHz band is likely to be less useable than 26 GHz. Nevertheless, considering the longer term situation, when 26 GHz and 40 GHz are considered together, H3G would already hold 37% of the sum of the mmWave spectrum assigned at 40 GHz and that to be auctioned at 26 GHz. In this situation we consider that a cap on total mmWave spectrum H3G can hold would be appropriate in order to (i) promote competition in the delivery of services that mmWave spectrum would uniquely enable; and (ii) promote competition in the provision of mobile services in key locations where very high density of mobile traffic occurs.

Given the mmWave bandwidths are far larger than those of sub-6GHz bands, their very different technical attributes and future importance for provision of mobile services in certain important locations where very high traffic densities need to be supported by competing operators, we consider that a specific cap for mmWave bands is required (like Ofcom has previously applied a specific sub-1 GHz cap).[40]

BT/EE supports a 'precautionary' mmWave spectrum cap of 37% to mitigate risks to competition under Option 1

Since H3G already has circa two-thirds of the 40 GHz spectrum going into the 26 GHz auction, a precautionary cap of 37% should be applied to all mmWave spectrum holdings. This would limit H3G to a maximum 2000 MHz in the mmWave bands and to acquire a sub-national assignment of 26 GHz spectrum, H3G would need to relinquish or trade some of its national 40 GHz spectrum assignment.

We note this is equivalent to the 37% cap on total spectrum holdings proposed by Ofcom in the most recent 5G auction.

There are two factors that we have considered in support of a precautionary cap of 37%:[41]

- **Immediate vs future usable spectrum**: Unlike 26 GHz spectrum, 40 GHz is not likely to be immediately useable (except for FWA, although should be in the longer term). Hence it may be appropriate to consider whether to apply a lower weighting to the 40 GHz band. For example, if all 40 GHz spectrum were weighted at a factor of 0.75, H3G would presently have 32% of all mmWave spectrum (based on its current 2000 MHz holdings of 40 GHz).
- **National vs local licences**: Ofcom proposes to award local licences for 26 GHz compared with the currently assigned national licences for 40 GHz. This could imply a lower weighting for the 26 GHz licences reflecting the restriction on mmWave deployments to 40 pre-specified cities in the UK (vs unrestricted mmWave use in 40 GHz). For example, a weighting of 0.75 applied to all the 26 GHz licences would suggest that H3G already has a 42% share of all mmWave spectrum (based on its current 2000 MHz holdings of 40 GHz).

[40] In the 2013 4G combined award Ofcom proposed a sub-1 GHz spectrum cap of 2 x 27.5 MHz limiting each of Vodafone and O2 to acquiring no more than 2 x 10 MHz of 800 MHz on top of their existing holdings of 2 x 17.5 MHz of 900 MHz. This measure was designed to mitigate the risk of highly asymmetric spectrum holdings after the auction leading to lower competitive intensity.

[41] The examples used below to weight 26 GHz and 40 GHz spectrum are for illustration purposes only and do not indicate BT/EE's view of the relative valuation of 26 GHz and 40 GHz.

These considerations taken together tend to cancel each other and are assumed to have an overall neutral effect.

We understand that the competition measures would be subject to further consultation, if Ofcom were to select its Option 1 for the 40 GHz band. The above suggestions are initial thoughts. We will provide our formal position if, and when, Ofcom brings forward specific proposals for consultation.

12 Next steps

We note Ofcom's plan to issue a Statement in Q3/2022-23 and a further consultation document on the details of the proposed auction, possible revocation of licences and other matters.

We suggest that Ofcom consults again on the proposed final areas to be included in the auction licences, taking into account BT's proposals and any that other parties may propose.

We would be happy to meet with Ofcom to clarify any points in this response and to share our views on any other related issues Ofcom may receive in responses that it receives.

Annex A: Additional places for inclusion with auction licences

Below we detail important locations that are not included in Ofcom's top 80 areas that we believe are important high traffic density areas that Ofcom should include in the licences to be auctioned. We include the locations that should be included in the license coverage of BT's proposal as discussed in section 4.2, if OFCOM chose to adopt this approach.

Table A1: List of additional important sites to be included in auction licences

SECTOR	NAME	Easting	Northing	Top 80 Covered %	BT proposal: Top 80 "Squared" % Covered
AIRPORT	Aberdeen Airport	388000	812500	0%	100%
AIRPORT	Belfast International Airport	128100	537100	0%	0%
AIRPORT	Bristol Airport	350400	165100	0%	0%
AIRPORT	Cardiff Airport	306400	167400	0%	0%
AIRPORT	Doncaster Sheffield Airport	465900	398700	0%	0%
AIRPORT	East Midlands Airport	445000	325900	0%	0%
AIRPORT	Edinburgh Airport	315000	673900	0%	100%
AIRPORT	Leeds Bradford Airport	422400	441600	0%	100%
AIRPORT	Newcastle Airport	418600	571400	0%	100%
AIRPORT	Stansted Airport	554100	223100	0%	0%
AIRPORT	Gatwick Airport, North Terminal	527500	141700	0%	100%
AIRPORT	Gatwick Airport, South Terminal	528500	141200	0%	100%
AIRPORT	Manchester Airport Terminal 3	381900	384600	0%	100%
BUSINESS_PARK	Abbeywoods Business Park	427000	545800	0%	0%
BUSINESS_PARK	Abingdon Business Park	448300	197300	0%	0%
BUSINESS_PARK	Adwick Business Park	450700	412700	0%	0%
BUSINESS_PARK	Alderley Park	384600	375700	0%	0%
BUSINESS_PARK	Alexandra Retail Park	526900	410100	0%	0%
BUSINESS_PARK	Babraham Research Campus	551100	250500	0%	0%
BUSINESS_PARK	Bankhead Business Park	329200	699000	0%	0%
BUSINESS_PARK	Barham Business Park	620000	147700	0%	0%
BUSINESS_PARK	Begbroke Science Park	447900	213600	0%	0%
BUSINESS_PARK	BioPark	524000	212500	0%	100%
BUSINESS_PARK	Birch Lane Business Park	406900	302400	0%	100%
BUSINESS_PARK	Blackminster Business Park	407300	245000	0%	0%
BUSINESS_PARK	Bloomfield Shopping Centre & Retail Park	164200	534200	0%	0%
BUSINESS_PARK	Blythe Valley Business Park	413800	274900	0%	100%
BUSINESS_PARK	Bowcombe Business Park	446900	86800	0%	0%
BUSINESS_PARK	Brackenholme Business Park	470000	430100	0%	0%
BUSINESS_PARK	Brathens Eco-Business Park	367700	798400	0%	0%
BUSINESS_PARK	Bretby Business Park	428900	321600	0%	0%
BUSINESS_PARK	Bridgewater Business Park	365700	399700	0%	100%
BUSINESS_PARK	Brimfield Business Park	352400	268100	0%	0%
BUSINESS_PARK	Brooke Business Park	652900	292800	0%	0%
BUSINESS_PARK	Business Park	341400	554200	0%	0%
BUSINESS_PARK	Cambridge Research Park	548300	267900	0%	0%
BUSINESS_PARK	Carrington Business Park	373600	392700	0%	100%
BUSINESS_PARK	Chadkirk Business Park	393800	389500	0%	100%
BUSINESS_PARK	Chesterford Research Park	553400	242100	0%	0%
BUSINESS_PARK	Church Farm Business Park	369100	165400	0%	100%
BUSINESS_PARK	Colworth Science Park	498000	260100	0%	0%
BUSINESS_PARK	Compton Green Business Park	373100	228400	0%	0%
BUSINESS_PARK	Cranfield Technology Park	493800	241900	0%	0%
BUSINESS_PARK	Culham Science Centre	453500	195400	0%	0%
BUSINESS_PARK	Cyfarthfa Retail Park	304000	206500	0%	0%
BUSINESS_PARK	Daresbury Science and Innovation Campus	357500	383300	0%	100%
BUSINESS_PARK	Discovery Park Enterprise Zone	633100	159500	0%	0%
BUSINESS_PARK	Earles Colne Business Park	584500	226700	0%	0%
BUSINESS_PARK	Eastlands Boat Yard & Business Park	449900	110200	0%	100%
BUSINESS_PARK	Edinburgh Technopole	324600	663600	0%	0%
BUSINESS_PARK	Electronics & Photonics Innovation Centre (EPIC)	287900	58300	0%	0%
BUSINESS_PARK	Elvingston Science Centre	346100	673900	0%	0%

BUSINESS_PARK	Exeter Science Park	297400	93500	0%	100%
BUSINESS_PARK	Foxmoor Business Park	316100	120400	0%	0%
BUSINESS_PARK	Gapton Hall Retail Park	651600	306300	0%	0%
BUSINESS_PARK	Goodman Science Park Gp (Uk) Ltd	413700	274600	0%	100%
BUSINESS_PARK	Granary Court Business Park	311800	383900	0%	0%
BUSINESS_PARK	Granta Park	552000	248900	0%	0%
BUSINESS_PARK	Greendale Business Park	302000	89600	0%	0%
BUSINESS_PARK	Grove Business Park	438500	189700	0%	0%
BUSINESS_PARK	Harwell Science and Innovation Campus	447800	187400	0%	0%
BUSINESS_PARK	Highfield Business Park	376300	821900	0%	0%
BUSINESS_PARK	Hillborough Business Park	620900	167700	0%	0%
BUSINESS_PARK	Holly Farm Business Park	423600	273100	0%	0%
BUSINESS_PARK	Horn Park Business Park	346400	102700	0%	0%
BUSINESS_PARK	Interchange Business Park	489000	243200	0%	100%
BUSINESS_PARK	Junction 7 Business Park	374200	430700	0%	0%
BUSINESS_PARK	Keele University Science Park	382200	345400	0%	100%
BUSINESS_PARK	Kent Science Park	590200	160500	0%	0%
BUSINESS_PARK	Kirton Business Park	529900	339400	0%	0%
BUSINESS_PARK	Ladygrove Business Park	367200	218400	0%	0%
BUSINESS_PARK	Lancashire Business Park	354000	423600	0%	100%
BUSINESS_PARK	Lancaster Science Park	348500	457300	0%	0%
BUSINESS_PARK	Langford Business Park	448200	214600	0%	0%
BUSINESS_PARK	Langstone Technology Park	471300	105700	0%	0%
BUSINESS_PARK	Long Ashton Business Park	354900	170200	0%	100%
BUSINESS_PARK	Malvern Science Park	378800	245200	0%	0%
BUSINESS_PARK	Martins Grove Business Park	355300	217200	0%	0%
BUSINESS_PARK	Melbourn Science Park Ltd	538900	245100	0%	0%
BUSINESS_PARK	Menai Science Park Ltd	249000	372100	0%	0%
BUSINESS_PARK	Miers Business Park	345900	136800	0%	0%
BUSINESS_PARK	Milton Science & Technology Park - South Oxfordshire	449000	191600	0%	0%
BUSINESS_PARK	National Agri-Food Innovation Campus - York	467600	458400	0%	0%
BUSINESS_PARK	NETPark - The North East Technology Park	435500	530800	0%	0%
BUSINESS_PARK	Northwood Business Park	449000	94000	0%	0%
BUSINESS_PARK	Oakley Business Park	407100	139400	0%	0%
BUSINESS_PARK	Pentland Science Park Ltd	325400	663400	0%	0%
BUSINESS_PARK	Pera Business Park	474800	319700	0%	0%
BUSINESS_PARK	Perrywood Business Park	528900	146500	0%	100%
BUSINESS_PARK	Pineapple Business Park	346000	96700	0%	0%
BUSINESS_PARK	Pool Business Park	423800	445500	0%	0%
BUSINESS_PARK	Progress Business Park	342300	431900	0%	100%
BUSINESS_PARK	Prospect Business Park	412200	551500	0%	0%
BUSINESS_PARK	R J Cook Business Park	468900	246400	0%	0%
BUSINESS_PARK	Riverside Business Park	278500	377300	50%	50%
BUSINESS_PARK	Romany Works Business Park	395300	92000	0%	0%
BUSINESS_PARK	Roslin BioCentre	327000	663800	0%	0%
BUSINESS_PARK	Spectrum Business Park	443400	548100	0%	0%
BUSINESS_PARK	Stirling University Innovation Park	281000	696100	0%	0%
BUSINESS_PARK	Stockwood Business Park	399700	259500	0%	100%
BUSINESS_PARK	Taylor Business Park	365700	394500	0%	100%
BUSINESS_PARK	Tetricus BioIncubator	420700	136700	0%	0%
BUSINESS_PARK	The Bolsover Business Park	446300	371000	0%	100%
BUSINESS_PARK	The Craggs Country Business Park	400700	422100	0%	0%
BUSINESS_PARK	The Heath Business and Technical Park	351200	381100	0%	0%
BUSINESS_PARK	The University of Essex Research Park	603000	224000	0%	100%
BUSINESS_PARK	Thistle Business Park	206700	560600	0%	0%
BUSINESS_PARK	Tweed Horizons	358600	631900	0%	0%
BUSINESS_PARK	Ulster Science & Technology Park	58900	582800	0%	0%
BUSINESS_PARK	University Of Warwick Science Park	429900	264300	50%	50%
BUSINESS_PARK	Warren Business Park	383600	188200	0%	0%
BUSINESS_PARK	Warrenby House Business Park	458300	525000	0%	0%
BUSINESS_PARK	Waveney Valley Business Park	634000	290000	0%	0%
BUSINESS_PARK	Westlakes Science & Technology Park	299600	514900	0%	0%
BUSINESS_PARK	Westwood Business Park	636000	168800	0%	0%
BUSINESS_PARK	White Cross Business Park	347900	461300	0%	0%
BUSINESS_PARK	Winfrith Technology Centre	382000	86900	0%	0%
BUSINESS_PARK	Wolf Valley Business Park	241400	88600	0%	0%
BUSINESS_PARK	Worcestershire Food Science Park Ltd	408100	270900	0%	0%

BUSINESS_PARK	Writtle College	567700	207000	0%	100%
BUSINESS_PARK	Wrotham Business Park	524800	199200	0%	100%
EXHIBITION_CENTRE	Devonshire Park Centre	561200	98500	0%	0%
EXHIBITION_CENTRE	Donnington Exhibition Centre	441900	326100	0%	0%
EXHIBITION_CENTRE	EventCity	377600	396600	0%	100%
EXHIBITION_CENTRE	NAC Stoneleigh Park	432500	271600	0%	0%
EXHIBITION_CENTRE	Telford International Centre	370200	308400	0%	0%
SHOPPING_CENTRE	Cwmbran Centre	329300	195400	0%	0%
SHOPPING_CENTRE	Eden	486200	193000	0%	100%
SHOPPING_CENTRE	intu Trafford Centre	376900	396500	0%	100%
SHOPPING_CENTRE	Telford Shopping Centre	369800	308800	0%	0%
SHOPPING_CENTRE	The Centre	305500	666700	0%	0%
SPORTING_VENUE	Adams Park	483100	193100	0%	100%
SPORTING_VENUE	Alexandra Stadium	370900	354600	0%	0%
SPORTING_VENUE	Almondvale Stadium	304900	667000	0%	0%
SPORTING_VENUE	Balmoor	412300	846800	0%	0%
SPORTING_VENUE	Bayview Stadium	338100	700000	0%	0%
SPORTING_VENUE	Borough Briggs	321300	863200	0%	0%
SPORTING_VENUE	Broadwood Stadium	272800	674300	0%	0%
SPORTING_VENUE	Brunton Park	341500	556000	0%	0%
SPORTING_VENUE	Cappielow Park	229800	675400	0%	0%
SPORTING_VENUE	Castleford Tigers RLFC	443600	426200	0%	0%
SPORTING_VENUE	Central Park	316300	691500	0%	0%
SPORTING_VENUE	Crown Ground	375600	430000	0%	0%
SPORTING_VENUE	Darlington Mowden Park RFC	430200	512600	0%	0%
SPORTING_VENUE	Dumbarton Football Stadium	240100	674700	0%	0%
SPORTING_VENUE	Durham Dynamos	428300	550600	0%	0%
SPORTING_VENUE	East End Park	310300	687900	0%	0%
SPORTING_VENUE	Edgar Street	350900	240500	0%	0%
SPORTING_VENUE	Ewood Park	367800	425900	0%	0%
SPORTING_VENUE	Falkirk Stadium	290800	680500	0%	0%
SPORTING_VENUE	Field Mill	453500	360400	0%	0%
SPORTING_VENUE	Forthbank Stadium	281200	693500	0%	0%
SPORTING_VENUE	Galabank	319400	567400	0%	0%
SPORTING_VENUE	Gayfield Park	363700	740200	0%	0%
SPORTING_VENUE	Glanford Park	486500	410800	0%	0%
SPORTING_VENUE	Glebe Park	359900	760600	0%	0%
SPORTING_VENUE	Globe Arena	344700	463800	0%	0%
SPORTING_VENUE	Highbury Stadium	332800	447200	0%	0%
SPORTING_VENUE	Huish Park	352800	117000	0%	0%
SPORTING_VENUE	Kent Spitfires	615800	156600	0%	0%
SPORTING_VENUE	Leigh Centurions	364900	399200	0%	100%
SPORTING_VENUE	Links Park	372000	758100	0%	0%
SPORTING_VENUE	Macron Stadium	364600	409500	0%	100%
SPORTING_VENUE	McDiarmid Park	309000	725200	0%	0%
SPORTING_VENUE	Moss Rose	391600	371700	0%	0%
SPORTING_VENUE	New Broomfield	277400	664700	0%	100%
SPORTING_VENUE	Oakwell	435400	406300	0%	100%
SPORTING_VENUE	Ochilview Park	287000	683200	0%	0%
SPORTING_VENUE	Palmerston Park	296400	576300	0%	0%
SPORTING_VENUE	Pirelli Stadium	425200	325000	0%	0%
SPORTING_VENUE	Plainmoor	292000	65200	0%	0%
SPORTING_VENUE	Recreation Park	289500	693000	0%	0%
SPORTING_VENUE	Rugby Park	242100	637400	0%	0%
SPORTING_VENUE	Salford Red Devils	375200	397100	0%	100%
SPORTING_VENUE	Scarborough CC	503900	489200	0%	0%
SPORTING_VENUE	Scarlets	253000	199900	0%	0%
SPORTING_VENUE	Shielfield Park	399100	651800	0%	0%
SPORTING_VENUE	Somerset Park	234500	622700	0%	0%
SPORTING_VENUE	St Helens RLFC	351900	394800	0%	100%
SPORTING_VENUE	Stair Park	206900	560500	0%	0%
SPORTING_VENUE	Stark's Park	327400	690300	0%	0%
SPORTING_VENUE	Station Park	345800	751500	0%	0%
SPORTING_VENUE	The Caledonian Stadium	267200	847200	0%	0%
SPORTING_VENUE	The Lamex Stadium	524400	222800	0%	0%
SPORTING_VENUE	Turf Moor	384900	432500	0%	0%
SPORTING_VENUE	Victoria Park, Dingwall	255500	858800	0%	0%
SPORTING_VENUE	Weston Homes Community Stadium	599400	229000	0%	100%

SPORTING_VENUE	Widnes Vikings	351000	385600	0%	100%
UNIVERSITY_CAMPUS	Aberystwyth University	259700	282000	0%	0%
UNIVERSITY_CAMPUS	Aberystwyth University - Institute Of Geography & Earth Sciences	259600	281900	0%	0%
UNIVERSITY_CAMPUS	Bath Spa University	369600	164100	0%	100%
UNIVERSITY_CAMPUS	Caledonia Campus - Ochil Centre (Focus School)	287100	693300	0%	0%
UNIVERSITY_CAMPUS	Campus Training Ltd	547300	121600	0%	0%
UNIVERSITY_CAMPUS	Canterbury Christ Church University	615700	157700	0%	0%
UNIVERSITY_CAMPUS	Canterbury Christ Church University College	615700	157700	0%	0%
UNIVERSITY_CAMPUS	Castlereagh Campus	148500	527200	0%	100%
UNIVERSITY_CAMPUS	Cranfield University	494100	242700	0%	0%
UNIVERSITY_CAMPUS	Cronton Campus	350400	388300	0%	100%
UNIVERSITY_CAMPUS	Downpatrick Campus	158300	498600	0%	0%
UNIVERSITY_CAMPUS	Durham University	445500	518700	0%	100%
UNIVERSITY_CAMPUS	East Dunbartonshire Campus	265400	673600	0%	0%
UNIVERSITY_CAMPUS	Edge Hill University	342200	407400	0%	100%
UNIVERSITY_CAMPUS	Fakenham Community Campus Trust Ltd	591900	329800	0%	0%
UNIVERSITY_CAMPUS	Falmouth University	180700	32200	0%	0%
UNIVERSITY_CAMPUS	Halesworth Campus Ltd	638400	276700	0%	0%
UNIVERSITY_CAMPUS	Harper Adams University	371300	320300	0%	0%
UNIVERSITY_CAMPUS	High Wycombe Bucks University	486400	192900	0%	100%
UNIVERSITY_CAMPUS	Lancaster University	348500	457400	0%	0%
UNIVERSITY_CAMPUS	Lancaster University Management School	348500	457100	0%	0%
UNIVERSITY_CAMPUS	Leeds Trinity University	423400	439200	0%	100%
UNIVERSITY_CAMPUS	Newtownards Campus	161500	528700	0%	0%
UNIVERSITY_CAMPUS	Open University	146700	529400	83%	100%
UNIVERSITY_CAMPUS	Royal Agricultural University	400500	201200	0%	0%
UNIVERSITY_CAMPUS	Students Union University For The Creative Arts	483500	147000	0%	100%
UNIVERSITY_CAMPUS	The University Of Buckingham	469300	233500	0%	0%
UNIVERSITY_CAMPUS	The University Of Hull Scarborough Campus	504700	486400	0%	0%
UNIVERSITY_CAMPUS	University Campus Barnsley	434400	406600	0%	100%
UNIVERSITY_CAMPUS	University College	427300	542300	0%	0%
UNIVERSITY_CAMPUS	University For The Creative Arts	615700	157400	0%	0%
UNIVERSITY_CAMPUS	University Of Bedfordshire	506600	250400	0%	0%
UNIVERSITY_CAMPUS	University Of Bedfordshire Putteridge Bury Campus	512000	224800	0%	100%
UNIVERSITY_CAMPUS	University Of Brighton School Of Health Professions	559900	97500	0%	0%
UNIVERSITY_CAMPUS	University Of Chichester	486500	105800	0%	0%
UNIVERSITY_CAMPUS	University Of Cumbria	337600	504900	0%	0%
UNIVERSITY_CAMPUS	University of Cumbria	337600	504900	0%	0%
UNIVERSITY_CAMPUS	University Of Exeter Cornwall Campus	176900	34800	0%	0%
UNIVERSITY_CAMPUS	University Of Kent	614200	160000	0%	0%
UNIVERSITY_CAMPUS	University Of South Wales	307900	188700	0%	0%
UNIVERSITY_CAMPUS	University Of South Wales Students' Union	308100	188500	0%	0%
UNIVERSITY_CAMPUS	University Of St Andrews	351000	716900	0%	0%
UNIVERSITY_CAMPUS	University Of Stirling	280800	696400	0%	0%
UNIVERSITY_CAMPUS	University Of Sussex	534600	109300	0%	100%
UNIVERSITY_CAMPUS	University Of Sussex School Of Education & Social Work	534500	109300	0%	100%
UNIVERSITY_CAMPUS	University Of Ulster	149900	539400	33%	33%
UNIVERSITY_CAMPUS	University Of Wales T S D	239700	220300	0%	0%
UNIVERSITY_CAMPUS	University Of Wales Trinity Saint David	258000	248300	0%	0%
UNIVERSITY_CAMPUS	University Of Winchester	447200	129100	0%	0%
UNIVERSITY_CAMPUS	University Of Wolverhampton Telford Campus	371300	309600	0%	0%

Other high traffic sites not included in the top 80 area

There are important places outside Ofcom's top 80 towns/cities where some of our busiest sites are located, as well as seasonal traffic locations and historical towns with a high density of tourist traffic. We propose such places need to be included in auction licences.

Places with busiest sites outside Ofcom's top 80 areas

For example, our next busiest 153 sites that are not included in Ofcom's top 80 areas, fall in the following places:

Alexandria, West Dunbartonshire; **Atherstone**; Aylesbury; Barrow in Furness; Bedford; **Billingham**; Blackburn; Boston, Lincolnshire; Braintree; Bridgend; Bridgwater; Burnley; Burton-on-Trent**; Bushey Heath;** Cannock; **Canvey Island, Essex; Cheshunt;** Chichester; Cleethorpes; Clifton, Nottinghamshire; **Clydebank**; Clyst St. George; Corby; Cwmbran; Darlington; Didcot; **Eccles; Fareham; Gatwick;** Glossop; **Gowerton**; Greenock; Grimsby; **Halesowen**; **Harlow; Haughton Green, Manchester;** Haverfordwest; **High Wycombe;** Hinckley; **Hoddesdon**; **Hyde**; Isle of Sheppey, Kent; Kettering; **Killingworth, Newcastle;** Kimberley, Nottinghamshire; Kirkby-In-Ashfield; Leamington Spa; Llanelli; Macclesfield; **Maidstone**; Mambeg, Gareloch; Mansfield; Merthyr Tydfil; Morecombe; Neath; Newark; Newbridge, Caerphilly; **Nuneaton**; Paignton; Pontefract; Pontypool; Pontypridd; Porth, Wales; **Potters Bar;** Prestatyn; Retford; Rhyl; Rugby; Rugeley; Scunthorpe; Sheerness; Sittingbourne; Spalding; **St Helens;** Stevenage; **Stourbridge; Stretford, Manchester; Sunbury-on-Thames;** Sutton-in-Ashfield; Swadlincote; Taunton; Telford; **Thornaby**; Torquay; Treorchy; **Tunbridge Wells; Walton-on-Thames;** Whitley Bay; Windermere; Wishaw, North Lanarkshire; Witham, Essex; Wyke Regis, Weymouth; Yeovil; Ystrad Mynach.

Note: Places in **bold** in this list would be included in the high density areas under BT's proposal of the top 80 Ofcom areas modified to form larger rectangular areas.

Additional historical, tourist and other towns/areas

Examples are Cotswolds and Torquay, Stevenage etc., some already included in the previous list above.

[✂

]

Note: Places in bold in this list would be included in the high density areas under BT's proposal of the top 80 Ofcom areas modified to form larger rectangular areas.

Motorways

Motorways are of interest for mmWave deployments given some of the future use case that can be envisaged related to vehicles, the high density of traffic that these often support and the fact that these are often long sections of straight road with regular gantries and other assets that could support mobile network infrastructure. All UK motorways[42] should be included in sub-national licences for the high traffic areas. We estimate that if Ofcom's top 80 high density areas were modified to the larger regular squares as we have proposed in Section 4 of the response, 69% of motorways would be included in that area. Whilst only 21% of the UK motorways are covered by Ofcom's top 80 areas.

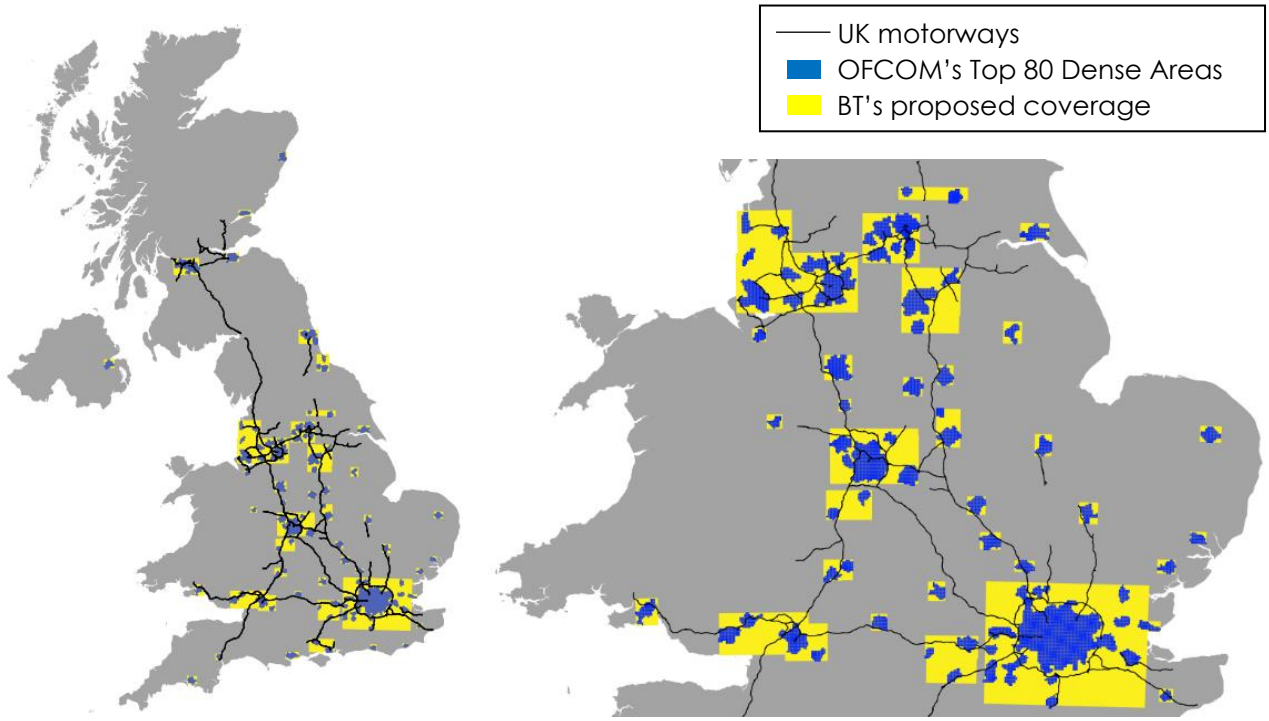


Figure A-1: Motorways (a) overview (b) detail

Train stations / ports

We propose that all ports and major train terminals are included in the auction licences.

[42] A suitable dataset is at https://www.ordnancesurvey.co.uk/business-government/products/open-map-roads

Annex B: Examples of high traffic areas not in top 40/80 high density areas

Introduction

This annex to BT's response to Ofcom's mmWave consultation provides the results of analysis that BT has undertaken to assess Ofcom's proposed "high density" auction licence areas against the places where we find that traffic density is highest in our network today as well as locations that we think could be of particular importance to us to serve future requirements of our customers using mmWave frequencies.

Coincidence of our busiest sites and Ofcom's proposed top 20/40/80 high density areas

A significant proportion of our coverage from busiest sites is outside Ofcom's mmWave areas

Table B1 shows the numbers of the busiest EE sites that fall within the top high density areas that Ofcom has specified. Numbers are incremental, e.g. 68 more sites fall in top 40 areas than the 700 that are in top 20 areas..

Table B-1: Analysis of EE's busiest site locations compared to Ofcom's high density areas

Count of Sites	Primary OFCOM Area					
Busy Hour Ranking	Inside Top 20	Inside Top 40	Inside Top 80	Outside Top 80	Unknown	Grand Total
0001-1000	700	68	78	153	1	1,000
1001-2000	532	71	84	309	4	1,000

Busiest sites defined as those within top 2,000 sites for busy hour PRB demand (Mar-22).
A site is within a mmWave area if site coverage (over UK mainland) >= 50% (principal area applied).

These top 2,000 sites handle [✂] of all traffic, as shown in Table B2.

Table B-2: Analysis of traffic falling in Ofcom's high density areas

Percentage Of Traffic	Primary OFCOM Area					
Busy Hour Ranking	Inside Top 20	Inside Top 40	Inside Top 80	Outside Top 80	Unknown	Grand Total
0001-1000	14.79%	1.35%	1.52%	2.85%	0.03%	20.53%
1001-2000	7.08%	0.94%	1.10%	4.05%	0.05%	13.22%

Locations with busy sites that are only in top 41-80 high density areas

[

✂

]

Figure B 1: Oxford – Eight busy sites but only a top 80 area

[

✂

]

Figure B 2: Cambridge – seven busy sites but only a top 80 area

[

✂

]

Figure B 3: York – Top 80 area but five high demand sites

[

✂

]

Figure B 4: Bath – six high demand sites but only a top 80 area

[

✂

]

Figure B 5: Teesside – Middlesbrough is only a top 80 area but has many busy sites

Locations with busy sites outside top 80 high density areas

[

✂

]

Figure B 6: South Wales – High demand in the valleys always outside top 80 areas

[

✂

]

Figure B 7: Torquay and Paignton – Busy sites but outside top 80 areas

[

✂

]

Figure B 8: Milton Keynes and Bedford – Many busy sites but MK is only in top 80 and Bedford is outside top 80

[

✂

]

Figure B 9: Burton and Swadlincote – Busy sites but outside top 80 areas

Busiest sites not correlated with highest population

[

✂

]

Figure B 10: Cheltenham and Gloucester – Busiest sites in Cheltenham but only Gloucester is a top 40 area

Busy airport sites excluded from top 80 high density areas

[

✂

]

Figure B 11: Gatwick – Busy airport sites outside top 80 areas

[

✂

]

Figure B 12: Aberdeen – Busy airport site outside top 80 areas

[

✂

]

Figure B 13: Edinburgh – Busy airport site outside top 80 areas


BT