Annex

Response to "Spectrum Roadmap: Delivering Ofcom's Spectrum Management Strategy"

Proposed Future Work Areas: Better Data for Better Spectrum Management

Meta supports Ofcom's conclusions about the need for more effective, data-driven spectrum regulation. Knowing how, and how much, sustainable investment and innovation a given proposed spectrum use will produce represents a critical first step in deriving the greatest public benefit from public spectrum resources.

Although no one can reliably predict demand for specific services or the future direction of new technologies, a holistic approach to evaluating the relative merit of different possible uses offers Ofcom the best opportunity to make informed predictive judgments. Judgments informed by a holistic approach have the greatest potential to promote investment, stimulate deployment, protect the environment, and encourage innovation.

When confronted with a choice between different technologies competing for the same resource, regulatory authorities have an interest, if not an obligation, to take a holistic approach. Ofcom, therefore, rightly identifies an array of criteria to consider when adopting new rules, including (i) costs to consumers; (ii) feasibility of coexistence with incumbent operators, (iii) spectrum efficiency; (iv) environmental effects; and (v) the incentives for innovation and investment.

One factor not currently addressed in the Ofcom Road Map, however, is (vi) the degree to which a proposed rule advances a desirable technology ecosystem. Cost-effective wireless communications depend on the realization of scale economies. A regulator's technical decisions are, in this sense, as much a choice about which technologies will achieve scale and which will not as about the specifics of how those technologies need to operate. Scale can also determine precisely which interconnected technology ecosystem a nation's innovation centres will occupy and, in turn, whether an interdependent network of diverse entities can spur innovation across the economy, or whether newly concentrated international sourcing options emerge to leave a nation more vulnerable to systemic risk from exogenous shocks or disruptions. A diverse, interconnected, and allied technical ecosystem has value and deserves a prominent place in the Ofcom Road Map.

The 6 GHz Band: An Example of the Importance of Data.

The debate around the 6 GHz band offers a prime example of how Ofcom can employ data to draw conclusions about how to develop a spectrum band. An analysis of available data for the 6 GHz band shows that:

(1) The vast majority of the traffic delivered to consumers is through fixed broadband infrastructure and Wi-Fi. Mobile networks deliver only a sliver of the broadband traffic that consumers need;

(2) RLAN is compatible with 6 GHz incumbents and would lead to increased sharing in the 6 GHz band, whereas IMT would require the removal of fixed link and satellite operations from the 6 GHz band;

(3) The spectrum efficiency of Wi-Fi is much greater than the spectrum efficiency of mobile networks. The spectral efficiency of Wi-Fi in the U.K. would increase with the addition of the upper 6 GHz while the spectral efficiency of mobile broadband would decrease if the upper 6 GHz is allocated to IMT due to deployment restrictions necessary to coexist with incumbent services;

(4) The propagation characteristics of the 6 GHz band make it especially appropriate for RLANs, and especially inappropriate for mobile, due to high building penetration loss;

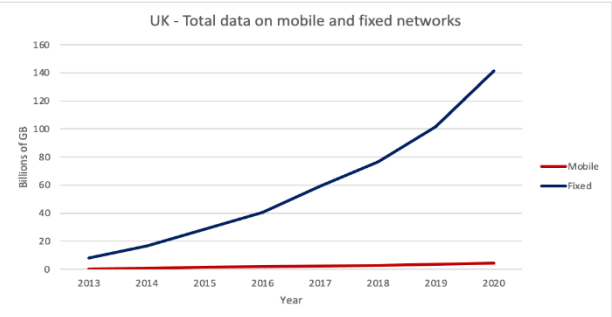
(5) An unlicensed allocation in the 6 GHz band would spur significant innovation and investment, while an IMT allocation in the band would delay innovation; and

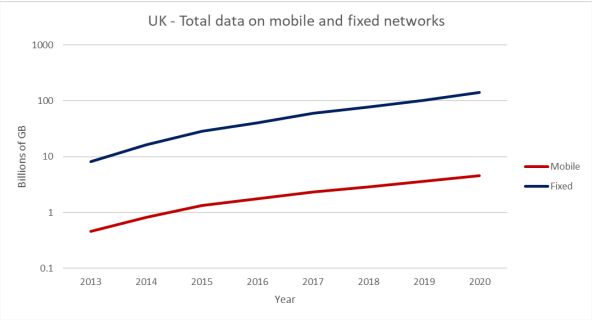
(6) Unlicensed operations in the 6 GHz band would have a negligible environmental impact, while IMT operations would have negative environmental impact throughout densely populated centres.

Network Traffic Data:

Proponents of allocating the 6 GHz band for IMT argue that there is a demand for additional mobile capacity in city centres throughout the U.K. The growth of traffic on mobile networks is the primary argument used for seeking new spectrum allocations for mobile usage and, indeed, Ofcom's data show that mobile traffic is growing.

However, this argument ignores the reality of internet traffic in the U.K. As the below graphs demonstrate, while mobile and fixed broadband consumption is growing at the same rate, the total data consumed on fixed broadband networks is many times greater than the data consumed on mobile networks. Data shows that this trend will continue.[1] Indeed, mobile traffic was forecasted to constitute 6.2% of total Internet traffic in 2021 in the U.K., while fixed/Wi-Fi and fixed/Wired traffic was projected to constitute 53.5% and 40% of total internet traffic in the U.K. in 2021, respectively.[2]





[1] *See* Ofcom Communications Market Report 2021, https://www.ofcom.org.uk/research-and-data/multi-sector-research/cmr/cmr-2021/interactive-data. The two graphs show the same data, but the Y-axis has a linear scale on the left and has a logarithmic scale on the right.

[2] *See* https://www.cisco.com/c/dam/m/en_us/solutions/service-provider/vni-forecast-highlights/pdf/United_Kingdom_2021_Forecast_Highlights.pdf, p. 2.

The disparity between mobile traffic and fixed traffic is poised to increase, as more U.K. residents turn to faster fixed broadband services, such as residential fiber-to-the-premise, to meet their network speed needs in work and life.[3] This shift towards faster fixed broadband services is set to create a greater demand for unlicensed technologies.[4] An IMT allocation in the 6 GHz band is incompatible with this rising unlicensed demand. Ofcom should consider this data when deciding how to allocate the 6 GHz band.

Spectrum Sharing Data:

At the core of the debate whether to authorize fixed or mobile networks to operate in the 6 GHz band is the question of whether new services can coexist with incumbents in the 6 GHz band. Available data shows that, although fixed unlicensed networks can share the 6 GHz band with incumbent operations, coexistence between IMT and incumbent operations is unclear.

In the international context, regulators have repeatedly found that unlicensed operations can exist with satellite, fixed link, and radio-astronomy incumbents in the 6 GHz band. In the United States, the Federal Communications Commission (FCC) examined exhaustive Monte Carlo analyses and used this analysis to determine that unlicensed operations could coexist with 6 GHz incumbents.[5] While traditional models select a single value for each variable, Monte Carlo analyses use a range of possible values for each variable, and then run hundreds, thousands, or tens of thousands of simulations to produce a range of possible outcomes. Relying on repeated random samplings provides a more accurate picture of likely real-world conditions than using fixed, typically average, values for every possible variable. The FCC conducted a serious analysis of the data and concluded the risk of harmful interference would be "vanishingly low." When wireless industry operators later challenged the FCC's decision in court, the U.S. Court of Appeals for the District of Columbia Circuit upheld the decision as both reasonable and well supported based on the evidence.[6]

While data shows that unlicensed operations can coexist with incumbents in the 6 GHz band, there is no data to show that IMT operations may coexist with 6 GHz incumbents. Tellingly, GSMA's latest study advocating for an IMT allocation in the 6 GHz band entirely ignores coexistence.[7] In the United States, the FCC and mobile operators found it necessary to sunset FSS and FS in order

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[3] *See* Ofcom Connected Nations 2021: UK Report, https://www.ofcom.org.uk/__data/assets/pdf_file/0035/229688/connected-nations-2021-uk.pdf, p. 10 ("Our data shows that 28% / 8.2m residential premises in the U.K. are now served by full fibre – an increase of 10 percentage points, representing over three million additional premises, in the past year").

[4] *See* The Socioeconomic Benefit of The 6 GHz Band, https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=69042233&file=310121-The-socioeconomic-benefits-of-the-6-GHz-band.pdf, p. 12.

[5] *See* FCC 6 GHz Report and Order, https://www.fcc.gov/document/fcc-opens-6-ghz-band-wi-fi-and-other-unlicensed-uses-0, para. 114; *see also* CableLabs 6 GHz Low Power Indoor (LPI) Wi-Fi / Fixed Service Coexistence Study, https://www.fcc.gov/ecfs/file/download/DOC-5bc9642b74c00000-B.pdf?file_name=20191218_6GHz_InterferenceSimulation_final.pdf.

[6] *See* US Court of Appeals for the District of Columbia 6 GHz Ruling, https://bit.ly/3G53F9l.

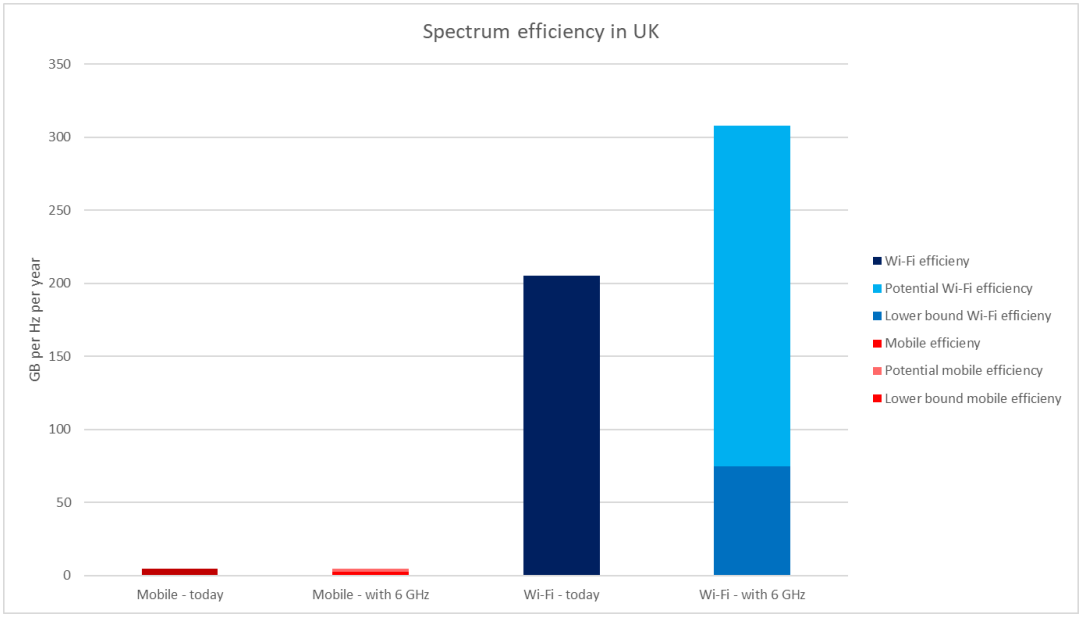
[7] The Socioeconomic Benefits of the 6 GHz Band - GSMA.

to allow mobile operations into the band.[8] Given the overlap of 6 GHz incumbents in the US and the U.K., it is imperative that data shows that coexistence between incumbents and licensed operations could occur.

In deciding how to allocate spectrum generally, and the 6 GHz band specifically, Ofcom should carefully evaluate data on whether a new entrant can coexist with incumbent operations. Rather than create a problem which will have to be addressed at a later date, Ofcom should allocate spectrum for operations that can readily coexist with incumbents.

Spectrum Efficiency Data:

The potential of allocating new spectrum to either Wi-Fi or mobile can be best understood when comparing data relating to spectrum efficiency, as measured by comparing the amount of wireless traffic carried annually to the amount of spectrum available to carry it. As the graph below shows, this metric is significantly greater for Wi-Fi than for mobile networks, which means that each Hertz of unlicensed spectrum carries significantly more data over the course of a year than each Hertz of mobile broadband spectrum.[9]



[8] *See* FCC 6 GHz Report and Order, https://www.fcc.gov/document/fcc-opens-6-ghz-band-wi-fi-and-other-unlicensed-uses-0, paras. 203-206 ("CTIA requests that the 'upper portion' of the 6 GHz band be repurposed for new licensed services, while Ericsson specifically requests that both the proposed U-NII-7 band (6.525-6.875 GHz) and U-NII-8 band (6.875-7.125 GHz) be repurposed").

[9] To create this data, we merely calculated the data delivered by a specific wireless technology divided by the overall spectrum available for the specific technology. The data volumes delivered by mobile networks and fixed networks respectively is consistent with the data from Ofcom's reports. Communications Market Report - Ofcom. Additionally, we assumed Wi-Fi to carry 92.3% of broadband traffic, which is consistent with ASSIA data. State of Wi-Fi Report - ASSIA. The spectrum efficiency for Wi-Fi does not account for lower 6 GHz spectrum, as equipment supporting the band was not available when the latest Ofcom broadband reports were published.

If the upper 6 GHz is allocated for IMT use, the restrictions on deployment in 6 GHz—including potential limitations on the EIRP, duty cycle, channel usage, number of base stations, and location of deployment—would mean that the average spectrum efficiency for mobile use is likely to decrease or, at best, stay the same.

Should the 6 GHz band be allocated for unlicensed use, the spectrum efficiency of Wi-Fi would remain many times higher than the current spectrum efficiency of mobile. Even examining the "[l]ower bound Wi-Fi efficiency" data, which assumes that traffic does not increase due to the availability of the 6 GHz band, the spectrum efficiency of Wi-Fi operations will still be 16 times greater than the current spectrum efficiency of mobile. The "[p]otential Wi-Fi efficiency" data highlights the more likely result of introducing unlicensed use in the 6 GHz band: spectrum efficiency will increase significantly. And it is reasonable to expect that the spectrum efficiency would skyrocket; the upper 6 GHz band will enable the most efficient version of Wi-Fi 7, including support for two additional extra-wide 320 MHz channels.

The data above shows that an IMT allocation in the 6 GHz band will do little to actually improve mobile connectivity and the allocation would be an inefficient use of the 6 GHz band. On the other hand, the 6 GHz band is well suited for unlicensed use, and Wi-Fi capability will be greatly improved by an unlicensed allocation in the 6 GHz band.

Ofcom should consider spectrum efficiency data generally, and in the 6 GHz particularly, when evaluating how to optimally use the spectrum. Simply put, spectrum is scarce and the entire communications ecosystem must be considered when decided how to allocate a band. Spectrum efficiency data is an important factor in deciding how to best allocate spectrum.

Propagation Data:

Ofcom should develop, seek, and analyse propagation data when deciding how to allocate the 6 GHz band. It is commonly understood that the lower bands have better propagation characteristics for coverage and indoor penetration, whereas the higher bands are more suitable for outdoor hot-spot and indoor deployments with relatively poor outdoor-to-indoor coverage capabilities. Accordingly, proponents of IMT operations in the 6 GHz band envision utilizing the 6 GHz band in urban areas.[10] As a result of this, U.K. consumers who live or work outside of densely populated areas may not benefit from an IMT allocation in the 6 GHz band.

Even within densely populated urban areas, the benefits of a 6 GHz IMT allocation are uncertain; IMT operations in the 6 GHz band will have heightened building entry loss, meaning the quality of service for indoor mobile users will be poor. The *extent* of the building entry loss is a matter of debate and uncertainty.

Given this uncertainty, Ofcom should develop, collect, and analyse data indicating whether—and where—mobile operators could deploy mobile operations in the 6 GHz band.

Investment & Innovation Data:

[10] *See* The 6 GHz Opportunity for IMT, http://www.coleago.com/app/uploads/2020/09/The-6GHz-Opportunity-for-IMT-Coleago-1-Aug-2020-002.pdf, p. 7.

Ofcom should seek and analyse data on how an allocation will spur (or deter) investment and innovation. This makes sense, as innovation has the power to impact, improve, and change the way we live. In the present case, an unlicensed allocation in the 6 GHz band would bring incredible innovation to consumers.

Access to the entire 1200 MHz of the 6 GHz band for Wi-Fi use would empower Wi-Fi 6 and the upcoming Wi-Fi 7 to take advantage of the technological advancements in ways not possible before:

> When Wi-Fi operation is limited to the 2.4 GHz and 5 GHz bands, there is insufficient bandwidth to accommodate the growth in demand with the expected Quality of Service (QoS) of the current applications (video streaming, gaming, voice, etc.) and, at the same time, to enable new innovative services and usage scenarios to make use of the Wi-Fi network. Therefore, user experience is compromised due to channel congestion. Allocation of the 1200 MHz of contiguous spectrum in the 6 GHz band to unlicensed operation provides sufficient bandwidth such that Wi-Fi 6E and the next generation of Wi-Fi, namely Wi-Fi 7, can benefit from cleaner, non-overlapping performance of larger channel bandwidths up to 320 MHz.[11]

As the above quote from Intel explains, current innovation is hamstrung by the lack of bandwidth available to applications. Intel supports this statement with meticulous data. An example of how innovation is hamstrung by Wi-Fi standard can be found in AR/VR technology. VR rendering relies on Wi-Fi and requires end-to-end latencies of under 10 ms with 99.9% reliability and single-stream throughput of around 100 Mbit/s. The network performance for AR/VR and other delay-sensitive residential, enterprise, and industrial applications of Wi-Fi 7 is impacted by the amount of available spectrum.

Intel's Wi-Fi 7 study concludes that in moderate- to high-traffic load environments, a single 320 MHz channel would be insufficient to maintain the end-to-end delay and reliability requirements for AR/VR applications. In such environments, "[o]nly the availability of three non-overlapping 320 MHz channels would be able to cope with the increase in demand and keep the performance at acceptable levels even for highly loaded scenarios.[12]

In all, Intel's data show that—to successfully introduce emerging applications and spur innovation—the 6 GHz band should be made available for unlicensed operations to allow Wi-Fi 7 to access the needed three non-overlapping 320 MHz channels. If Ofcom forgoes allocating unlicensed use in the upper 6 GHz band, it will compromise the ability for emerging technologies to flourish. As Intel's study shows, the available bandwidth in the 2.4 and 5 GHz bands are inadequate for emerging technologies to flourish. The same is true for the available bandwidth in the 6 GHz band if unlicensed use is only allocated in the lower portion of the band. Only by

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[11] *See* Spectrum Needs of Wi-Fi 7 by Intel, https://www.intel.com/content/dam/www/central-libraries/us/en/documents/spectrum-needs-wi-fi-7-whitepaper.pdf, p. 2.

[12] *See* Spectrum Needs of Wi-Fi 7 by Intel, https://www.intel.com/content/dam/www/central-libraries/us/en/documents/spectrum-needs-wi-fi-7-whitepaper.pdf, p. 6.

allocating unlicensed use in the entire 6 GHz band can emerging technologies—like AR/VR—truly flourish.

Available data also show which *types* of innovation will be brought about by an unlicensed allocation in the 6 GHz band. For example, AR/VR will revolutionize countless industries, including the medical and education industries. The U.K. National Health System has begun using the Oculus Go's virtual reality capabilities to stimulate senior citizens who might be suffering from dementia.[13] The VR device is used to improve the lives of people with dementia.

VR technology can also improve education in classrooms and beyond by providing more memorable and immersive learning experiences for students.[14] In the higher education and professional training context, the technology has shown promise for enhancing learning of abstract concepts and allowing hands-on experience in low-risk virtual settings.[15] For example, hospitals have begun using VR technology to train new emergency room doctors and staff on responding to trauma cases.[16] Although the full potential of AR/VR has not yet been realized, we can see how AR/VR technology will create incredible change.

In terms of the economic benefits from introducing unlicensed use into the 6 GHz band, economic analyses find that by 2025 AR/VR in Europe will be a €35 billion to €65 billion industry and create up to 860,000 jobs.[17] And this estimate is only for AR/VR and does not encompass the other emerging technologies finally made possibly by unlicensed use in the entire 6 GHz band.

As a stark contrast from unlicensed use, IMT operations in the 6 GHz band offers negligible innovation. It is important to understand *what* services would result from an IMT allocation in the upper 6 GHz band. The Coleago report, which was issued by proponents of the 6 GHz band, clearly lays out that IMT operations in the 6 GHz band will be used for additional 5G capacity in dense city centers. Mobile operators plan to use the 6 GHz band to merely avoid densification of networks and deploy additional capacity in dense urban areas. As an initial matter, U.K. consumers outside of the densely populated city centers would not benefit from this use of the 6 GHz spectrum. Additionally, proponents of an IMT allocation in the 6 GHz band are unable to point to any new innovations that would be spurred by this allocation; an IMT allocation would merely provide additional capacity in areas which will already receive mobile 5G services.

Environmental Data:

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[13] *See* How Virtual Reality is Helping People with Dementia, https://www.bbc.com/news/av/business-49654052.

[14] *See* VR for Education, https://immersionvr.co.uk/about-360vr/vr-for-education/; *see also* 7 Ways Augmented Reality Is Changing Education Industry in the UK: The Future of Learning Is Now, https://arpost.co/2020/03/10/7-ways-augmented-reality-education-the-uk/.

[15] *See* The Promise of Immersive Learning: Augmented and Virtual Reality's Potential in Education, https://bit.ly/3FY8z8d.

[16] *See* VR for the E.R. – Preparing for Emergencies Before They Happen, https://www.oculus.com/vr-for-good/stories/preparing-for-emergencies-before-they-happen/.

[17] *See* XR and Its Potential for Europe, https://xreuropepotential.com/assets/pdf/ecorys-xr-2021-report.pdf.

In its Spectrum Roadmap, Ofcom "expect[s] stakeholders to increasingly consider the environmental impact of their operations."[18] Given Ofcom's acknowledgement of the importance of the environmental impact of communications operations, it should carefully develop, seek, and analyse data on the environmental impact of potential allocations in a band.

From an environmental standpoint, an unlicensed allocation in the entire 6 GHz band would have a much lower environmental impact than would an IMT allocation in any part of the 6 GHz band. As data shows, an unlicensed allocation which would provide Wi-Fi supported by a fiber network requires a fraction of the energy consumption needed for an IMT deployment over the 6 GHz band.[19] France's ARCEP reached the same conclusion: "1 Gb relayed over fibre consumes less energy than 1 Gb relayed over an electrical conductor" and "1 Gb relayed over WiFi consumes les energy than 1 Gb relayed over a cellular network."[20] In addition, allocating the upper portion of the 6 GHz band for unlicensed use—including Wi-Fi operations—would improve Wi-Fi capacity without requiring new access points or devices. As a result, the additional allocation would not create an additional environmental footprint.

Introducing IMT operations into the 6 GHz band would create a significantly larger environmental footprint. A typical 5G base station consumes more power to overcome naturally occurring propagation and in-building penetration losses than a typical consumer or enterprise hotspot, which operate indoors or in a highly localised area using comparatively little power. Each of those 5G base stations will also require more backup battery capacity to satisfy power consumption and service-reliability demands, and for years providing 5G backup power has meant using lead-acid batteries, which are less costly than lithium-ion batteries but have low energy density and can contaminate both ground and water if not recycled properly. Moreover, the energy consumption and battery back-up power demands of 5G technologies will only increase as consumer demand for broadband services continue to expand because deploying a denser layer of power-hungry small cells will be the most logical mechanism to increase 5G network capacity in the absence of unlicensed spectrum opportunity.

As an additional consideration, for several years mobile operators have used technologies that leverage unlicensed spectrum, such as licensed-assisted access ("LAA") using currently available unlicensed bands. This trend will likely continue with 5G New Radio over Unlicensed ("NR-U") in unlicensed 6 GHz spectrum to opportunistically provide additional capacity and bandwidth mostly in urban areas.[21] In other words, allocating 6 GHz for unlicensed does not preclude mobile operators from using the spectrum to improve 5G networks. Rather, mobile operators can still utilize an unlicensed allocation to deploy LAA and NR-U technologies in a more environmentally-

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[18] *See* Ofcom Spectrum Roadmap, https://www.ofcom.org.uk/__data/assets/pdf_file/0021/234633/spectrum-roadmap.pdf, Section 4.7.

[19] *See* The Power of Wireless Cloud, https://ceet.unimelb.edu.au/publications/ceet-white-paper-wireless-cloud.pdf.

[20] *See* Achieving Digital Sustainability - Autorité de Régulation des Communications Électroniques, des Postes et de la Distribution de la Presse (ARCEP), https://en.arcep.fr/uploads/tx_gspublication/achieving-digital-sustainability-report-dec2020.pdf.

[21] *See* How Does Unlicensed Spectrum with NR-U Transform What 5G Can Do for You, https://www.qualcomm.com/media/documents/files/presentation-how-nr-u-can-transform-what-5g-can-do-for-you.pdf.

friendly fashion: rather than rely on energy-inefficient mobile technologies, mobile operators can utilize low energy consuming unlicensed technologies to improve their 5G network.

When choosing between different types of service to allocate into a particular band, Ofcom should consider environmental impact data in helping decide how to best allocate spectrum.

Global Ecosystem Data:

As a final consideration, data shows the USA, Canada, Brazil, South Korea and most of the UK's strongest allies are building a global Wi-Fi ecosystem with access to the full 5925-7125 MHz.[22] On the other hand, proponents of an IMT allocation are already aggressively requesting protection of the upper 6 GHz band from unlicensed users in the lower portion of the 6 GHz band. The requested protections by IMT proponents would require filtering and deviating from the global unlicensed ecosystem.

If the U.K. and Europe favour an IMT allocation in the upper portion 6 GHz band, it will prevent U.K. from leveraging the global ecosystem and will create a device asymmetry between the U.K. and its closest allies abroad. An IMT allocation in the 6 GHz band would endanger the ability for U.K. citizens to use their devices overseas or for citizen from USA, Canada and South Korea to use their Wi-Fi devices in the U.K. The U.K. would be unable to align with its US, Canadian, and South Korean counterparts to achieve economies of scale for devices that would operate in the 6 GHz band, and would need to exclusively operate in the Chinese and Russian communications ecosystems to achieve such economies of scale.

[22] *See* Wi-Fi Alliance Report on Countries Enabling Wi-Fi 6E, https://www.wi-fi.org/countries-enabling-wi-fi-6e.