A1. Comments on Ofcom's Spectrum Roadmap

Comments on the structure or design of the roadmap

Stakeholder comments	Ofcom response
Suggestions for the *'Spectrum Use in the UK'* section The **Joint Radio Company (JRC)** noted that whilst groups such as maritime, aeronautical, amateur and PMSE are identified in the table of user classes, the utilities sector is not. The **JRC** would welcome a dedicated category for the utilities sector in future publications. **Julian Thompson** provided a number of suggestions on how to improve the 'Spectrum use in the UK' section, including areas that he thought needed further clarification.	The sector categories we use in the Roadmap are primarily based on those used internationally in the ITU Radio Regulations. Given the trends toward network convergence and our strategy to make access to spectrum more flexible we do not intend to add additional, sector specific categories. However, we will be exploring the use of spectrum by utilities as part of the dedicated project set out in our Annual Plan of Work.
A future spectrum pipeline for mobile **BT** registered concern that the roadmap did not set out concrete proposals for identifying additional spectrum for public mobile networks. BT hoped this would be resolved as Ofcom considers comments on the recent '*Meeting future demand for mobile data'* discussion document, and as the UK positions for the ITU WRC23 are confirmed. Similarly, **Virgin Media O2 (VMO2)** argued the roadmap should clearly set out the timelines for release of suitable additional spectrum for mobile use over the coming years.	We will publish a statement following our discussion paper on "Meeting future demand for mobile data" later this year and also set out our proposed next steps. We published a call for input on "UK preparations for the World Radiocommunication Conference 2023 (WRC-23)" on 24 June, which includes items relevant to spectrum suitable for public mobile networks.
Reference to UK Industry fora **BT** argued that Ofcom's Spectrum Roadmap could perhaps make reference to the work of the UK Spectrum Policy Forum, including stating a willingness to consider any recommendations that may come from its work, or the output of other UK industry fora.	We will continue to take into account all relevant evidence and submissions when developing our policies.

Omission of a consultation **Eutelsat** noted that the consultation on *'proposals to amend the authorisation conditions for the use of certain short-range devices'* was not included in the spectrum roadmap and suggested it should be explicitly referenced to bring visibility to the topic.	We have noted this point. The consultation closed on 4 July and we published a statement on 28 September. These documents are are published on our website. We generally consult on updates to the authorisation conditions for short-range devices annually. Given the programmatic nature of this work we do not normally include it in our Annual Plan of Work.

Ofcom's current priority projects

Stakeholder comments	Ofcom response
Mobile Spectrum Demand We received a number of responses relating to the future allocation of spectrum to mobile, both for and against. Whilst not all of these explicitly referenced the *Mobile Spectrum Demand* project, we have grouped comments here for ease of reference. Related to this, **Eutelsat** argued that Ofcom should defer conclusions on mobile spectrum until studies and consultations conclude on network convergence, arguing this would enable a decision to be made based on the full picture, including the role of satellites. **OneWeb** suggested that before considering any additional IMT frequencies, it was essential for the mobile industry to demonstrate more efficient use of already identified IMT frequencies. It noted that WRC-19 identified 17.5 GHz of bandwidth for IMT, with only a very small proportion of it having been licensed. It argued that reallocating spectrum to mobile would negatively impact new satellite capabilities.	We will be considering these comments in conjunction with responses to our discussion paper on "Meeting future demand for mobile data". We expect to set out our initial conclusions on mobile networks and spectrum by the end of 2022. In relation to the international aspects of these bands, we have set out provisional views and positions for WRC-23 in a call for input. (We discuss this in more detail under *"Preparation for WRC 2023* below).

Upper 6 GHz Several UK MNOs - **BT, Virgin Media O2 (VMO2**) and **Vodafone** - argued that the upper 6 GHz band should be made available for mobile use. **BT** said that the band would provide much needed additional spectrum capacity, and that meeting future demand would be impractical by other means, such as building large numbers of small cells. **VMO2** also argued for the need for mid-band spectrum (highlighting a report from Coleago[1]). **Vodafone** said that without the band, mobile networks would become congested and that mmWave did not present an economically viable substitute as the idea of deploying tens of thousands of small cells is detached from investment realities. All three called for further analysis, with **BT** noting the need to consider the economic benefits of different policy options, and **Vodafone** arguing that Ofcom should consider investment incentives in more detail. A number of other stakeholders argued the band should be made available for licence exempt use to enable Wireless Access Systems (WAS) or Radio Local Area Networks (RLANs). A joint response from **Apple, Broadcom, Cisco, HPE and Meta** said that this would enable larger Wi-Fi channel bandwidths of 320 MHz, which would increase spectrum efficiency and enable high-bandwidth applications and services.[2] They, alongside a separate response from **Meta,** noted that the majority of current consumer traffic today is through fixed broadband and Wi-Fi, and that broadband speeds are growing, meaning more spectrum will be required to support the high-bandwidth applications that faster broadband will make possible. **Meta** argued that a licence exempt allocation would offer many benefits relative to mobile, including greater compatibility with incumbents, greater spectral efficiency, and a lower environmental impact. Meta also said that an unlicensed allocation would spur innovation in new services. such as advanced VR, whereas an IMT allocation would offer few benefits other than avoiding densification costs. **Meta** and **Shure** noted that an unlicensed allocation would align with countries like the USA, Canada and South Korea, whereas failure to do so may result in the need to operate in the Chinese	

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

[2] The response also suggested that further consideration should be given to regulatory changes to enable higher performance for Wi-Fi 7. They argued it would be preferable if larger 320 MHz channels could operate at 3 dB higher power, to maintain the PSD of a 160 MHz channel.

and Russian communications ecosystems to achieve economies of scale. The **Wireless Broadband Alliance (WBA)** and the **Dynamic Spectrum Alliance (DSA)** also thought that Ofcom should allocate the band for licence exempt operation. The **WBA** argued that Wi-Fi is the single most impactful technology in UK's citizens' everyday lives, and that as fibre rolls out, the full 6 GHz band would be needed to ensure users get to experience new high-capacity connectivity.[3] It also said that spectrum sharing through an AFC system could enable greater efficiency to avoid interference with incumbents. The **DSA** noted that licence exempt 6 GHz devices would continue to offload traffic from cellular networks. ***600 MHz*** Several UK MNOs – **BT, Virgin Media O2 (VMO2**) and **Vodafone** – discussed the 600 MHz band in their responses. **BT** noted the omission of a project considering possible future changes to DTT spectrum and argued that it should be part of the roadmap. It also noted that the UK Spectrum Policy Forum is planning to look at this topic and that its output may be helpful to Ofcom. **Vodafone** also thought that Ofcom should launch a review of future DTT usage, taking into account changing viewing habits, with the potential of repurposing spectrum for mobile usage. **VMO2** said that allocating the band to mobile would help meet demand and improve mobile service quality across the widest areas of the UK, minimising a rural-urban divide (citing a Plum Consulting report[4]). It also argued that the value and efficiency of DTT as a mode of providing television would decrease over time. It said that if current users wish to vacate the spectrum ahead of the 2034 licence expiry date, Ofcom should be agile to close down DTT before licence expiry, and that in the meantime Ofcom should support a co-primary designation to mobile at WRC-23. However, several stakeholders noted concerns about the future of DTT spectrum, including the **Confederation of Aerial Industries (CAI).** The **CAI** were concerned about mobile services being made co-primary with broadcast in the 470 MHz to 694 MHz band, arguing that disparities in broadcast and mobile	

[3] The WBA notes recent studies highlight the need for multiple 320 MHz channels in 6 Ghz for Wi-Fi 7 to support scaling of applications: https://www.intel.com/content/www/us/en/wireless-network/spectrum-needs-of-wi-fi-7.html
[4] https://plumconsulting.co.uk/the-future-use-of-uhf-in-itu-region-1/

networks would make sharing the band very difficult. **MTECH** noted interference from other services already causes signal problems and the need to retune, and that customers would struggle to understand further interference. The **Voice of the Listener and Viewer (VLV)** said it was opposed to any dilution of DTT access to spectrum, and that it is neither judicious nor safe to relegate all public communications to online-only. The **VLV** also argued that as fibre penetration grows, pressure on mobile spectrum may ease as handsets can increasingly offload onto domestic and 'hotspot' Wi-Fi. **Webro** said that there are barriers to many consumers switching to online or satellite TV, and that the interference risk from a shared band would be significant. Its response opposed sharing DTT spectrum unless it could be proven that adequate protection ratios could be achieved with interfering in-band signals. A number of other stakeholders spoke about the continued need for sub-1 GHz spectrum to enable PMSE equipment (see **'***Programme Making and Special Events (PMSE) Spectrum'* below). ***Lower 2300 MHz Band and Spectrum sharing*** **VMO2** said that the current limited use of the 2310 – 2350 MHz band was suboptimal and urged Ofcom to facilitate the release of the spectrum, potentially at the same time as 1492-1517 MHz. Its response argued that if the band was made available for high power mobile use, it could provide capacity to meet the growing demand for mobile data. More generally, **VMO2** suggested that Ofcom's spectrum sharing framework should be more multidirectional. Its response noted that sharing opportunities exist for other users to access MNO spectrum, but that opportunities for MNOs to access spectrum used by other spectrum users have not been considered or progressed. It suggested that Ofcom should carry out scoping work to assess the feasibility of high-power mobile services being authorised to use spectrum in bands such as the lower 2300 MHz band and the 3.8-4.2 GHz band.	***Lower 2300 MHz Band and Spectrum Sharing*** In relation to the 2300 MHz band, our initial analysis indicates that it is not feasible at this point to clear all MoD use and that it currently appears unlikely to be feasible for high power mobile to be fully deployed across a majority of locations alongside these MOD uses (but low power, indoor use may be possible). We are continuing to explore with MOD whether there are sharing criteria that could be applied for other forms of outdoor access in the longer term.

Future use of the 1.4 GHz band for wireless broadband The **Joint Radio Company (JRC)** noted members are currently migrating to clear all remaining point-to-point links from the 1.4 GHz band. They noted that other regulators, in Ireland, Spain and France, have moved away from the concept of supplemental downlink spectrum for the band. The JRC encouraged Ofcom to compare plans with the approach of EU regulators. More generally, its response suggested that Ofcom investigate the establishment of a 'migration fund' to facilitate transfer of systems from one band to another, or to alternative connectivity options. They noted a fund previously used to assist the PMSE sector's migration from the 700 MHz band.	We are required to make the 1.4 GHz band available for mobile (which is consistent with our overarching strategy to support the roll-out of mobile services across the UK), and we plan to consult in 2023 on the specific use of this band for mobile supplemental downlink (SDL). With regard to the suggestion to establish a 'migration fund', we have previously written to the JRC in 2020 to explain that we do not consider it would be appropriate to provide funding for licensees to vacate the 1.4 GHz band. Our position on this has not changed.
Opening access to mmWave for mobile The **Joint Radio Company (JRC)** noted that closure of the 26 GHz band to new fixed links and the eventual revocation of licenses will require costly migrations by several utility companies. It suggested that the decision to clear this band may prove unnecessary, or at least premature, given the lack of progress internationally in these bands. (See *above* for discussion on a possible 'migration fund'). **Vodafone** requested that Ofcom focus on releasing mmWave at a price that reflects the challenging deployment economics. **Valeport** requested the 24.6 GHz band be kept clear of 5G transmissions to avoid interference with short-range tide height measuring radar that it manufactures.	We will be considering these comments as part of our work to enable access to mmWave spectrum for new uses. We consulted on our proposals on 9 May and the consultation closed on 18 July. The consultation and responses can be viewed here.
Space spectrum strategy **OneWeb** said that Ofcom should facilitate technologies that can demonstrably bring connectivity to rural areas and promote digital inclusion, including Low Earth Orbit systems, and that these systems need to have long term certainty regarding access to harmonised spectrum.	We have shared these comments with colleagues working on the space spectrum strategy. The space spectrum strategy statement has now been published on our website.

Vodafone noted that its collaboration with AST would largely make use of existing mobile spectrum bands for communications to user terminals – as such the policy adjustments needed would largely be to allow non-terrestrial usage of its licensed spectrum.	
Increasing access to the 14 GHz band **Vodafone** said that it supported the provision of further spectrum for NGSO usage but noted that the fixed links in the 14 GHz band support safety-of-life applications, meaning careful consideration must be given to revocation. We received a number of responses from **prospective Starlink customers.**[5] The majority of these simply asked for Ofcom to enable Starlink as quickly as possible. In addition, some noted that they need Starlink as they cannot get fast enough broadband to meet their needs, despite living in an urban area. Two respondents reported dissatisfaction with the services offered by BT and Virgin and argued Starlink would provide greater competitive pressure.	We have shared these comments with colleagues working on the 14 GHz project. The statement on this subject has now been published on our website.
Preparation for WRC 2023 **Virgin Media O2 (VMO2)** urged Ofcom to update the roadmap to include a commitment to seek harmonisation of the upper 6 GHz and 600 MHz bands, alongside details on preparations for WRC23. However, several stakeholders expressed reservations relating to these bands (see '*mobile spectrum demand*'). Specifically, the **British Entertainment Industry Radio Group (BEIRG)** requested that Ofcom take a clear position of 'no change' to the allocation of the 470 – 690 MHz band in (ITU) Region 1, which is Agenda Item 1.5 in WRC23. The **Dynamic Spectrum Alliance** also noted it did not support an IMT identification in the 6425-7125 MHz band at the upcoming World Radiocommunication Conference 2023 (WRC-23) under Agenda Item 1.2.	The positions on individual agenda items that Ofcom will take into next year's WRC are still under discussion. To this end, Ofcom published a call for input on "UK preparations for the World Radiocommunication Conference 2023 (WRC-23)" on 24 June to help inform the UK position for WRC-23, alongside the existing UK stakeholder engagement processes. We are currently reviewing responses to that publication. That document set out Ofcom's preliminary view in relation to Agenda Item 1.5, i.e. that a "No Change" result would meet the UK's interests. However, we also note that Ofcom is aware of arguments in support of

[5] When a postcode is entered on the Starlink website that Starlink cannot currently serve, a message is displayed which includes the Spectrum Roadmap inbox [as of 10/06/22].

	greater flexibility through the addition of a mobile allocation and possibly IMT identification in the band. Ofcom would expect to engage actively in these discussions, although our position to support the "No Change" option, in both the European and international deliberations, remains. In relation to Agenda Item 1.2, the call for input set out that, at present, Ofcom has an open mind on whether to support, or oppose, an IMT identification for 6425-7025 MHz in Region 1 (Europe, Africa, Middle East) and 7025-7125 MHz (globally). While we are still considering the future approach to the upper 6 GHz band in the UK, we do not want to rule out potential alternative uses (e.g., for Wi-Fi and other licence exempt uses) at this stage. Therefore, our view at this point in the WRC-23 cycle is that, as a minimum, the option of "No Change" should be considered in the wider process internationally. This possible outcome would not preclude IMT use of these bands in the UK in the future. The call for input closed on 6th October and responses will be published on this webpage in due course.
BT said that it would be useful to see some more details on the process that Ofcom will follow to establish specific UK	In response to **BT**, we note that Ofcom has regular stakeholder

objectives and positions for international meetings (ITU, CEPT etc.). It also suggested that Ofcom should have regular and ongoing engagement with UK industry.	meetings, either individually or through the WRC preparatory processes that Ofcom manages. The UK develops its position on topics over time and therefore we do not feel it appropriate to set positions too early in international discussions as it might limit later negotiation potential.
Ericsson noted the importance of globally harmonised and common technical and regulatory spectrum regimes. It argued that alignment with the WRC is critical alongside technical coordination at the ITU and in standardisation bodies such as 3GPP.	In response to **Ericsson,** we note that Ofcom recognises the value in the alignment of the regulatory processes and those bodies working on mobile standardisation. We also note that standardisation bodies, such as 3GPP, have exercised flexibility in defining bands for mobile standardisation that have limited, or in some cases no, IMT identification at an international regulatory level.
<u>Planning small scale DAB radio</u> **Better Media** proposed that Ofcom should maintain a public log and risk assessment of small-scale DAB delivery, including detailed data relating to how closely coverage matches the areas we advertise, and placing requirements on small-scale DAB multiplex licensees to make mitigation statements if their coverage does not incorporate all of an advertised area, so that consumers are aware of whether they will be able to receive their chosen services. Better Media proposed that Ofcom regularly assesses where FM/AM coverage is or is not contiguous with small-scale DAB coverage and what mitigation requirements we will require where there are coverage shortfalls, as well as 'giving emphasis to areas with historically poor broadband and mobile phone coverage, and where local analogue radio services are not covered by SSDAB services'. Better Media also suggested that Ofcom should publish assessments of any broadcasters that are unable to serve their target areas due to mismatches with actual coverage achieved	Ofcom publishes a number of items of information on radio services when they come on-air. We will be publishing maps of the coverage that each small-scale licensee achieves when its service has launched, as well as technical details of the transmitters. The industry postcode checker (Postcode checker - Digital Radio UK (getdigitalradio.com) includes coverage for small-scale radio services which should be used by consumers considering buying a DAB radio. However, we do not intend to assess or maintain a log of the

by small-scale multiplexes, as well as tracking the economic viability of programme services on multiplexes.	extent to which the coverage of small-scale radio multiplex services matches the areas we advertise, nor require licensees to take steps to address unserved areas. This is because the geographical areas defined in advertisements for small-scale radio multiplex licences provide a framework against which applicants can target their coverage (one of the factors Ofcom must take into account when awarding licences), based on likely demand and spectrum availability. They are not based specifically on the coverage areas of analogue services, and there is not a requirement for a licensee to provide coverage of all of the area advertised. Once a small-scale radio multiplex licence has been granted, the coverage area achieved by implementation of the final technical plan becomes the small-scale radio multiplex service's licensed area and the former advertised area 'polygons' cease to have any licensing significance. Details of the original shapes will remain available on our website, and interested stakeholders can make comparisons if they wish. We set out in our 2019 consultation and subsequent statement the criteria we would consider when deciding in which order to advertise small-scale DAB areas. We do not intend taking into account

	considerations beyond those criteria, although we will consider feedback from stakeholders on the likely demand from potential providers of either radio or multiplex services in specific areas, as well as on the shape of the areas we advertise. We do not intend tracking the economic viability of individual programme services due to the burden that this would place on Ofcom and licensees, and do not see a benefit in imposing this burden.
Increasing spectrum access for analogue radio services **Better Media** was supportive of Ofcom's recent initiative to make more spectrum available for radio restricted services (RSLs). It urged Ofcom to expand this proposal, and to undertake a review of the available spectrum on the AM and FM bands, with the intention of identifying the likely additional capacity that modifications such as the relaxation of the RSL licensing arrangements would generate. Better Media also suggested that Ofcom should undertake an urgent review of the impact that the BBC's proposed switching-off of AM radio services would have on other radio services sharing transmitter sites, as well as maintaining a risk register for management of a potential move to all-digital radio broadcasting.	We have recently consulted on making changes to the way we plan and license Radio Restricted Services (RSLs) with the aim of making more FM spectrum available and simplifying some aspects of the previous licensing framework. Now that the new framework is in place, we do not anticipate making any further changes to how we license RSLs. We will however monitor demand from licensees or potential licensees for RSLs as well as how well we are able to satisfy that demand within the available spectrum resources. One of the conclusions of the Government's Digital Radio and Audio Review in October 2021, was that a transition from FM to digital (both DAB and IP) will not be possible before 2030. It recommended that the radio industry should start to make plans for a transition, and that a

	further review should be carried out by 2026. We therefore do not intend publishing a risk register for a digital transition for radio at this time, although we will work with Government and industry stakeholders in supporting the review, and any plans that are developed. This is likely to include assessment of the implications if some analogue services switch off before 2030.

Spectrum for Utilities **Energy UK** encouraged Ofcom to continue engagement with the energy industry, in particular in view of the sunsetting of 2G/3G and the challenges involved in migrating energy networks (smart metering) to later technology generations. It also noted that some connectivity requirements in the energy sector will be reliant on mobile networks. As these requirements may differ from consumer data requirements, it suggested that Ofcom should consider this broader view of connectivity needs when setting policy. **Julian Thompson** noted the fact that the Government expects smart meters to be future proof, even as they transition away from 2G and 3G. The **Joint Radio Company (JRC)** noted that proposals to increase spectrum sharing may impact the performance of incumbent users. It noted that utility systems which are used to monitor and control critical national infrastructure require overall system availability of over 99.999%, meaning any performance degradation would likely have a detrimental impact. The **JRC** also noted that utility companies are incurring costs as they migrate from several bands (see '*Future use of the*	We recognise the importance of continued engagement with the energy industry. On 2G/3G switch-off, the MNOs have agreed with DCMS that these networks will be switched-off by 2033 at the latest.[6] The MNOs are switching off 3G networks first, and we have recently published a guide on our website which sets out each MNOs planned timetable, as well as further details on how it might affect customers and steps they will need to take. We are working closely with the mobile providers and other relevant stakeholders, including those in the energy

[6] See DCMS Statement

1.4GHz band for wireless broadband' and '*Opening access to mmWave for mobile'* for more detail*).* **Vodafone** argued that Ofcom's utilities work should concentrate on areas where current multiservice networks (e.g. mobile or fixed) cannot meet utilities needs. This analysis would allow an assessment of whether a bespoke network is needed, or if an augmented existing multiservice network could satisfy requirements.	sector, to monitor and support the switch-off process with the aim of minimising disruption and protecting customers from harm. In response to the **JRC** and **Vodafone** we will be exploring the use of spectrum by utilities as part of the dedicated *'Spectrum for Utilities'* project set out in our Annual Plan of Work.
<u>Understanding industry demand for spectrum</u> The **Ofcom Advisory Committee for Scotland** suggested that Ofcom engages with companies in Scotland that may be impacted by spectrum decisions, including drone companies (e.g. Glasgow-based Gibson Robotics) and satellite companies (including Alba Orbital and Spire Global Data and Analytics). **Virgin Media O2 (VMO2)** said that Ofcom should monitor and evaluate take-up of licences within the 3.8-4.2 GHz shared access band. It suggested that if there is relatively little usage, Ofcom should explore alternative uses and should set out conditions that would indicate whether the regime has been successful (e.g., a number of licences issued by a given date). **VMO2** also suggested Ofcom should assess the feasibility of high-power mobile services being enabled to use the spectrum (see *'mobile spectrum demand'*). The **Dynamic Spectrum Alliance (DSA)** argued that introducing new licensing options, supported by automated dynamic spectrum sharing technology, is the best path towards industry deployments. Whilst the DSA sees Ofcom's 3.8-4.2 GHz Shared Access framework as an excellent first step, it encouraged Ofcom to leverage commercially available automated shared access technology for Shared Access Licenses. The DSA noted the success of CBRS in the US. **Vodafone** said that the focus of the project may be wrong; industry has a demand for applications (which may consume spectrum), but not spectrum itself. It said that Ofcom's focus should not be on promoting a particular type of spectrum licensing (e.g. local and shared access), but instead on ensuring	We will continue to engage with industry to understand their wireless connectivity needs and preferences for spectrum access. We will continue to monitor take up of Shared and Local Access licences and explore options for providing more flexible access (including the potential for higher power use) as part of our work on accelerating innovation and exploring new spectrum sharing techniques. In response to **Vodafone,** we note that Ofcom makes spectrum available using a number of different licensing approaches with the goal of maximizing value. We will also

that spectrum is efficiently used when meeting industrial application demand.	continue to ensure potential spectrum users are aware of the various spectrum options available.

Enabling growing demand for the use of drones **Vodafone** welcomed Ofcom's analysis and offered to continue to work with Ofcom on this issue, but noted the consultation was due in April but had not yet been published.	We published a consultation on spectrum for unmanned aircraft systems on 10 June. The consultation closed on 5 September. The consultation is published on our website; responses will also be published here in due course.
Local indoor access in the upper 6GHz band A number of stakeholders expressed reservations on proposals for local indoor access in the upper 6 GHz band. The **Dynamic Spectrum Alliance (DSA)** suggested it may result in market uncertainty, which may discourage market adoption. The DSA recommended that Ofcom instead consider implementation of an Automated Frequency Coordination (AFC) system to enable more flexible licence-exempt operations while also ensuring protection of incumbent users.	We published a statement on 30 June setting out our decision not to proceed with the proposals for local indoor licences in the upper 6 GHz band that we consulted on in February 2022.
Terahertz *No specific comments*	*N/a*

Improving propagation models See *'Using real-world data to improve propagation and coexistence modelling'* for stakeholder comments relating to propagation models.	*N/a*

Noise floor measurements Among other benefits, **Federated Wireless** noted that automated spectrum sharing technology may allow the collection of real-world data on the noise floor.	We plan to explore the synergies in data collection across the various 'better data' initiatives that we are taking forward.
Database approach to spectrum management **Federated Wireless** noted a number of approaches to automated licensing and spectrum sharing and suggested that automated spectrum sharing could bring a number of benefits.[7] It urged Ofcom to implement machine-to-machine automated licensing across all shared bands as soon as possible, with the goal of supporting 'full' dynamic spectrum access where suitable. The **Dynamic Spectrum Alliance (DSA)** expressed full support for efforts to automate Ofcom's shared access framework. Both **Federated Wireless** and the **DSA** argued that Ofcom should consider already available dynamic shared access systems, including technologies developed under DCMS-funded projects. The **Ofcom Advisory Committee for Scotland** also noted DCMS funded work, suggesting '5G New Thinking' work would be worth considering. **Virgin Media O2** noted the possibility of a database approach to enable compatibility between high power mobile and shared access uses in the 3.8-4.2 GHz band. **Ericsson** cautioned that careful consideration needs to be given to the introduction of database tools promoting the concept of dynamic spectrum access. It noted that network infrastructure deployment requires significant time and investment and policies that introduce uncertainty to long term spectrum availability may impact investment. Similarly, **Apple, Broadcom, Cisco, HPE and Meta** said that any introduction of innovative approaches to spectrum management, including light-licensing possibly using databases needs to be carefully considered and balanced, noting the complexity in the design and implementation of databases.	We will take this feedback into account as we develop the scope of our spectrum sandbox and other sharing projects.
Future use of unpaired 2100 MHz (1900-1920 MHz) spectrum	We plan to consult on our proposals for future use of this spectrum in the first half of 2023

[7] Including greater spectrum efficiency and density of usage and speed of licence application processing. See Federated Wireless response for further detail

The **DECT Forum** noted that it is crucial to preserve DECT quality of service for incumbent users in the 1880-1900 MHz band, meaning any new technologies in the 1880-1920 band should not interfere or disturb incumbents. Several stakeholders, including the **DECT Forum, Association of Professional Wireless Production Technologies (APWPT)** and **Shure Inc.** suggested that Ofcom should consider expanding the 1880-1900 MHz DECT band to 1880-1920 MHz. The **DECT Forum** said that DECT-2020 NR (or 'DECT NR+'), which is recognised within ITU-R as an IMT-2020 technology, will enable new capabilities and applications, including smart cities, industrial IoT and PMSE and that as a result extending the band would provide high value to the economy. **APWPT** and **Shure Inc.** also expressed concern over the possible use of drones in the band. **APWPT** thought that drones using an unpolite protocol, e.g. LTE, would damage the efficient DECT sharing system.	and will take this feedback into account.
<u>Annual licence fees</u> **Vodafone** said that Ofcom should review the market mechanisms applied to spectrum. In particular, Vodafone argued that ALFs set at market value impede efficient trading and that an obligation to commit spend to hold a spectrum licence needn't require spend coming out of the industry; ALF obligations could be repurposed as a requirement for MNOs to invest in coverage and quality.	As set out in our Revised Framework for Spectrum Pricing (SRSP), our policy on setting spectrum licence fees is to reflect the opportunity cost of spectrum. As we say in the SRSP: "If the cost of spectrum reflects its true opportunity cost … then business will make the trade-off between investment in spectrum and equipment in a way that maximises benefits generated from their use" (SRSP, paragraph 3.34). ALFs are therefore important because they reflect the opportunity cost of spectrum and thus encourage efficient investment. That is: a. By charging ALFs, we give MNOs the incentive to consider the opportunity cost of spectrum when making decisions about holding the spectrum, trading it, surrendering it to Ofcom, or

	investing in complementary assets. b. This contributes to an efficient allocation of spectrum and efficient investment over time. Ofcom's long-established approach is to rely on market mechanisms to allocate spectrum, where possible and effective, whilst undertaking regulatory action where necessary. Our market-based approach is supported by tools including auctions as a means to allocate spectrum, and spectrum pricing to incentivise users to make efficient use of spectrum (Spectrum Management Strategy 2021, paragraph 2.18). The most appropriate tools, and their design, may depend on the specific circumstances of the market or evolve over time. For example, while in previous large spectrum auctions we have awarded indefinite licences, which are subject to ALFs after an initial term, in mmWave we have consulted on the option to award fixed-term licences, in part due to the uncertainty of future use cases for spectrum in this band.
<u>Delivering a single online licensing platform</u> The **Dynamic Spectrum Alliance (DSA)** encouraged Ofcom to leverage commercially available automated shared access technology to further streamline and enhance users' experience with the Shared Access licensing opportunity, noting the 3.8-4.2 GHz band specifically.	We will take this feedback into account as we develop the scope of our spectrum sandbox and other sharing projects.

Other comments relating to ongoing work, or proposing new work

Stakeholder comments	Ofcom response
700 MHz Spectrum The **Ofcom Advisory Committee for Scotland** noted that the 700 MHz band is suitable for providers serving rural areas. The Committee urged Ofcom to consider allocating spectrum in this band for shared spectrum allocations for use by local ISPs and alternative & innovative commercial models, such as co-operatives, and other local initiatives. It pointed towards the part-DCMS funded '5G New Thinking' work and their 'rural connectivity toolkit' as worth of consideration in a review of shared spectrum.	We note that the 700 MHz band is already largely allocated to the UK MNOs. However, we recognise that MNOs may not deploy their spectrum holdings everywhere. As such, Ofcom has already made available Local Access Licenses, which enables access to existing MNO-held spectrum bands in geographic areas where mobile operators have not yet utilised it and have no immediate plans to do so.
Amateur Radio **Julian Thompson** said that Ofcom has been slow to grant UK Radio Amateurs access to designated pan-European bands, but have been quick to remove bands for shared or alternative use. Mr Thompson also noted that quantifying numbers of 'Business Radio' users and 'Ham' users requires clarification, commenting that Ofcom has previously understated the number of 'Hams'. Mr Thompson also argued that Amateur bands that are out of sync with the ITU/CEPT regulators have impacted the price and availability of equipment. As a result, Mr Thompson suggested a long-term roadmap could provide stability and enable manufacturers to meet amateur needs.	Under the UK Amateur Radio Licence, radio amateurs enjoy access to a wide variety of bands across the radio spectrum, from LF frequencies around 135 kHz through to EHF frequencies at 250 GHz and beyond. In many cases, bands are allocated to other services (often the MOD) on a primary basis, with the amateur radio allocations being secondary. Ofcom has periodically asked primary users about expanding amateur radio access to these 'secondary' bands (for example around 5 MHz) and we are guided by their reply. Frequencies in bands at 2.3 GHz and 3.4 GHz were part of the Public Sector Spectrum Release. Amateur radio access to these bands (and the nature and duration of that access) was the subject of consultation in 2013.

	We now publish open data from which numbers of active amateur radio stations at each class can be derived. It is for individual administrations to determine, in light of other calls on the radio spectrum domestically, which internationally-agreed allocations may be made available to radio amateurs and other hobbyists. More generally, we note we have also made spectrum available for innovation and research, for example at 70 MHz and 146 MHz.
General approach to sharing **Vodafone** commented that Ofcom should be careful not to conflate the most intensive usage of spectrum with spectrum efficiency. Spectrum efficiency means achieving the most value (economic and social) from spectrum assets – this doesn't mean ensuring every Hz is intensively used. For example, an incremental user may detract more value from existing usage than they add with their own.	We consider promoting spectrum sharing as an important goal and consistent with our duties, particularly as more flexible access can encourage innovation and increase efficient use of spectrum. In part, this is why **promoting spectrum sharing** is one of the 'areas of increased focus for the next decade' in our spectrum management strategy. However, we recognise that sharing will not necessarily constitute 'optimal use' in all bands, particularly where additional users may detract value from existing users. In our view, 'optimal use' means that spectrum is used in a way that maximises the benefits that people, businesses and other organisations derive from its

	use, including the wider social value of spectrum use.
Regulatory burden on stakeholders may limit engagement **Vodafone** suggested that stakeholders may struggle to meaningfully engage and respond to information requests arising from proposed work, given the competing demands on resources from a number of other regulatory areas (incl. Telecoms Security, High Risk Vendor removal, supply chain diversification, the Shared Rural Network, 5G rollout and implementation of the ECC).	We note this point, and when gathering data we will consider the burden and proportionality against the benefit. Where possible, we will look to use data that is already being collected.
Health implications of EMF **Electrosensitivity UK** said that around 3.6% of the population are negatively impacted by man-made radio communications. It argued that Ofcom should not point to Public Health England, but instead follow a scientific approach and adopt international guidelines (Bioinitiative, EUROPAEM 201, IGNIR or Seletun). It also thought that Ofcom should also conduct an Environmental Impact Assessment to consider the impact on insects, viruses and bacteria.	We have previously set out our response to suggestions that Ofcom should adopt different guidelines to those recommended by the UK Health and Security Agency (UKHSA, previously PHE), as well as concerns about environmental impacts. See for example paragraphs 3.22-3.26 and 3.52-3.54 of our EMF Statement. Our position on these points has not changed.
Programme Making and Special Events (PMSE) Spectrum A number of stakeholders flagged the importance of spectrum below 1 GHz for PMSE applications. The **Association of Professional Wireless Production Technologies (APWPT)** noted that even as new technologies develop, including WMAS, DECT 2020-NR and 5G, these would not eliminate the audio PMSE requirement of dedicated, interference-free spectrum. The **British Entertainment Industry Radio Group (BEIRG)** noted that PMSE has access to nearly 50% less spectrum than 10 years ago, and that as demand for content grows, alongside better video and audio quality, demand for spectrum enabling content capture will grow. **Shure Inc.** argued that continued access to 470 – 698 MHz for audio PMSE is critical for the industry. It noted that studies suggesting < 100 MHz is sufficient for the daily use of audio PMSE do not take into account large events which may generate demand far in excess of 100 MHz.	We are aware of the importance of the 470-694 MHz band to the UK's PMSE users. The band is allocated in Region 1, on a primary basis, to the broadcasting service with footnote recognition for PMSE applications. (See *'Preparations for WRC 2023'* for Ofcom's position).

APWPT specifically requested that the duplex centre gaps in the mobile IMT bands below 2 GHz are opened for audio-PMSE use.[8]	In response to **APWPT**, spectrum has been available for audio PMSE at 823-832 MHz and 1785-1805 MHz for several years. We also took the decision in 2017 to allow PMSE users continued access to the 700 MHz guard band (694-703 MHz).
APWPT and **Shure Inc.** also asked Ofcom to consider the 1350-1400 MHz band for PMSE use and advocated the expansion of DECT to 1880-1920 MHz (see '*Future use of unpaired 2100MHz (1900-1920 MHz) spectrum'* above).	Regarding the **1350-1400 MHz band**, use of the band is split. The upper part, 1375-1400 MHz, is allocated for use by UK MOD. The lower portion of the band, 1350-1375 MHz, is used by fixed links and we have not identified it as a suitable candidate band for audio PMSE. On the **expansion of DECT to 1880-1920 MH**z, we note the potential role that DECT-2020 NR may have in the PMSE industry. At the moment, 1900-1920 MHz is allocated to mobile network operators. We are considering the future of this band as part of the '*Future use of unpaired 2100MHz (1900-1920 MHz) spectrum'* project and will take these comments into account.

[8] However, they noted that these bands are not sufficient for high professional audio PMSE applications, which require more frequency spectrum, which is clean and interference free from adjacent IMT services.

Key market and technological trends

Stakeholder comments	Ofcom response
A number of stakeholders expressed broad agreement with the trends identified. **BT** noted that these trends provide an important context to what the roadmap needs to ultimately deliver. The **Dynamic Spectrum Alliance** noted a key trend is the use of automation, cloud-computing, and machine learning to increase spectrum efficiency and access. It argued that cloud-computing can enable more predictable QoS, congestion avoidance and improved coordination. **Federated Wireless** noted a number of trends, including: • Adoption of the cloud for application deployment improves the case for database-enabled spectrum access and management • Automated dynamic spectrum sharing is spurring the growth of private networks, for example CBRS. It can accommodate new business models and use cases that were previously too complex for traditional licensing frameworks (e.g. short-term spectrum needs for events) • The growth of edge-computing means that database enablement does not have to mean a fully centralised system – coordination and sharing can be facilitated on smaller timescales and geographies. These 'edge' databases can still achieve the benefits of scale when joined with centralised databases. **Ericsson** noted that ICT has the potential to enable other industries to move towards a low-carbon economy; technologies like 5G, AI and IoT are essential drivers of decarbonisation. Spectrum strategies and policies should therefore consider impacts on sustainable development goals.	We plan to explore the opportunities to use technologies such as databases and machine learning in the spectrum sandbox and other sharing projects that we will be taking forward.

Proposed future work areas

Network evolution and convergence

Stakeholder comments	Ofcom response
Monitoring and influencing the development of next-generation network technologies **Ericsson** noted the 6G research journey has already begun. It said that the lower frequency bands, in particular 8 – 15 GHz, would be especially important, including to provide wide area coverage. Ericsson also noted that mmWave bands in the 24 GHz to 52 GHz range pioneered by 5G would likely soon be extended up to 100 GHz, and would be used by 6G as well. The **Dynamic Spectrum Alliance (DSA)** noted developments in Wi-Fi as the industry moves towards Wi-Fi 7 and restated the argument that Wi-Fi 7 will require access to the full 6 GHz band. The **Wireless Broadband Alliance (WBA)** also noted a number of recent and future developments in Wi-Fi technology, which among other things may improve reliability and reduce interference.	We will take these comments into account as part of our ongoing work on Mobile Spectrum Demand and our new work on use of the upper 6 GHz band.
Developing a cross-sectoral understanding of evolving spectrum demand at 6GHz A number of respondents referred to the 6 GHz band (see '*meeting mobile demand*'), with many calling for further Ofcom analysis and work.	N/a
Impact of fibre roll-out on future use of wireless fixed links *No specific comments not addressed elsewhere*	N/a
Assessing the implications of new technologies on how we manage spectrum use *No specific comments not addressed elsewhere*	N/a
Review potential for migration from 'dedicated' to 'general purpose' networks The **Wireless Broadband Alliance (WBA)** argued that Wi-Fi advances mean it is increasingly able to support a wider set of applications and use cases, demonstrating a transition towards being a 'general purpose' network.	We note this point and will take it into account as we progress this work.

Accelerating innovation and sharing

Stakeholder comments	Ofcom response
A number of stakeholders commented positively on sandbox proposals. **Federated Wireless** agreed with the use of sandboxes, noting international examples of experimentation that demonstrate the direct involvement of a regulator can reduce uncertainty, promote confidence and facilitate commercial adoption. It noted that it had developed a software tool for the Shared Access licensing framework as part of the Rural Connected Communities project. It also noted that the use of automated dynamic spectrum sharing technology may help Ofcom manage the boundary between sandboxes and the 'real world', manage access within the sandbox, and simplify the transition of technologies from sandbox to commercial use. The **Met Office** encouraged Ofcom to include expert stakeholders from the remote sensing community in sandbox activities, to ensure that accurate sensor characteristics are used in studies and to strengthen trust between the remote sensing community and other spectrum users. The Met Office noted that it would be interested to know more about this work area. ***3.8-4.2 GHz*** The **Dynamic Spectrum Alliance (DSA)** said that demonstrating automation in the 3.8-4.2 GHz band and demonstrating Wi-Fi 6E together with AFC to permit higher power and outdoor operations, would be excellent places to start. **Shure Inc.** also supported proposals to explore the 3.8-4.2 GHz band, noting that the CBRS approach in the US could be considered or adapted. ***Upper 6 GHz*** Several stakeholders, including a joint response from **Apple, Broadcom, Cisco, HPE and Meta** and the **Wireless Broadband Alliance (WBA)** suggested that a spectrum sandbox approach need not be limited to the lower 6 GHz band and could extend into the upper 6 GHz. Both noted that equipment and database	We will take these comments into account as we develop our proposals for taking forward our work on spectrum sandboxes

standards which support sharing with Fixed Links already exist in the US, so could be utilised for trials. The **WBA** noted that Wi-Fi operates on a multi-modal regulatory framework, including different power levels. It suggested that, in developing a spectrum toolbox, this multimodal approach should be considered as each mode of operation will require its own set of tools to enable spectrum sharing and co-existence. The WBA also thought that the use of AFC in 6 GHz should be limited to the standard Power mode of operation only. **Apple, Broadcom, Cisco, HPE and Meta** commented that, if considered for the upper 6 GHz band, AFC or light-licensing should only apply to higher power WAS/RLAN. It thought that user equipment or client devices should not be subject to light-licensing or registration.	

Better data for better spectrum management

Using real-world data to improve propagation and coexistence modelling A number of stakeholders commented positively on these proposals. The **Dynamic Spectrum Alliance (DSA)** particularly noted fixed links would be an appropriate starting point. **Federated Wireless** commented that measurements should be used to progressively refine models, not just for propagation, but for patterns of use, access and interference. Federated Wireless noted that API-enabled automated dynamic sharing technologies may aid quick data-gathering. The **Met Office** noted that it is working in partnership with NPL on atmospheric impacts on active 77 GHz automotive radar systems at a weather testbed, including path loss measurements. It suggested this would straightforwardly generalise to other 5G / 6G bands and that it would be interested to learn more and be involved in this work. The **Joint Radio Company (JRC)** noted that measurements may be helpful in refining the modelling of interference into the UK from mainland Europe in the reverse-aligned 450-470 MHz range.	We will take these comments into account as we develop our projects under the better data theme and seek to build on knowledge already gained by stakeholders in this area.

Ericsson cautioned that when taking measurements to inform co-existence modelling, performance measured at a specific point in time differs from performance across all potential environmental conditions. In addition, co-existence based on measurements may not characterise all equipment in the market. The **Voice of the Listener and Viewer (VLV)** similarly commented that, given propagation varies with time, geography and terrain, there is a practical limit to the quality and accuracy of propagation prediction data.	
Improving our understanding of the real-world performance of active antenna systems (AAS) A number of stakeholders expressed support for this proposed future work area but no detailed comments were received.	N/a
Improving receiver resilience A number of stakeholders commented positively on these proposals. The **Met Office** noted that, as the UK's representative in EUMETSAT, it has an extensive understanding of current and future EESS receiver characteristics. It said it would be interested to know more about this area of work, how it relates to the sandbox work, and how it could get involved. The **Joint Radio Company (JRC)** argued that a focus on improved receiver characteristics is positive, as higher quality receivers may help improve the co-existence of systems. However, the JRC encouraged Ofcom to allow sufficient time for changes to be introduced, and to seek to understand associated costs. The **Voice of the Listener and Viewer (VLV)** suggested that Ofcom should consider the performance of consumer reception equipment and its contribution to spectrum efficiency, particularly as consumer devices are generally built under cost constraints and assuring high performance is challenging. Even if upgraded, consumers may not wish to change their receiving equipment (e.g. TVs) too often.	We welcome the support for these proposals and will engage specifically with the Met Office on this and other future policy proposals. In response to the JRC and VLV, we recognise that equipment replacement cycles and the cost of delivering higher cost receivers will need to be taken into account as we develop our thinking on how to improve receiver resilience.
Using real-world data to improve the efficiency and effectiveness of our spectrum assurance work A number of stakeholders commented positively on these proposals. The **Dynamic Spectrum Alliance (DSA)** specifically suggested that the use of automated dynamic shared access systems could be leveraged to collect and analyse such data.	We plan to explore the opportunities to leverage common technical solutions across our spectrum sandbox, sharing and better data initiatives.

The **Met Office** noted it has an MoU with Ofcom in relation to interference caused by non-compliant RLAN equipment. Whilst this works well, it involves significant effort to investigate and tackle interference, so the Met Office would be interested in hearing more about plans for improved assurance efficiency and effectiveness.	
Measuring utilisation in selected spectrum bands A number of stakeholders commented positively on these proposals. The **Dynamic Spectrum Alliance (DSA)** specifically noted that the use of automated dynamic shared access technology could greatly facilitate the voluntary gathering of spectrum usage data. The **Joint Radio Company (JRC)** supported the use of measurements, noting many systems remain licensed following decommissioning, which may give a false impression of actual channel occupancy. Further measurement may show some frequency bands are not as congested as Ofcom's records would indicate, which may be an inefficient use of spectrum. **BT** also agreed real-world data on spectrum utilities is important, including licence-exempt bands used for Wi-Fi. However, to be most useful the data should be sourced from the widest possible range of stakeholders.	