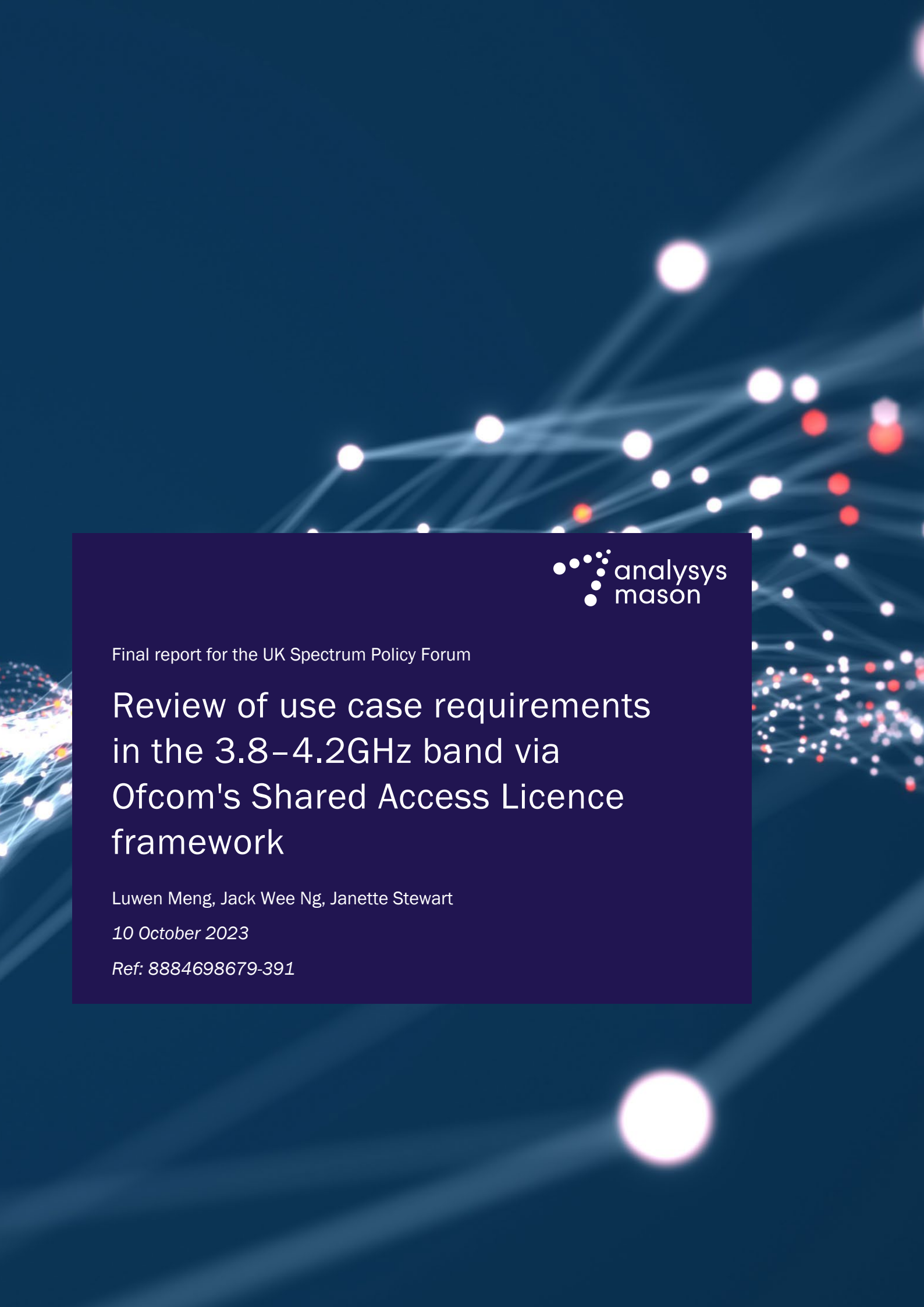

analysys mason

Final report for the UK Spectrum Policy Forum

Review of use case requirements in the 3.8–4.2GHz band via Ofcom's Shared Access Licence framework

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About this report

This final report has been prepared by Analysys Mason for techUK, on behalf of the UK Spectrum Policy Forum (SPF).

Analysys Mason would like to thank the various organisations that have provided their views and contributed to the study both through one-to-one interviews and participation during the SPF's meetings and the workshop.

About the UK SPF

The UK SPF is the industry sounding board to government and Ofcom on future spectrum management and regulatory policy with a view to maximising the benefits of spectrum for the UK. The UK SPF is open to all organisations with an interest in using spectrum. A Steering Board performs the function of ensuring the proper prioritisation and resourcing of the SPF's work.

About techUK

techUK facilitates the UK SPF. techUK is a trade association which brings together people, companies and organisations in the digital technology sector in the UK.

1 Executive summary

This document is the final report of a study carried out by Analysys Mason for techUK, on behalf of the UK Spectrum Policy Forum (SPF), to explore the technical conditions of current and future use cases in the 3.8–4.2GHz band. The 3.8–4.2GHz band is one of the spectrum bands available for use in the UK for local access connectivity via Ofcom's Shared Access Licence (SAL) framework.

The aim of this study has been to review current use cases in the band, and how these use cases could evolve, and to identify how the SAL framework could be improved to meet current and future needs. The study also seeks to provide insight on use cases and the licensing approach that might feed into European discussions concerning the use of the 3.8–4.2GHz band, specifically discussions within the Electronic Communications Committee (ECC) Project Team 1 (PT1) who is studying the technical conditions for shared use of the 3.8–4.2GHz band by terrestrial wireless broadband systems providing local area network connectivity.

The research we have conducted during this study has identified that the SAL approach to making spectrum available for local network solutions in the UK has been widely welcomed by a range of users. There is support from within the wireless industry for the foundations of the UK process to be replicated in other European markets. We have identified the following specific areas of development and improvement to the framework that could be considered as use cases evolve:

- increase the rate at which licences are granted
- increase the visibility of the licence process, and make the process more accessible, such as identifying a single point of contact in Ofcom for licensing queries relating to SALs
- put the application process online
- consider whether medium-power licences can be authorised in locations other than rural postcodes, subject to co-ordination and based on ongoing review and judgment over whether availability of spectrum in relation to expected demand for low-power licences can be accommodated[1]
- consider whether multiple medium-power base stations, if desirable in a single solution (e.g. to provide coverage between buildings in a large site), could be covered via a single licence
- ensure usage conditions – specifically transmitted powers – can be applied to systems using active antenna systems (AAS). We note that in Ofcom's recent statement, "Enabling mmWave spectrum for new uses",[2] power levels are expressed as total radiated power (TRP) instead of effective isotropic radiated power (EIRP), because of the likely use of products with AAS. A similar approach could be applied to define power limits for the 3.8–4.2GHz SALs

1 We note once Ofcom has collated several years of licensing data on use of the SAL framework, patterns of demand could become evident (e.g. in relation to the number of shorter-term licence requests vs. licences that continue to be renewed annually).

2 See https://www.ofcom.org.uk/__data/assets/pdf_file/0033/268656/Statement-Enabling-mmWave-spectrum-for-new-uses.pdf

- take account of antenna solutions in the co-ordination process for mitigating the risk of interference, such as directivity, down-tilting[3] or AAS.

We have found that the 3.8–4.2GHz band is being used for a variety of private wireless network and local wireless network use cases, using 5G radio technology and private 5G network configurations. Currently, the band is mostly used for proven use cases (e.g. fixed-wireless access (FWA)) and emerging 5G enterprise and industrial use cases (e.g. private wireless networks for enterprise and industrial companies). Another key use is for live video and audio content production by the media industry.

The number of SALs in the UK has gradually increased and our research suggests this trend will continue. We note that some use cases (specifically, audio and video content production) have a requirement for licences over a finite duration (since content production is to cater for a specific event with a short duration). Hence, not all SAL use cases require licences with long/indefinite duration, and some assignments are only needed over a short, finite duration (for example, to provide localised connectivity to support content production during a live event). Hence it is not known how many licences have been assigned in total since the 3.8–4.2GHz band became available for SAL use.

Our research also suggests that demand for the use of the 3.8–4.2GHz band could increase both in the UK and in Europe as the ecosystem for private 5G networks expands (these ecosystem developments are already evident, based on our research). Alignment in licensing approaches and usage conditions for this band between the UK and other countries in Europe is expected to provide further support for the evolving product ecosystem.

Whilst noting that some parties are expressing a desire for opportunistic access to spectrum via design of a dynamic spectrum access (DSA) solution, our conclusion is that the current Ofcom-managed process for co-ordinated use of the 3.8–4.2GHz band appears optimal to address current and future use cases requiring customised licences in terms of geographical area and bandwidth. We note that a fully automated DSA process with geolocation and sensing (e.g. like the CBRS[4] approach designed for different tiers of use to be co-ordinated in the 3.5GHz band in the USA) would rely on radio equipment used under SALs communicating with DSA database solutions and sensing the local environment. These capabilities would take time to implement.

We think key priorities for the licensing process are to reduce application timescales, and to give more visibility of the co-ordination process. Allowing greater flexibility (e.g. allowing applications for medium-power licences in locations other than rural postcodes) could prevent spectrum access being denied. Our conclusion that the Ofcom-managed approach is optimal remains true even if application volumes increase, primarily due to the bespoke nature of many of the local networking

3 Refers to directional antennas on base stations positioned with a tilt to optimise coverage and capacity, whilst also reducing radiation in the direction of other systems.

4 CBRS: Citizens Broadband Radio Service.

systems being applied for, which benefit from an Ofcom-managed process to grant exclusive and co-ordinated spectrum assignments in a given location and bandwidth.

Whilst we are of the view that DSA implementation for opportunistic access to the available spectrum is not a priority, putting the application process online via a web-based tool would be highly desirable. Regarding the current pricing structure of the framework, we do not believe any changes are needed, however the charges being applied for sub-annual licence durations could be clarified in the SAL guidance. As demand patterns for licences using the SAL framework become clearer, further consideration of how the framework accommodates use cases with different licence durations (e.g. very short durations possibly of less than a month for content production use cases, compared to indefinite duration for a private 5G network located at an industrial site) could be beneficial.

Figure 1.1 below summarises our suggestions for improvement to the framework (in descending order of priority) to encourage adoption of SALs.

Figure 1.1: Summary of improvement suggestions to the SAL framework [Source: Analysys Mason, 2023]

No.	Recommendations	Priority
1	Seek to increase rate of licence application granting and make the process more visible (such as by putting the application process online, providing an earlier indication of chances of applications being approved for given locations, and reducing timescales between application and approval). Appoint a single point of contact at Ofcom for licensing queries relating to SALs	High
2	Consider whether a high-level summary of existing low- and medium-power assignments can be made visible to applicants through an easy-to-view interface, to give greater visibility over availability of spectrum at given locations (such as via a map showing the location of currently approved licences)	High
3	Provide an online indication (e.g. yes/no/subject to further co-ordination) as to the status of applications, to give an idea to applicants of likelihood of application being approved	High
4	Include details of antenna pattern in the technical details requested from applicants so that directionality of antenna radiation can be incorporated into the co-ordination process	High
5	Consider clarifying technical conditions to enable use of AAS under the current medium-power licence	High
6	Improve the visibility of the 'exceptions process' (i.e. the co-ordination process undertaken by Ofcom to consider applications that depart from the standard conditions). Greater transparency to applicants on timescales for the process, and better dialogue over mitigation factors that might improve the success of co-ordination (e.g. antenna directivity, change in location, down-tilting, etc.) could be beneficial	High
7	Consider if medium-power licences can be applied for in non-rural postcode areas	Medium
8	Give flexibility to applicants to apply to use more than one base station in deployments at a given location under a medium-power licence (e.g. to provide coverage between buildings in a larger site)	Medium

No.	Recommendations	Priority
9	Offer more flexible short-term licence durations for content production deployments and update the fee structure accordingly for shorter-duration licences to encourage efficient use of the spectrum	Medium
10	Examine how to maintain a level playing field for multiple applicants applying for a SAL to respond to the same customer need (e.g. in response to a customer who has issued a request for proposals via a competitive tender). Consider adding 'customer name' to the application so that Ofcom is able to identify where multiple applicants are applying for spectrum to respond to the same customer	Low
11	Continue to allow applicants to resolve co-ordination issues locally through suitable market means, such as synchronisation of TDD[5] timing using GPS[6]	Low

5 TDD: time division duplex.

6 GPS: global positioning system.

2 Introduction

This is the final report of a study carried out by Analysys Mason for techUK, on behalf of the UK Spectrum Policy Forum (SPF), concerning use cases in the 3.8–4.2GHz spectrum band. The 3.8–4.2GHz band is one of the bands available under Ofcom's Shared Access Licence (SAL) framework. The available bandwidth and inclusion of this band within 3GPP specifications[7] makes this band well suited to private wireless network deployment via 5G technology.

The SPF is the UK's cross-industry advisory body to Ofcom and the UK government on spectrum policy. In the context of maximising the use and benefits of radio spectrum for the UK, the SPF has commissioned this study to contribute to ongoing discussions in both the UK and in European spectrum groups in relation to increasing the use of the 3.8–4.2GHz spectrum band for local wireless coverage solutions, including private wireless networks.

2.1 Context for the study

In July 2019, Ofcom published a statement, "Enabling wireless innovation through local licensing", which proposed two new licensing types aiming at allowing greater access to radio spectrum in the UK on a locally licensed basis.[8] The two licence frameworks are:

- **Shared Access Licence (SAL):** grants access to four spectrum bands (1800MHz, 2300MHz, 3.8–4.2GHz and the lower 26GHz band[9]), also known as the shared access bands, which support mobile technology.
- **Local Access Licence:** grants access to spectrum that has already been licensed nationally to the UK's mobile network operators (MNOs), in locations where the spectrum is not used by the MNOs (subject to co-ordination and agreement with the holder of the national licence, which is managed by Ofcom).

Ofcom identified that access to suitable spectrum for local deployment could play a crucial role in driving innovation across various industries and sectors where there is demand for bespoke solutions.

In its SAL implementation, Ofcom has made four spectrum bands available, which are summarised in Figure 2.1.[10]

7 3GPP is the Third Generation Partnership project, which is the industry standards body for cellular mobile technologies.

8 Ofcom, "Enabling wireless innovation through local licensing: Shared access to spectrum supporting mobile technology", https://www.ofcom.org.uk/__data/assets/pdf_file/0033/157884/enabling-wireless-innovation-through-local-licensing.pdf

9 The lower 26GHz band (24.25–26.5GHz) is currently only allowed for indoor deployment, while other bands are allowed for both indoor and outdoor deployment.

10 Ofcom, "Shared Access Licence: Guidance document", https://www.ofcom.org.uk/__data/assets/pdf_file/0035/157886/shared-access-licence-guidance.pdf

Figure 2.1: Summary of Ofcom's SAL frequency bands [Source: Ofcom, 2022]

No.	SAL frequency band	Bandwidth available	Rationale for making the band available
1	1781.7–1785MHz paired with 1876.7–1880MHz	2×3.3MHz	• This is a small part of the wider 1800MHz mobile band that has not been licensed for national mobile services. This band is supported by commercially available mobile base stations and equipment, and by many mobile handsets • Due to its lower frequency, the 1800MHz band has good propagation characteristics but the limited bandwidth means it is unable to transmit a significant high volume of data
2	2390–2400MHz	10MHz	• Part of the 2300MHz mobile band and sits above the 2350–2390MHz band, which is licensed for nationwide mobile use in the UK[11] • This band is supported by commercially available mobile base stations and equipment, including many mobile handsets • The 2300MHz band has good propagation characteristics and has a larger bandwidth compared to the 1800MHz band for data transmission
3	3.8–4.2GHz	390MHz	• This band sits above the 3.4–3.8GHz band that is nationally licensed for 5G use in the UK. Being part of 3GPP specifications for 5G use, this band is supported by chipsets, base stations and devices using 5G technology • According to recent Ofcom data regarding licences issued for shared access bands, the 3.8–4.2GHz band has seen the most significant demand and growth of all of the bands available via SALs[12]
4	24.25–26.5GHz[13]	2.25GHz	• This band is currently only available for indoor use, but Ofcom is planning to make updates to the availability of this band including shared access licensing for

11 The 2350-2390MHz band is licensed for use by Virgin Media–O2 (VMO2).

12 Ofcom, "Evolution of the Shared Access Licence Framework: Call for inputs", https://www.ofcom.org.uk/__data/assets/pdf_file/0032/255965/call-for-inputs-evolution-of-shared-access.pdf

13 Spectrum in 24.25–26.5GHz is available for indoor low-power use across the UK. Ofcom is planning to auction the upper part of the 26GHz band (25.1–27.5GHz) plus the 40GHz band (40.5–43.5GHz) in high-density areas (HDAs). Once the auction concludes, Ofcom will add additional bands to the SAL framework for both outdoor and indoor use, which are 24.45–25.1GHz in HDAs for low-power use, and 24.45–27.5GHz and 40.5–43.5 GHz in non-HDAs for both low-power and medium-power use. See https://www.ofcom.org.uk/__data/assets/pdf_file/0015/255030/03-23-statement-and-consultation-mmwave.pdf

No.	SAL frequency band	Bandwidth available	Rationale for making the band available
			outdoor locations alongside city-wide licences, which are to be auctioned • The 26GHz band could support 5G applications requiring very high bandwidth in very localised areas

In this report, we focus on the SAL framework for the 3.8–4.2GHz band. This band sits above the 3.4–3.8GHz band that is licensed on a national basis for 5G deployment in the UK, as in many other countries in Europe. The 3.8–4.2GHz band supports 5G technology, and, with spectrum available via the SAL framework, 5G technology can be deployed on a local coverage basis. These locally deployed solutions could be well suited to meet the wireless connectivity demands of a variety of industry verticals such as ports, manufacturing, mining, healthcare and others. Any form of local solution provider can apply for a SAL, and MNOs can also apply for SALs to provide localised solutions, although the 3.8–4.2GHz band cannot be used by MNOs in their public mobile networks.

The primary focus of this study has been to provide an independent assessment of current and future use cases using the 3.8–4.2GHz frequency band and to consider priorities for the evolution of the SAL framework for this band as demand evolves. Whilst focused on the UK's SAL framework, the study also aims to provide insights into use cases beyond the UK (and especially in the wider European market) that could contribute to discussions being held within the European Communications Committee (ECC) Project Team 1 (PT1) regarding the technical conditions for using the 3.8–4.2GHz band in Europe.

2.2 Structure of this report

The remainder of this document is laid out as follows:

- Section 3 provides an overview of the 5G use cases that are of primary interest to the study
- Section 4 discusses how the 3.8–4.2GHz band is currently used in the UK
- Section 5 summarises the analysis we have conducted for this study on the potential evolution of use case requirements
- Section 6 provides a summary of our recommendations on how the SAL framework in the 3.8–4.2GHz band could be developed to meet future use case requirements.

The report includes a number of annexes containing supplementary material:

- Annex A provides summaries of our one-to-one interviews with stakeholders
- Annex B includes additional research and data analysis conducted for the study.

3 Overview of use cases in the 3.8–4.2GHz band

In this section, we provide an overview of the 5G use cases that could be enabled through the SAL framework in the 3.8–4.2GHz band. We also discuss private 5G networks, and the types of SALs currently available in the 3.8–4.2GHz band.

3.1 Overview of 5G use cases

A key motivation behind Ofcom's decision to make SALs available in the 3.8–4.2GHz band was to provide locally accessible spectrum suited to 5G, to support a potentially diverse range of localised use cases spanning numerous industries that might be adopters of 5G technology. These possible use cases range from smart-city applications and industrial automation through to remote healthcare and remote monitoring.[14]

5G technology can be used in private wireless network deployments, and be tailored to provide bespoke coverage and capacity needs. Since 5G technology delivers substantially faster data speeds, lower latency and greater capacity for connecting large device volumes compared to previous generations of cellular wireless technology, the use cases that private 5G networks might support are extremely varied.

A report published by the UK Department for Digital Culture, Media and Sports (DCMS, now the Department for Science, Innovation and Technology, or DSIT) in May 2022, prepared by Analysys Mason together with Oxera, gives examples of some of the potential use cases that could be enabled by 5G.[15] All of the examples below represent typical 5G use cases that can potentially be deployed in the 3.8–4.2GHz band based on our research.

The current use cases related to Ofcom's SAL 3.8–4.2GHz spectrum are further discussed in Section 4.

Figure 3.1: 5G use cases [Source: "Ensuring wireless connectivity needs are met" study prepared by Analysys Mason and Oxera on behalf of DCMS, 2022]

Use case	Details
Transport	Transport sub-sectors that might deploy localised 5G solutions include wireless connectivity for rail, roads, airports, seaports and other transport hubs. In the 3.8–4.2GHz band currently, one of the use cases identified is that of 5G technology used in ports for operational

14 It is noted that 5G is not the only wireless technology that is used for enterprise and industrial networking, with other common technology choices including previous generations of cellular technology (e.g. LTE), and Wi-Fi. In the context of this study, we are focusing on the use of the 3.8–4.2GHz band, which is one of the bands supported by 5G technology.

15 DCMS, "Ensuring future wireless connectivity needs are met", https://www.gov.uk/government/publications/ensuring-future-wireless-connectivity-needs-are-met

Use case	Details
	efficiency and safety reasons, such as remote controlling of cranes and automatic driving of container trucks.[16]
Manufacturing	5G technology in the 3.8–4.2GHz band can be used to support smart factories and automated warehousing solutions. Use cases include low-latency connectivity between machines, sensors and control systems in smart factories and warehouses, real-time monitoring of production lines, predictive maintenance, robotics and automation, and other Internet of Things (IoT) applications.[17]
Venue-based connectivity	5G can provide connectivity for ultra-high definition (UHD) video and augmented and virtual reality (AR/VR) applications. At venues and other event locations, a private 5G network could be used to enable live streaming of content and instantaneous replays of live events to portable devices,[18] with AR/VR applications also providing more immersive and personalised user experience.[19]
Content production	Content production refers to the use of 5G technology for audio and video content capture at live events, such as capture of video and audio footage for live broadcasts.
Rural wireless connectivity for homes and buildings, and for rural industries	5G can provide rural broadband connectivity to homes and buildings via 5G fixed-wireless access (FWA). In addition, private 5G networks can be deployed to provide localised connectivity for industries located in rural areas, such as agriculture, forestry, fishing, mining or utilities. In agriculture, 5G can enable real-time data collection and analysis to optimise agricultural processes. Remote monitoring in forestry or at utility locations could be enabled via a private 5G network. In mining, 5G can enable remote equipment monitoring and autonomous vehicle operation within mines.
Health and social care	In the health and social care sectors, private 5G networks could provide real-time wireless connectivity for wireless sensors, medical devices and/or other equipment involved in patient monitoring and healthcare delivery.
Education	Private 5G networks could be used in schools or universities to provide video streaming to support online learning, and to provide connectivity for use of AR/VR supporting immersive learning experiences.
Emergency services	Emergency services could use 5G connections to control and retrieve UHD live video footage from drones and robots in rescue missions or for live video footage at the scenes of incidents.[20]
Energy and utilities	Smart grid and energy site operations could use private 5G networks for use cases such as real-time monitoring of remote assets, network control and optimisation, and collection and real-time analysis of sensor data.[21] Applications could include remote management and monitoring of infrastructure in remote locations such as solar farms or

16 The ports use case is also described in a report by the GSMA, "5G in Verticals in China 2022", https://www.gsma.com/iot/resources/greater-china-5g-vertical-2022/

17 Manufacturing use cases are also described by Ericsson in https://www.ericsson.com/en/about-us/company-facts/ericsson-worldwide/united-states/5g-smart-factory

18 See https://www.nokia.com/thought-leadership/articles/how-5g-will-transform-live-events/

19 See https://www.verizon.com/about/news/indianapolis-500-fans-verizon-5g-ultra-wideband

20 For example, as described in https://www.verizon.com/about/news/5g-drone-impact-search-rescue

21 See https://www.ericsson.com/en/reports-and-papers/industrylab/reports/bringing-5g-to-power

Use case	Details
	wind turbines, which are required to support the industry's commitments towards achieving net-zero carbon emissions.
Smart cities	5G could support multiple smart-city applications, such as real-time data collection, urban planning, autonomy of vehicles, real-time information conveyance to the public and energy optimisation in buildings.[22]
Construction	In the construction sector, 5G could enable real-time collaboration, remote monitoring of construction sites and the use of drones or robotics for site surveys and automated construction operations.

3.2 Private 5G networks

As described above, 5G can support a wide variety of use cases, which have specific performance characteristics. One of the key drivers for demand in the 3.8–4.2GHz band in particular is to create the opportunity for local wireless network solutions in which the connectivity characteristics are bespoke to the individual user(s) or organisation(s) using the network. These local wireless networks are also widely referred to as private 5G networks.

Local wireless networks refer to dedicated communication infrastructure exclusively owned, operated and controlled by a private entity. They are typically designed to facilitate internal communication and data exchange within the organisation over a local coverage area, enabling secure and efficient connectivity amongst devices, systems and users. Local wireless networks using 4G technology (i.e. LTE) have been available for some time.[23] 5G technology operating in 5G mid-band spectrum is able to achieve lower-latency connections and higher-bandwidth data transfers than 4G technology. Therefore, private 5G networks have the capability to address most real-time applications that demand a high level of connection reliability, which cannot be met by 4G technology. These applications include automated guided vehicles (AGVs), AR/VR, industrial robotic equipment and real-time asset tracking.

Using SALs, users can commission or self-deploy private 5G networks (or private wireless networks using other technologies complying with the stated technical conditions). These private networks can have a higher degree of customisation, security, resilience and reliability than is currently possible via the public 5G networks in the UK that are designed to provide wide-area coverage for smartphones and other mobile devices used widely in the consumer sector.

3.3 Types of deployment in the 3.8–4.2GHz band currently

Ofcom offers two types of licence as part of the SAL framework: low-power licences and medium-power licences. Each is granted on a 'first-come, first-served' basis. The co-ordination process for granting SALs is managed by Ofcom. Once licences are granted, the licence term is indefinite,

22 GSMA, "5G in Verticals in China 2022", https://www.gsma.com/iot/resources/greater-china-5g-vertical-2022/

23 DCMS, "Ensuring future wireless connectivity needs are met", https://www.gov.uk/government/publications/ensuring-future-wireless-connectivity-needs-are-met

subject to continuous use and payment of an annual fee. Our understanding is that, for the 3.8–4.2GHz band, there is currently a minimum licensing period of one month.[24]

Low-power licence

With a low-power licence, a private network can support applications in a requested location outdoors or indoors, anywhere in the UK. Base stations must operate with antenna systems limited to 10 metres above ground level.[25]

Low-power licences enable licensees to deploy as many base stations as they require to meet their needs within a circular area with a radius of 50 metres, centred on a co-ordinate provided by the licensee. The base stations can be moved around within the licensed area without further approval from Ofcom. A larger coverage area could be accommodated by applying for multiple low-power licences. Low-power licences offer indoor-only and indoor/outdoor options for users, if they would like to deploy their network partly or wholly outdoors. Users' base stations are permitted to connect to fixed, nomadic or mobile terminals.

Medium-power licence

Medium-power licences are provided for users looking to deploy a base station with a longer transmission range. It is noted that this type of licence only authorises a single base station and the user is unable to change the location of the base station after deployment. Due to their higher power and transmitting range, Ofcom has opted to use a geographical restriction on medium-power SALs in the 3.8–4.2GHz band whereby medium-power base station deployments are only permitted in rural areas. Therefore, this licence is particularly suitable for 5G-based FWA services providing wireless broadband connectivity in rural areas, and also for industrial or enterprise users located in rural postcodes that require a larger coverage area. Such locations could include factories, ports, agriculture or forestry.

Although there are four different shared access spectrum bands available, we have only summarised the technical conditions for low- and medium-power SALs in the 3.8–4.2GHz spectrum band, which is the band of interest for this study (see Figure 3.2 below).

Figure 3.2: Technical conditions for low- and medium-power SALs in the 3.8–4.2GHz spectrum band [Source: Ofcom, 2022]

Condition	Low-power licence	Medium-power licence
Permitted deployment	Indoor and outdoor, with outdoor antennas limited to 10m height above ground	Rural areas, but exceptions for legitimate users in urban

24 The indefinite duration of the licences is stated in Ofcom's supporting annexes on the shared and local access licensing framework, on page 24 https://www.ofcom.org.uk/__data/assets/pdf_file/0034/157885/annexes-1-5-supporting-information.pdf

25 Ofcom, "Shared Access Licence: Guidance document", https://www.ofcom.org.uk/__data/assets/pdf_file/0035/157886/shared-access-licence-guidance.pdf

Condition	Low-power licence	Medium-power licence
		areas can be considered on a case-by-case basis
Authorised bandwidth	10MHz, 20MHz, 30MHz, 40MHz, 50MHz, 60MHz, 80MHz and 100MHz	10MHz, 20MHz, 30MHz, 40MHz, 50MHz, 60MHz, 80MHz and 100MHz
Maximum base station power	• 24dBm/carrier for carriers ≤20MHz or • 18dBm/5MHz for carriers >20MHz (EIRP[26])	• 42dBm/carrier for carriers ≤20MHz or • 36dBm/5MHz for carriers >20MHz
Maximum terminal station (TRP[27] for mobile/nomadic; EIRP for fixed)	• 28dBm	• 28dBm TRP • 35dBM/5MHz EIRP
Frame structure requirements	N/A	N/A

26 Effective isotropic radiated power.

27 Total radiated power.

4 How the 3.8–4.2GHz band is currently used in the UK

In this section, we provide an overview of the number and types of SALs currently granted in the 3.8–4.2GHz band in the UK.

The UK was the first country in Europe to allow access to the 3.8–4.2GHz band for 5G-based local licence applications.[28] We have analysed several sources to determine the number of licences that have been granted/that are currently in use, and the use cases supported:

- Ofcom's Wireless Telegraphy Register (WTR) available via its Spectrum Information System[29]
- Analysys Mason's private 4G/5G networks tracker[30]
- Global Mobile Suppliers Association (GSA) private mobile networks tracker.[31]

We note that some use cases (specifically, audio and video content production) have a finite duration if content production is to cater for a specific event with a short duration. Hence, not all SALs remain in place indefinitely and some assignments are returned to Ofcom after the agreed licence period. Ofcom's WTR does not provide the number of licences granted at different points in the past; it only shows the number of licences in use currently.

4.1 Types of SALs currently used in the 3.8–4.2GHz band in the UK

Through the analysis of Ofcom's WTR database, we found that, currently, 674 SALs are in use by a total of 62 individual companies/organisations in the 3.8–4.2GHz frequency band as of July 2023.[32] As noted above, this represents the current number of active licences and we note that historical data (on volumes of licences active in the past, perhaps for shorter periods) is not available via the WTR.

The SALs are issued for two products: shared access low-power licences and shared access medium-power licences, with shared access medium-power licences accounting for about 72% of the total number of SALs issued.[33]

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28 Ofcom, "Evolution of the Shared Access Licence Framework: Call for Inputs", https://www.ofcom.org.uk/__data/assets/pdf_file/0032/255965/call-for-inputs-evolution-of-shared-access.pdf

29 See https://www.ofcom.org.uk/spectrum/information/spectrum-information-system-sis/spectrum-information-portal

30 See https://www.analysysmason.com/research/content/data-set/private-networks-tracker-rma17/

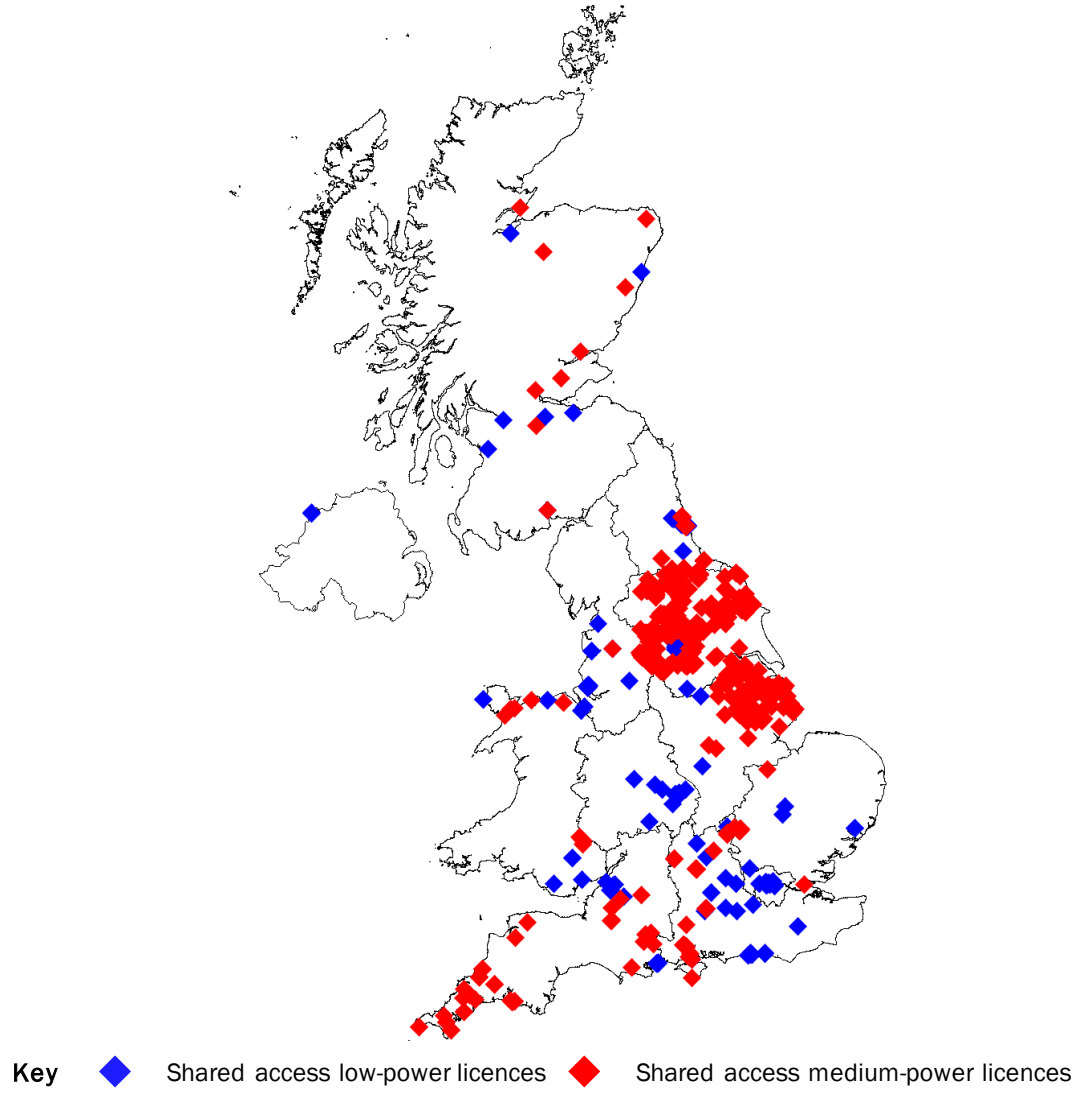
31 Global Mobile Suppliers Association, Private Mobile Networks Tracker, July 2023.

32 Apart from the 674 SALs, there are also ten fixed-link licences recorded in the WTR.

33 The 3.8–4.2GHz band also accommodates the national licence for the 3.9GHz (3.925–4.009GHz) band held by Three UK's subsidiary, UK Broadband Ltd (see https://www.ofcom.org.uk/__data/assets/pdf_file/0018/249120/SA-3.9-GHz-LICENCE-UK-Broadband-1295901-01-11-22.pdf), and the non-geostationary and permanent Earth stations for satellite uses (see http://static.ofcom.org.uk/static/spectrum/map.html), which are not captured in the WTR.

As can be seen in Figure 4.1, most of the currently active 3.8–4.2GHz SALs are located in England, with the remaining licences spread across the rest of the UK.

Figure 4.1: Map of existing SALs in the 3.8–4.2GHz band [Source: Analysys Mason based on Ofcom, 2023]



From Ofcom's database, it appears that most licensees request a 100MHz-bandwidth licence, with this type of licence making up 82% of the licences issued (see Figure 4.3 below). We have conducted further analysis into the number of licences per bandwidth and how these are distributed across the 3.8–4.2GHz band (please refer to Annex B).

Figure 4.2: Power limit of 3.8–4.2GHz SALs issued [Source: Analysys Mason based on Ofcom, 2023]

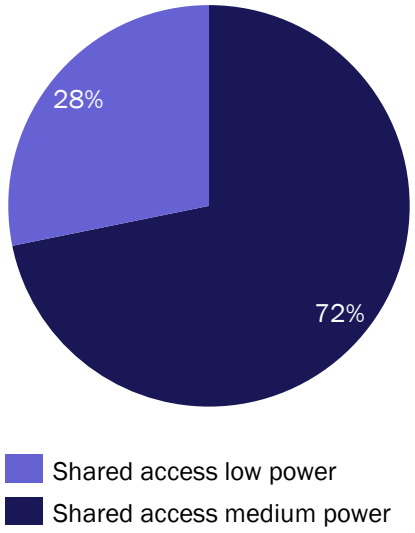


Figure 4.3: Bandwidth of 3.8–4.2GHz SALs issued [Source: Analysys Mason based on Ofcom, 2023]

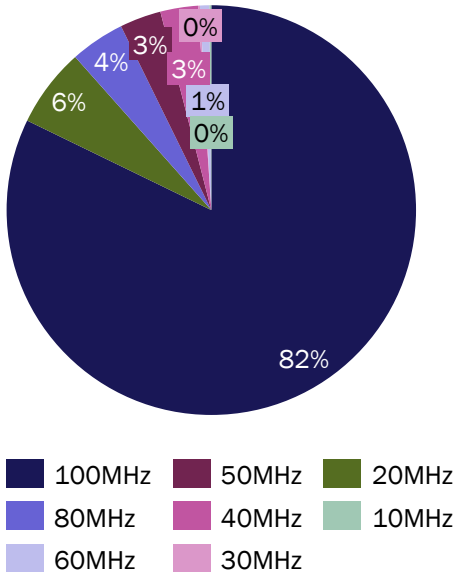


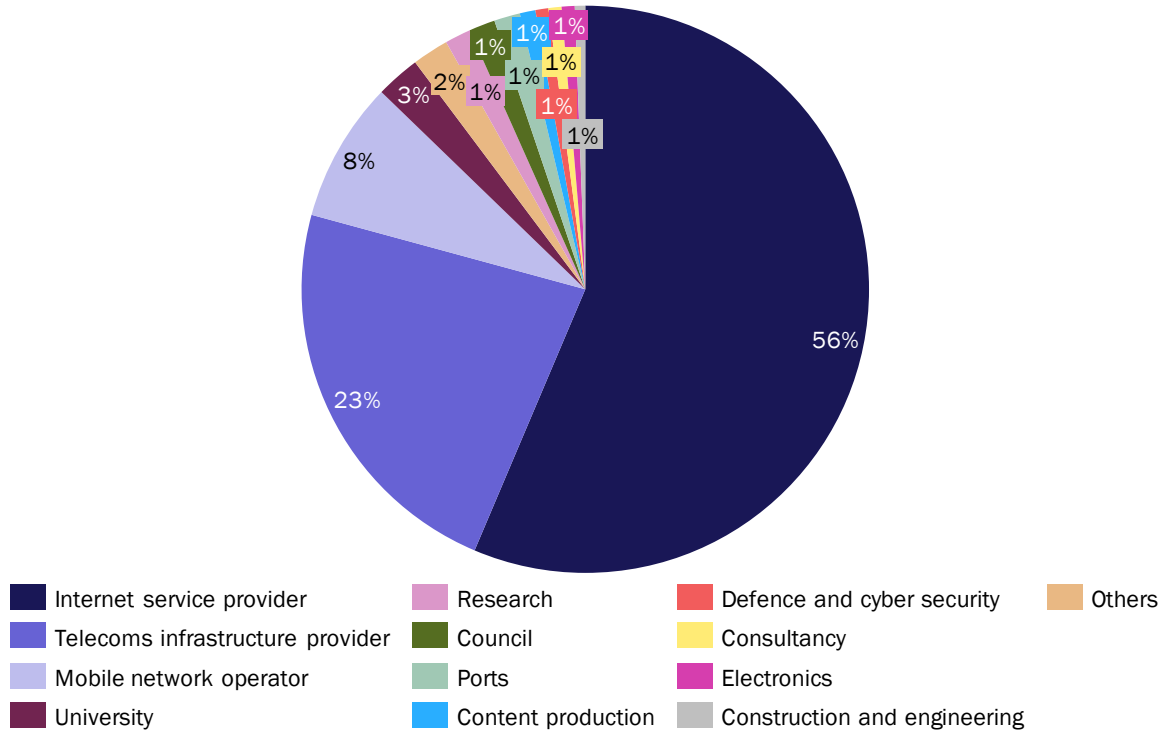
Figure 4.4 below shows that internet service providers (ISPs) make up the largest group of licensees (totalling 56% of licences) currently, followed by telecoms providers. We note that through Project Gigabit, the UK government is striving to achieve gigabit broadband coverage to at least 85% of total premises in the country by 2025 and 99% by 2030.[34] This is motivating ISPs to deploy FWA in rural areas to enhance broadband connectivity, which may be one reason why this use represents the largest volume of licences granted currently.

3.8–4.2GHz SALs can also be used across a wide range of industry verticals, which are interested in deploying private 5G networks. One of the key use cases of private 5G networks in the 3.8–4.2GHz band[35] for industry verticals is IoT. Some of the other industry verticals which have been granted licences are universities, city councils and broadcasters (for video/audio content production).

34 See https://www.gov.uk/government/publications/uk-wireless-infrastructure-strategy/uk-wireless-infrastructure-strategy

35 It is noted that industry standardisation body 3GPP has standardised equipment for use in the 3.8–4.2GHz band and that in 3GPP specifications, these frequencies form part of the 'n77' band.

Figure 4.4: Proportion of 3.8–4.2GHz SALs issued by vertical sector [Source: Analysys Mason based on Ofcom, 2023]

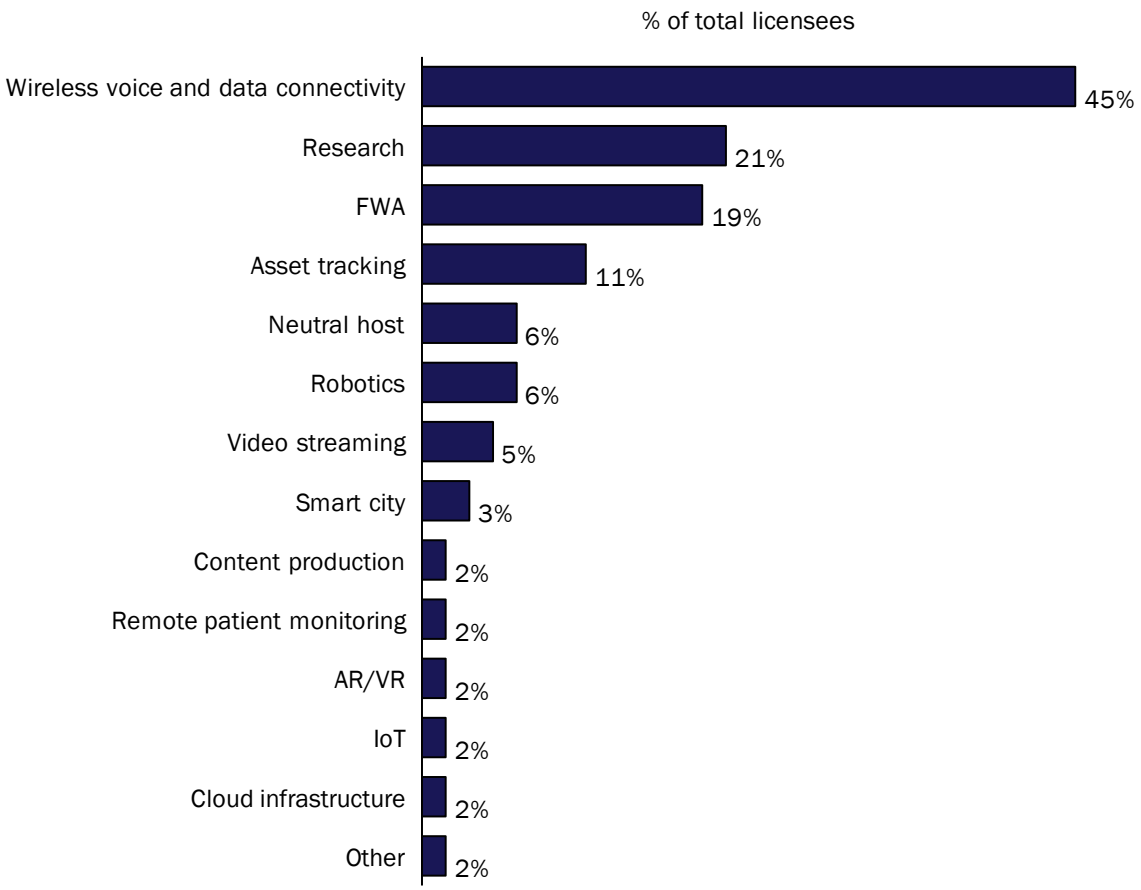


Ofcom's WTR database does not provide the use cases or applications of the licences, and most private networks are not publicly announced. In our analysis, we have therefore assigned the most plausible types of use for each licence based on publicly available information from the licensee's website and any other credible sources where possible (including primary research interviews conducted for this project). This has allowed us to form a view on the types of use cases and different types of use based on the licensees. It is important to note the difference between Figure 4.4 and Figure 4.5: the former is based on the number of licences and the latter on the number of licensees.

It should be noted that more than one use case can be adopted for each licensee. Based on our analysis (see Figure 4.5), it is understood that among the 62 licensees examined, a significant proportion (44%) has been granted 3.8–4.2GHz SALs for the purpose of facilitating wireless voice and data connectivity. This definition could span a wide range of functionalities, including voice and data communications between users, machines or other objects, tailored to bespoke capacity and coverage demands.[36]

36 See https://www.verizon.com/about/news/verizon-european-private-5g-deal-associated-british-ports

Figure 4.5: Use cases for 3.8–4.2GHz SALs by user group [Source: Analysys Mason based on Ofcom, 2023]



Approximately 20% of the licensees are using the 3.8–4.2GHz band for 5G or other wireless-based research endeavours. In particular, some of the SALs are for universities and research groups that are collaborating with industry stakeholders to trial 5G connectivity solutions. Some licences are understood to be associated with ongoing 5G research funded via the government's 5G testbeds and trials and other research programmes funded by the government. This kind of research-focused programme aims to explore and develop 5G wireless communication in various fields such as manufacturing, autonomy, content production and live radio or television broadcasting.

Other use cases in the 3.8–4.2GHz band, such as asset tracking, robotics and video streaming, are also being deployed in industries like ports, manufacturing and content production. Another environment in which SALs can be used is smart cities – for example, Milton Keynes Council has rolled out a private 5G network to run trial applications on three core themes of mobility, health and wellbeing, and energy.[37]

Specific case studies illustrating the range of use cases currently accommodated in the 3.8–4.2GHz band are described in Figure 4.6.

37 See https://www.semlep.com/news/2021/mk-5g/

Figure 4.6: Case studies related to current use cases for 3.8–4.2GHz SALs [Source: Analysys Mason, 2023]

Use case	Case study
Wireless voice and data connectivity	• Ferrovial, a construction and engineering firm, has deployed a private 5G network at its Silvertown Tunnel construction site to enable wireless connectivity in the tunnel and enhance site communications, access management and perimeter control[38] • Associated British Ports has deployed a private 5G network at the port of Southampton which helps address the issue with onsite data communication due to poor Wi-Fi connectivity, and enables near real-time analysis and data sharing between sensors, machines and devices[39]
Research	• The University of Sheffield Advanced Manufacturing Research Centre has deployed an on-premises dedicated private 5G network – the private 5G network helps solve scalability and data processing issues, as it enables real-time data analysis in the data centre located off-premises rather than locally in the research centre where processing power and reconfigurability are limited[40]
FWA	• Quickline, which holds the highest number of existing 3.8–4.2GHz SALs, has announced that it has developed and commercialised a 5G standalone, cloud-native OpenRAN network that uses the specified spectrum band for FWA service[41] – the network provides ultrafast mobile connectivity to rural communities in the North of England
Asset tracking	• Associated British Ports has deployed a private 5G network at the port of Southampton to provide the port with a reliable and secure private wireless data network[42] – the deployment will not only be used for onsite data communications, but will also enable new service advancements such as asset tracking, AGVs and predictive maintenance in the near future
Neutral host	• Dense Air has launched a 5G standalone neutral host network in Millbrook, which allows connected and autonomous vehicle testing – the network operates on spectrum in the 1800MHz, 2300MHz and 3.8–4.2GHz bands under the SAL scheme, offering ultra-low latency communications, massive machine-type communications and network slicing capabilities[43]
Robotics	• BT has deployed a purpose-built private 5G network at the Manufacturing Technology Centre's manufacturing research facility in Coventry, in partnership with West Midlands 5G (WM5G) and Worcestershire 5G (W5G)[44]

38 See https://newsroom.ferrovial.com/en/news/ferrovial-5g-in-silvertown/

39 See https://www.verizon.com/business/resources/customer-success-stories/associated-british-ports/#overview

40 See https://telent.com/case-studies/5g-private-network-for-the-amrc

41 See https://quickline.co.uk/blog/news/uks-first-broadband-provider-to-deliver-5g-sa-cloud-native-open-ran-solution/

42 See https://www.verizon.com/about/news/verizon-european-private-5g-deal-associated-british-ports

43 See https://denseair.net/dense-air-and-millbrook-partner-on-the-sustainability-of-the-5g-autoair-network/

44 See https://www.the-mtc.org/news/mtc-trials-private-5g-network-for-manufacturers/

Use case	Case study
	– the private network is a trial project that will allow manufacturers to explore 5G capabilities such as robotics and AGVs in the short term and multi-edge computing and other benefits in the longer term
Smart city	• Milton Keynes Council launched the MK:5G project in 2021, which is a new testbed in the Milton Keynes area for the deployment of dedicated 5G infrastructure[45] – the private 5G standalone mobile network uses the 3.8–4.2GHz SAL framework and is designed exclusively for research and development purposes that cover key sites, including rail stations, hospitals, universities and stadiums – the network is to trial applications across three core themes: mobility, health and wellbeing, and energy
Content production	• The British Broadcasting Corporation (BBC) and Neutral Wireless Ltd deployed a private 5G network to provide video streaming during the Coronation of King Charles III and Queen Camilla, in May 2023[46] – the broadcaster was able to upload the video footage and pictures through the private network to avoid data congestion issues with public mobile networks
Broadcast and wireless production	• British Broadcasting Corporation (BBC) Research and Development, Neutral Wireless Ltd and StrathSDR deployed networks in 3.8GHz to 4.2GHz spectrum for the broadcast and wireless production use case to allow cameras to be connected to 5G standalone (SA) networks in 100MHz channels • These networks are optimised for uplink transmission for traffic from the cameras, with downlink used for control and talkback • More than sixteen international broadcasters connected to an eight-cell network outside Buckingham Palace down to Trafalgar square in May 2023, to carry live video to global networks from the Coronation of King Charles III[47]
Remote patient monitoring	• Verizon, together with Visionable, a leading health technology company, has launched a technology-led centre dedicated to connected healthcare technologies for patient care[48] – the centre offers private 5G networks that showcase remote patient monitoring capabilities in various healthcare environments such as virtual ward, connected emergency services (e.g. wearable technology) and general practice surgery

4.2 Comparison against global private 5G networks use cases

Global private 5G networks trackers, such as the private wireless networks tracker from Analysys Mason's Research team, provide periodic snapshots of the latest private network deployments worldwide. It is worth noting that many private network deployments remain

45 See https://www.semlep.com/news/2021/mk-5g/

46 See https://www.bbc.co.uk/rd/blog/2023-05-5g-non-public-network-coronation

47 See https://www.ibc.org/technical-papers/ibc2023-tech-papers-5g-standalone-non-public-networks-modernising-wireless-production/10246.article

48 See https://visionable.com/wp-content/uploads/2022/05/Visionable-Verizon-Connected-Healthcare-Centre-launch-press-release-11.05.22.pdf

undisclosed, hence the total market could be considerably larger than the Analysys Mason Research tracker estimation.

As stated earlier, the UK stands as an early adopter among European countries in making the 3.8–4.2GHz band available for private networks and other use cases. We note the Belgian regulator, BIPT, has recently issued a consultation on enabling private network use in the 3.8–4.2GHz band. The key technical conditions proposed by BIPT (e.g. EIRP and antenna heights) align with the current limits set by Ofcom.[49] There is also a public consultation process in the Kingdom of Saudi Arabia, introducing the Spectrum Light Licensing Regulations, which proposes authorisation of private wireless networks in the 4.0–4.2GHz band.[50] Other noteworthy examples of private wireless network deployments can be observed in countries such as Germany, France and Sweden. These private networks are authorised in different bands to the UK, including 2.6GHz (France), 3.6GHz (Sweden) and 3.7–3.8GHz (Germany). They demonstrate a similar range of possible private 5G network uses to those being witnessed in the UK. The details of a selection of private networks are highlighted in Figure 4.7. We note that not all of these private wireless networks are using 5G (new radio, or NR) technology; some use 4G (Long Term Evolution, or LTE) technology.

According to the Analysys Mason Research data, the global commercial private wireless network market is experiencing growth, although the number of currently active networks is still relatively small. The publicly disclosed private wireless networks listed in the Analysys Mason Research tracker have experienced an annual growth rate of approximately 42%, rising from 256 in the third quarter of 2021 to 363 in the third quarter of 2022. Moreover, the proportion of networks using 5G (rather than LTE) technology has also seen an increase, from 41% to 48% over the same period.[51] The remaining 52% are private networks that use 4G LTE technology. This upward trajectory in use of private wireless networks is expected to persist as trial and proof-of-concept networks demonstrate their efficacy and transition to commercial deployment, and as the availability of modems and devices compatible with use in the 3.8–4.2GHz band increases. It is noted that the Analysys Mason Research tracker only covers commercially deployed private networks using LTE or 5G technology and for which publicly available information is available.

49 See https://bipt.be/index.php/operators/publication/consultation-regarding-the-draft-decision-regarding-local-private-networks-in-the-3800-4200-mhz-band

50 See https://regulations.citc.gov.sa/en/Pages/PublishedPublicConsultations.aspx#/PublishedPublicConsulationDetails/46

51 See https://www.analysysmason.com/research/content/short-reports/private-network-deployments-rma17/

Figure 4.7: Selected private networks from the Analysys Mason Research private wireless networks tracker (private networks using the 3.8–4.2GHz band are highlighted in blue) [Source: Analysys Mason, 2023]

Country	Frequency	Network owner	Network type	Technology	Sector	Use cases
France	700MHz, 2.6GHz	Group ADP (Hub One)	Commercial	LTE	Transport	AGVs
France	2.6GHz	Airbus	Commercial	LTE	Manufacturing	General connectivity
France	2.6GHz	EDF	Commercial	LTE	Utilities	General connectivity
France	3.5GHz	Lacroix Group	Trial/proof of concept	NR	Manufacturing	Wireless voice and data connectivity, AR/VR
France	2.6GHz, 26GHz	Le Havre Port	Trial/proof of concept	NR	Transport	Security cameras, asset tracking, industry equipment, smart grid
Germany	3.5GHz	Lufthansa	Commercial	NR	Logistics	General connectivity
Germany	3.6GHz	Osram	Commercial	LTE	Manufacturing	Not disclosed
Germany	3.6GHz	Arburg	Commercial	NR	Manufacturing	Robotics, industrial equipment
Germany	3.7–3.8GHz	Bosch	Commercial	NR	Manufacturing	AGVs, industrial equipment
Germany	3.7–3.8GHz	Bosch	Trial/proof of concept	NR	Manufacturing	AGVs, industrial equipment
Germany	3.7–3.8GHz	BMW	Commercial	LTE	Manufacturing	Not disclosed
Germany	3.7–3.8GHz	Fraunhofer Institute for Production Technology (IPT) (RWTH Aachen Campus)	Commercial	NR	Manufacturing	Asset tracking, industrial equipment
Germany	3.7–3.8GHz	RWTH Aachen University	Commercial	NR	Manufacturing	Not disclosed
Germany	3.7–3.8GHz	WLH	Testbed	NR	Education	Drones
Germany	3.7–3.8GHz	Media Broadcast	Testbed	NR	Entertainment	Massive data download, drones
Germany	3.7–3.8GHz	Technische Universität Kaiserslautern	Commercial	LTE, NR	Education	Not disclosed

Country	Frequency	Network owner	Network type	Technology	Sector	Use cases
Germany	3.7–3.8GHz	ARENA2036	Commercial	LTE, NR	Manufacturing	Not disclosed
Germany	3.7–3.8GHz	Volkswagen	Trial/proof of concept	NR	Manufacturing	Massive data download, AGVs
Germany	3.7–3.8GHz	Fraport	Commercial	NR	Transport	AGVs, robotics
Germany	3.7–3.8GHz	Cologne/Bonn Airport	Commercial	NR	Transport	AGVs, asset tracking
Germany	3.7–3.8GHz	Siemens	Trial/proof of concept	NR	Manufacturing	AGVs
Germany	3.7–3.8GHz	WISTA Science and Technology Park	Commercial	NR	Education	General connectivity
Germany	3.7–3.8GHz	Fraunhofer Institute for Integrated Circuits	Commercial	NR	Education	General connectivity
Sweden	3.7GHz	Scania	Commercial	LTE	Manufacturing	Industrial equipment, AGVs
Sweden	3.7GHz	Fiskarheden	Commercial	NR	Agriculture	General connectivity
UK	3.8–4.2GHz	Manufacturing Technology Centre (MTC)	Testbed	NR	Manufacturing	Robotics, AGVs, inspection cameras
UK	3.8–4.2GHz	Neutral Wireless & BT Media and Broadcast (at StoneX Stadium)[52]	Trial/proof of concept	NR	Entertainment	Video streaming
UK	3.8–4.2GHz	Neutral Wireless and QTV at Queens Departure from Scotland (Edinburgh Airport)[53]	Trial/proof of concept	NR	Entertainment	Video streaming

52 See https://www.vislink.com/casestudy/vislink-5g-wireless-camera-technology-supports-new-broadcast-innovations/

53 See https://www.holyrood.com/news/view,worldfirst-private-5g-network-technology

Country	Frequency	Network owner	Network type	Technology	Sector	Use cases
UK	3.8–4.2GHz	BBC R&D and Neutral Wireless Ltd, Kings Coronation[54]	Trial/proof of concept	NR	Entertainment	Video streaming
UK	3.8–4.2GHz	Ferrovial	Commercial	NR	Transport	Wireless data connectivity, voice communications, people tracking

54 See https://tech.ebu.ch/news/2023/09/the-story-of-bbcs-private-5g-network-for-contribution-for-the-coronation

In addition to the above, we have cross-checked the information in Figure 4.7 against the GSA private mobile networks tracker.[55] The GSA tracker lists 22 private mobile networks operating in the n77 band.[56] The networks listed in the GSA tracker are exclusively situated in the UK and Germany. As the private 5G mobile network ecosystem continues to evolve and more regulators are planning to make spectrum available for private network use, the GSA indicated in a recent report that it anticipates continued market development in the near future.[57]

For a detailed breakdown of the vertical sectors associated with these private networks, please refer to Figure 4.8.

Figure 4.8: Vertical sectors of private 5G mobile networks using the n77 band [Source: Global Mobile Suppliers Association Private Mobile Networks, 2023]

Vertical sector	Number of deployments
Manufacturing	13
Education	5
Smart city	1
Device testing and lab as a service	1
Public venues and other neutral hosts	1
Other	1
Total	**22**

The GSA devices tracker reveals a current global count of 1251 devices compatible with the n77 band up until September 2023 (shown in Figure 4.9).[58] Notably, a substantial 86% of these devices have already entered the commercial market, while a smaller proportion (accounting for 9% of the total) remains in the pre-commercial stage, and another 5% represents devices whose development status is unknown. In addition, we noticed that the number of n77-compatible devices in the market has grown exponentially since Ofcom made the 3.8–4.2GHz band available for SAL in 2019. This shows that device suppliers are well positioned to address the demand for this band and can quickly react should demand for n77-compatible devices pick up.

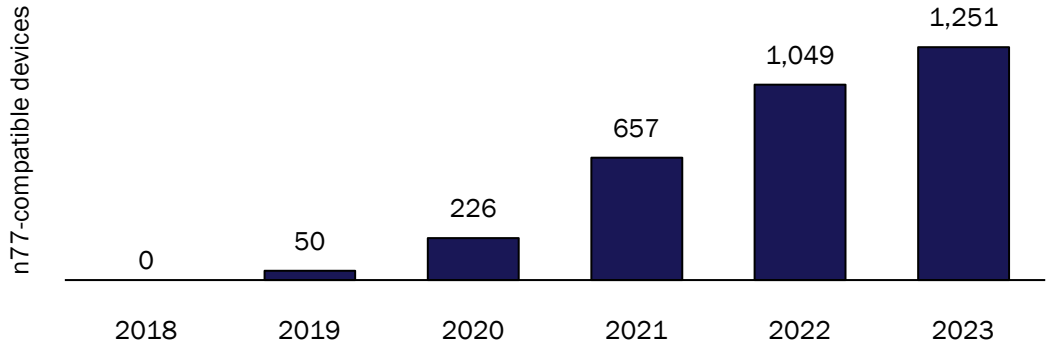
55 It is understood that the GSA private mobile networks tracker focuses on private networks whose contract value is at least EUR100 000, if that is publicly revealed. See https://gsacom.com/paper/private-mobile-networks-may-2023-summary/

56 Out of these 22 private networks, 16 are only using the n77 band to support 5G, and the remaining six deployments are also using the b43 band (3.6–3.8GHz) to support LTE alongside 5G.

57 Global Mobile Suppliers Association, "Private Mobile Networks, Member Report", June 2023. See https://gambod.gsacom.com/privateNetworks

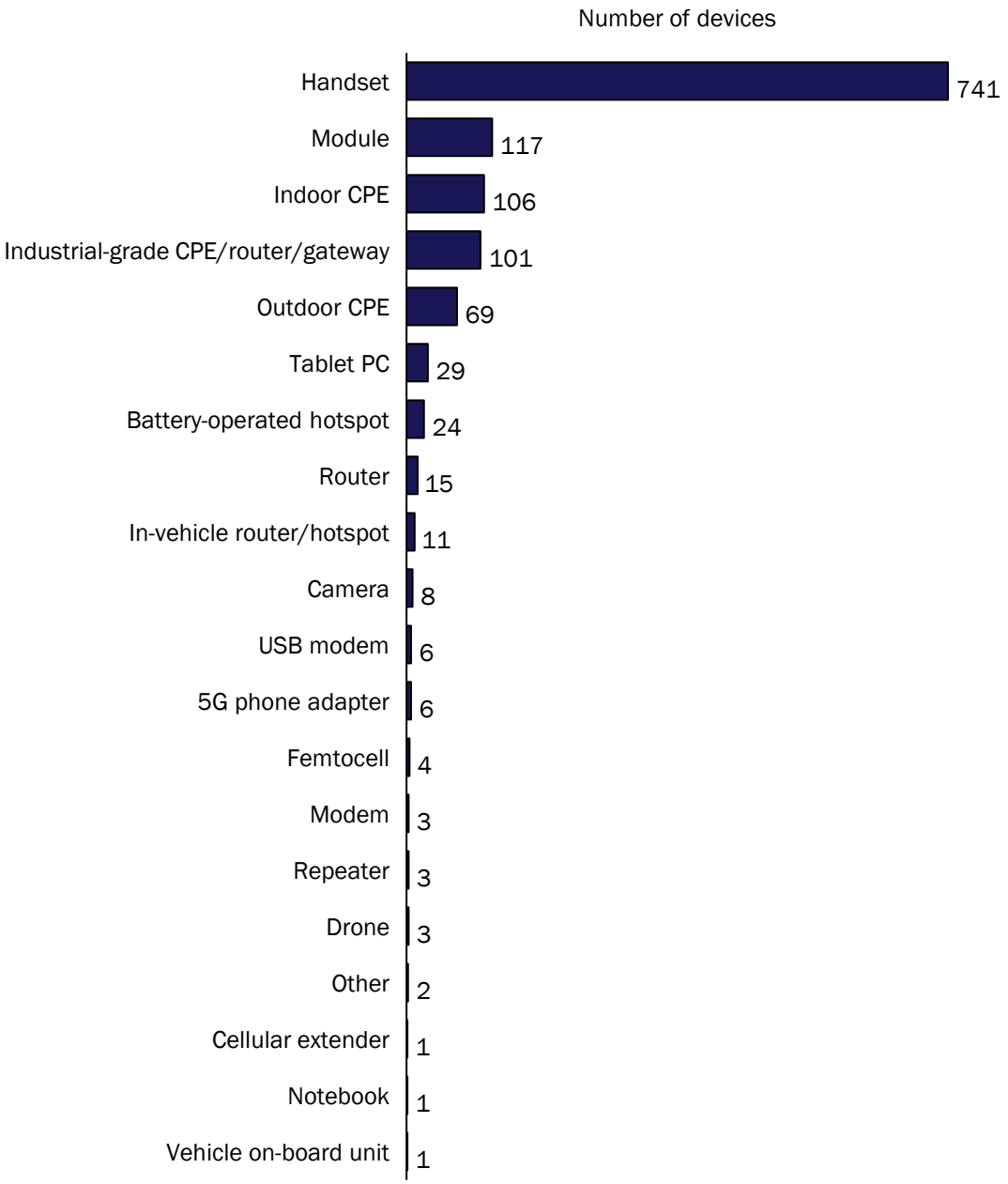
58 Global Mobile Suppliers Association, Devices tracker, September 2023. See https://gambod.gsacom.com/devices

Figure 4.9: n77-compatible devices [Source: Global Mobile Suppliers Association Device tracker, 2023]



Among these 1251 devices, smartphones represent a significant proportion of the supported device types. An additional category observed in the tracker is referred to as radio transmission devices, and includes a range of non-handset devices such as modules, customer premises equipment (CPE) and routers, indicating the expanded range of device types that are becoming available.

Figure 4.10: Number of devices compatible with the n77 spectrum band globally [Source: Global Mobile Suppliers Association Device tracker, 2023]



5 Summary of evidence captured during the study

This section summarises the evidence we have captured during this project through interviews and a workshop with the SPF membership, together with our own analysis, to consider i) how use case requirements might evolve in the 3.8–4.2GHz band, and ii) the implications of growing demand for the evolution of the 3.8–4.2GHz licensing framework.

In total, we interviewed eight companies/organisations to capture their views on the current use cases and their likely evolution, and to gather suggestions on how the licensing framework might evolve. To further inform our analysis, we also reviewed the responses submitted by several other organisations to Ofcom's 'Call for inputs' consultation on the SAL framework, and assessed Ofcom's own analysis on the various topics, such as evolution of use cases and licensing process.

A summary of our findings is provided below and more details are available in Annex A.

5.1 Current use cases and their likely evolution

We asked interviewees about the types of deployments that currently use the 3.8–4.2GHz band in the UK, and how these might evolve.

Responses from interviewees suggested current use of the 3.8–4.2GHz band ranges from experimental uses (e.g. proof of concept, technology trials, government-funded trials such as 5G test beds and trials), through to commercialised use cases. These commercialised uses include wireless broadband connectivity in rural areas, and various use cases are aimed at specific industry verticals, such as deployments in ports, manufacturing, and live content capture and distribution for stadiums and live events.

In line with wider trends in the digital technology sector, use cases could evolve in the near future to use more advanced technologies such as artificial intelligence (AI) – for example, for service optimisation – robotics, and AR/VR. The impact of this evolution could be that the volume of licence applications increases, and the capacity requirements per application remain at the higher end of the bandwidth options offered by Ofcom currently (i.e. 80MHz or 100MHz), or above.

Figure 5.1: Evolution of use cases [Source: Analysys Mason, 2023]

Use cases and deployment	
Type of use cases	Besides the current use cases which have already been commercialised, such as private 5G networks used for a variety of applications (e.g. sensors on cranes at ports), the capture of live video/audio content at live events and rural broadband via FWA networks, interviewees also suggested various types of new and evolving uses including AR/VR applications in several industrial sectors, real-time video surveillance, audio programme making and special events (PMSE), and many bespoke use cases within specific environments (e.g. hospitals and manufacturing plants).

Use cases and deployment	
	Many of these use cases are extensions of those that are already under trial currently as proof of concept, as described in Section 3. Some future use cases, such as audio PMSE, might have characteristics that are different to some current use cases – for example, in terms of the usage period for the licence. Whilst private 5G networks typically require a longer usage period, audio PMSE, like broadcast and wireless production (see Figure 3.1) may require access to spectrum over a shorter period.
Technologies to deliver the use cases	The most commonly deployed technology in the 3.8–4.2GHz band is 5G new radio (5G-NR) in 5G standalone network configuration, using band n77 devices. A specific alternative technology example given is use of DECT new radio plus (DECT NR+), which could be deployed to deliver audio PMSE and IoT use cases.[59]
Outdoor/indoor deployments	Interviewees suggested that the evolution of use cases could generate greater demand for outdoor deployments. For example, manufacturing plants containing multiple buildings and requiring seamless connectivity throughout the entire plant would increase demand for outdoor deployments. Similarly, a sea port with remote piloting of cranes in outdoor locations would require outdoor base stations to be used. Construction, airports and mines are also examples of use cases that include a significant outdoor environment. FWA is another example of an evolving use case using an outdoor deployment. It is noted that some deployments also require seamless connectivity for a combination of indoor and outdoor environment, especially in locations like warehouses and factories where AGVs are used to transport items between the two environments.
Desired bandwidth	Interviewees suggested that current licence applications are typically for 100MHz bandwidth (this is backed up by our analysis of Ofcom's SAL licensing data). This does not necessarily mean that every individual use cases require this bandwidth, but possibly reflects that applicants are applying for larger channel widths to maximise the capacity available to accommodate a widening range of use cases and volumes of usage per deployment.

5.2 Technical conditions associated with the licences

We considered how the evolution of use cases might affect the technical conditions for use of the 3.8–4.2GHz band.

Responses from some interviewees suggested specific configurations are needed so that power levels from n77 base station products comply with the power limits Ofcom stipulates (modifications can be needed to align products with licence conditions both for low-power and medium-power deployments). For example, some products require attenuators in the base station to lower the transmitted output power to achieve Ofcom's current base station power limits. Other products that

59 For example, see https://www.ofcom.org.uk/__data/assets/pdf_file/0029/263684/DECT-Forum.pdf#:~:text=DECT%20NR%2B%20is%20known%20as%20DECT-2020%20NR%20within,from%20point-to-point%20connections%20to%20star%20and%20mesh%20topologies.

use active antenna systems (AAS) cannot currently be deployed in the way they were designed to be, in the absence of a specific set of conditions for use of AAS solutions.

The primary impacts of the information we captured on technical conditions is that, in line with the evolution of the use cases identified above, there may be an increased demand for medium-power licences, and there could be a need for greater flexibility to accommodate both non-AAS and AAS-based systems, and to allow for variations in output power in line with product designs.

There will also be continuing demand for different uplink and downlink capacity in different use cases, meaning there is benefit in continuing with the current approach of not being prescriptive on frame structure.[60]

Figure 5.2: Technical conditions associated with the 3.8–4.2GHz SALs [Source: Analysys Mason, 2023]

Usage conditions for 3.8–4.2GHz SALs	
Downlink/uplink capacity requirements	Interviewees suggested use case requirements at locations such as live events, manufacturing plants, ports and transport hubs generate traffic that is either uplink dominated, or symmetrical between uplink and downlink. By contrast, downlink traffic in rural broadband (FWA) deployments is dominant. Respondents suggested future use cases could become more uplink-oriented (e.g. use of the n77 band for IoT sensor networks and increasing use of video uplink applications). Overall, these trends support Ofcom's current rules on frame structure being kept in place i.e. there is no requirement for a specific frame structure.
Medium- vs. low-power licences	According to the licences listed in Ofcom's WTR at the time of producing this report, it appears that most licensees currently use medium-power licences for their deployment. Medium-power licences are generally required on large outdoor deployment scenarios, such as ports, construction sites and mines for better coverage purposes. However it is noted that some use cases require access to spectrum over a shorter period (such as broadcast and wireless production), and these use cases are typically delivered using low-power licences.
Base station power limits	Interviewees made various suggestions to slightly increase the allowed transmitted power limits of low-power and/or medium-power base stations. Interviewees also suggested that base station power limits should be specified to enable use of AAS. We note that many of these points have already been identified in responses to Ofcom's earlier calls for

60 Frame structure refers to the ratio between uplink and downlink timeslots in 4G or 5G transmission using time division duplex technology (which is the type of technology used in 5G new radio). As per Ofcom's current SAL guidance, frame structure guidance is 'not applicable' for the 3.8–4.2GHz band, whereas a 3:1 frame structure applies for outdoor deployments in the 2.3GHz band. Without frame structure requirements, there is a possibility that systems operating in close proximity and using different uplink/downlink ratios could interfere with each other. Ofcom's notes suggest licensees in the 3.8–4.2GHz band operating in close proximity to one another are encouraged to work together to reach mutual agreement on how to avoid interference.

Usage conditions for 3.8–4.2GHz SALs	
	input, and Ofcom has already responded to many of these suggestions.[61] For example, some interviewees suggested that the current base station power level for low-power licences is too low, because some vendor equipment is not able to meet the low-power limit without attenuators being deployed, adding to the overall cost of the deployment. In addition, some interviewees suggested that the medium-power limit may be too low for FWA deployments in very rural locations. It was noted that the cautious approach that Ofcom is taking to granting medium-power assignments in the 3.8–4.2GHz band may not be merited in very rural locations where risk of interference is low. Additional power capability from base stations could help with FWA roll-out for specific rural locations. It was also noted that, to cover a large industrial area with multiple buildings, it would be beneficial to deploy more than one medium-power base station, whereas the current licence product for medium power is per base station.

Some respondents thought that the current technical conditions for use of the 3.8–4.2GHz band make deployments suited to 3GPP technologies only. A specific example given was DECT-NR+, which could be used to provide some of the use cases also being deployed in the 3.8–4.2GHz band (e.g. IoT). Our understanding is that providing non-3GPP technologies such as DECT-NR+ can use the same channel raster as the one Ofcom is already using and meet the stated technical conditions for use of the band (e.g. out-of-channel emissions), then there would not be further need to modify the framework in terms of the technical characteristics. However, noting that one of the potential use cases of DECT-NR+ is wireless microphones, these customers could require short-term frequency assignments that could be shorter than the one-month minimum licence term (similar to the video content production use case described previously).

5.3 Licence authorisation process

We asked interviewees about their views on the current SAL licensing process. Responses suggested several points where improvements could be made, including reducing the time taken between application and granting of licences, and increasing the transparency of the process. Various comments were made on pricing approaches, which are summarised below in Figure 5.3.

Summary of key points

The key points, in our view, are a desire to reduce the time between application being submitted and licence being authorised, and a desire for better visibility at the time of making the application of the likelihood of the application being successful. On pricing, various interviewees provided specific views, with differing views in favour of both higher fees and lower fees. Our own view is that

61 For example, there is discussion on transmitted power levels for base stations in Ofcom's description of co-ordination approach for SALs, here https://www.ofcom.org.uk/__data/assets/pdf_file/0034/157885/annexes-1-5-supporting-information.pdf

affordability is a key driver of enabling early-stage, innovative and localised solution deployments, and this was a key reason for introducing the SAL framework. On the basis that Ofcom's objective from SAL pricing is encouraging innovative uses on a localised basis, the current fees appear suitable. The current fee structure also offers a key benefit of being defined in a simple manner. Our conclusion is the fee structure could be re-considered if Ofcom's co-ordination process becomes more complex as a result of an increased volume of applications, but otherwise, we do not believe further changes are needed at the current time.

Figure 5.3: Comments on the current framework [Source: Analysys Mason, 2023]

Design of the current SAL framework	
Time to obtain licences	Many interviewees suggested the time to obtain licences is excessive. Without any up-front indication of whether an application is likely to be successful or not, there is a risk that the length of time for applications to be authorised could have a negative impact on adoption of SALs (for example, applicants bidding for competitively awarded contracts require timely confirmation of licence availability in a given location to meet the contract requirement). There was also a view that transparency is lacking in the process and that having a single point of contact within Ofcom for queries on the licensing process would be beneficial. The issues of increasing the pace at which licences are granted and providing more transparency over the process appeared to be common among all interviewees, irrespective of the use case.
Postcode-based applications	Some interviewees suggested the current postcode approach to deciding whether applications can be low or medium power is overly restrictive and risks inconsistencies. For example, some interviewees felt that applications for medium-power licences in urban postcodes could be granted if the application does not cause any interference to nearby networks. Hence, restricting medium-power licences to rural postcodes risks spectrum access being denied. These points were also linked to the comments above about demand increasing for medium-power licences. In summary, there is support for keeping the process flexible to allow medium-power licences to be granted on a case-by-case basis in non-rural postcodes. Whether there are any blanket changes Ofcom can make (e.g. to expand the definition of 'rural') is not clear without further analysis on location and distribution of licences. Hence, we have not identified an alternative approach to that of the current postcode approach that could enable a blanket increase in allowable medium-power allocations, other than to perhaps consider postcodes adjacent to rural postcodes as being candidates for medium-power licences.
Cost of licence	Most interviewees are of the view that the current cost-based pricing structure supports Ofcom's objectives to keep the process simple and tailored to local deployment, which will encourage take-up of licences.

Design of the current SAL framework	
	Some interviewees suggested that, as the current cost of licences is low, applicants are generally not deterred from applying for more bandwidth than they currently need. On the other hand, other interviewees suggested the fees should not be increased. Overall, our view is that the current fee structure provides the right balance for a licensing framework that is still being developed. Ofcom could consider including the licence fee structure for short-term licences (e.g. used by content production use cases) to reflect the licence duration, which would encourage the efficient use of the spectrum.
Licence duration	One interviewee suggested that there could be demand for use of the 3.8-4.2GHz band to support audio PMSE use cases. The characteristics of spectrum access for audio PMSE could differ from private 5G network use cases, since the usage period for audio PMSE can be short (e.g. for live audio production purposes).Private 5G networks, by comparison, are expected to have a longer usage period, reflecting the relatively high cost to industrial or enterprise private 5G network uses of deploying the network.

Other comments on the licensing framework

We asked interviewees about their views on how the SAL framework could be improved with a view to meeting future market requirements. One point discussed was whether opportunistic-based access, using a dynamic spectrum access (DSA)-type system, might be envisaged. Whilst acknowledging different views from individual parties on this topic, our conclusion from the comments received is that the exclusive and co-ordinated spectrum assignments needed for bespoke local deployments are well served by an Ofcom-managed process. However, we do think that streamlining the process, making it more transparent via a web-based application process, and reducing the application times is important to improve the efficiency and reduce the time between application and licence granting.

One stakeholder provided a view that the 3.8-4.2GHz band also has the potential to act as a resource in the provision of public mobile services, as it could provide the opportunity to deliver improvements in capacity and coverage in certain areas and scenarios, including shared neutral host networks, both indoors and outdoors. They said that flexible management of the band and the use of sharing mechanisms could enable Ofcom to respond to future changes in market circumstances in an agile manner, for example, by flexing the amount of spectrum that is set aside for low or medium-power use, and potentially enabling higher power use.

A summary of other suggestions is provided below in Figure 5.4.

Figure 5.4: Suggestions on the framework [Source: Analysys Mason, 2023]

Suggestions for improvement to the current framework	
Automation of the application process	Interviewees suggested Ofcom could streamline the application process by putting the application form online. A web-based tool

Suggestions for improvement to the current framework	
	providing some visibility over availability of spectrum, and giving an indication about application times and stage, might be beneficial. Interviewees suggested that there would be benefit in significantly reducing the application times from the current timeline (estimated at six weeks at best) and that an online process could be one factor to enable this. Some felt the transparency of the co-ordination process could be improved. For example, the current process gives no indication of likelihood of a successful application, until the licence is granted. This can cause unacceptable business delays (e.g. when bidding for competitive contracts for network deployment). Suggestions in this regard include having an immediate 'yes/no/needs further co-ordination' response available to applicants online, and to have some online indicator (visible to the applicant only) of the completion stage of the application (e.g. progress 50%/75%/100%). Also, easily accessible information on currently granted co-frequency assignments at the location being applied for could give visibility to applicants over whether the location is likely to be available or not (further discussed below).
Visibility of licence availability	Many interviewees suggested there would be benefit from implementing an online portal where applicants can easily check the availability of spectrum in desired locations. One of the interviewees suggested that Ofcom may consider indicating the level of potential network interference (e.g. red, amber and green) through a digital map tool online, where users can easily navigate and apply for SALs. This would provide users with an initial understanding of how congested the spectrum is in a given area and manage their expectations on the response from Ofcom assuming they do submit an application for a licence.
Frequency partitioning	There was also a suggestion to set aside a specific part of the band accommodating technologies with different technical conditions to those already defined in the 3.8–4.2GHz usage conditions (e.g. DECT-NR+), or to have different channels designated for different deployments (e.g. low power, or medium power). Our own view is that it is not clear how practical or efficient either of these options would be given the constraints of the current co-ordination process, and the distribution of licences across the band (as illustrated in Annex B).
DSA-type solutions	We noted various points for and against DSA-type solutions. Those in favour of DSA solutions seemed to consider that such a solution would enable opportunistic access to spectrum. Given the need for radio equipment to communicate with the database in order for a fully dynamic system to be implemented, our own view is that such opportunistic access would take time to implement. As such, DSA is not a short-term solution to meet the short-term priorities indicated in our comments above in relation to reducing application times. Our view is that the immediate priority seems to be to put the 3.8–4.2GHz SAL application process online. Ofcom could also give consideration as to how to make the overall process more transparent to applicants via online tools, and how to shorten the time between application and granting of licence. Appointing a single point of contact in Ofcom for questions relating to applications in progress could be

Suggestions for improvement to the current framework	
	a short-term solution ahead of any online tool development. From the interview comments, it seems the desired target timeframe for a licence authorisation is no more than a few weeks.
Influencing the European framework	Having established the SAL framework ahead of European counterparts, the UK experience in creating and administering the SAL co-ordination process seems very valuable to the wider European audience. Various interviewees supported that Ofcom could share relevant details of the process within ECC PT1 to facilitate alignment in Europe with the UK's approach. Harmonisation of European approach and technical conditions for use of the 3.8–4.2GHz band with that of the UK is likely to provide further encouragement for the device ecosystem for this band, which would support greater adoption of SALs both in the UK and in Europe.

6 Study conclusions and recommendations

This section summarises the overall findings and recommendations from our study.

6.1 Evolution of use cases

The sectors of use are likely to remain similar to those currently, which are private 5G networks, FWA, IoT and content production. Our research suggests a broader range of use cases emerging as the ecosystem evolves, tending towards real-time video, real-time data analytics and AR/VR, all of which consume larger bandwidths. Our conclusion is that demand for licences in the 3.8–4.2GHz band will remain towards the upper end of the bandwidths offered by Ofcom, i.e. 80MHz or 100MHz, or above.

The improving ecosystem for private 5G network products will likely drive greater adoption and variation in use cases and deployments. Localised solutions will continue to have bespoke quality-of-service requirements and varying traffic profiles such as having capacity provisioned to deliver more traffic in the uplink direction (e.g. for real-time video applications). Use cases we have identified through our research range from video uplinks and asset tracking through to content production for live events and bespoke IoT connectivity. There could be greater demand for uplink applications as 5G video uplink use cases evolve.

We envisage the characteristics of private 5G network use cases in Europe are likely to be similar to those in the UK.

This points to a conclusion supporting Ofcom's current rules on frame structure being kept in place i.e. there is no requirement for a specific frame structure.

Other than bespoke private 5G network use cases, IoT and content production, we see the other key use case that will evolve in the 3.8–4.2GHz band to be 5G-based FWA. The 3.8–4.2GHz band has already been used for commercial FWA purposes in the UK. In addition, the characteristics of the 3.8–4.2GHz band give a good balance between penetration and propagation, which makes it suitable to support the FWA use case especially in rural areas.[62]

We note that Ofcom received some responses to its 'Call for inputs' consultation on the evolution of the SAL framework identifying other types of use for which there could be future demand (such as DECT-NR+ type solutions for wireless microphones or for IoT). Providing non-3GPP technologies such as DECT-NR+ can use the same channel raster as the one Ofcom is already using, and conform with the technical conditions for use of the band (e.g. out-of-channel emissions), then

62 Views expressed in interviews conducted for this project were that millimetre-wave spectrum such as 26GHz could also provide gigabit connectivity for FWA solutions, but cannot achieve the same propagation and penetration as the 3.8–4.2GHz band. Hence, millimetre-wave may be suited to providing high capacity where needed in locations where FWA adoption is high, rather than being a substitute for the 3.8–4.2GHz band for the current rural FWA use case.

there would not be a need to modify the framework in terms of technical characteristics. However, noting that one of the potential use cases of DECT-NR+ is wireless microphones, these customers could require short-term frequency assignments that could be shorter than the one-month minimum licence term (similar to the video content production use case described previously).

6.2 Technical conditions

Power limits

Our conclusion is there is market demand for considering greater flexibility in deploying medium-power licences in non-rural postcode areas where the application can demonstrate co-ordination with existing licensees. In addition, Ofcom could also consider how to best accommodate user needs for more than one medium-power base station under a medium-power licence at a given location, subject to co-ordination. This could reflect a concern that some stakeholders have indicated whereby deployment to cover a factory campus containing multiple businesses currently requires multiple applications per single base station. Finally, feasibility of allowing power levels higher than the current medium-power limit for selected use cases in very rural locations (such as FWA) could be considered.

Co-ordination process for different antenna deployments

The radio solutions to use the 3.8–4.2GHz band are still evolving. Our interviews for this study suggested a mix of different antenna solutions is currently being tested and used. We note Ofcom suggested in its 'Call for inputs' consultation to reconsider the co-ordination method 'in the round' rather than focusing on specific solutions, such as AAS. Ofcom currently specifies maximum base station power as EIRP per sector, whereas there could be support from some equipment suppliers to consider how to modify the co-ordination criteria for base stations to use AAS.

We note that in Ofcom's recent statement, "Enabling mmWave spectrum for new uses", power levels are expressed as TRP instead of EIRP, because of the likely use of products with AAS. A similar approach could be applied to define power limits for the 3.8–4.2GHz SALs.

There could also be benefit in giving greater flexibility for applicants to demonstrate that risk of interference is reduced in a given location based on the following:

- including antenna directivity/antenna patterns in co-ordination calculation rather than basing co-ordination on EIRP[63]
- including antenna down-tilting in co-ordination calculation
- for AAS, stipulation of a coverage radius for the base station (to define the AAS beam characteristics).

63 The antenna patterns are required in the application form in the recently published consultation by CST, the regulator in the Kingdom of Saudi Arabia. See https://regulations.citc.gov.sa/Documents/IssuingDocument_REG-94/9c983101-3ae4-4bbb-90d3-66e637d1b0e8_Light%20Licensing%20Regulations%20for%20the%204%20GHz%20Frequency%20Band.pdf

Further than that, we think Ofcom could continue to encourage co-ordination between providers of locally deployed systems.

Bandwidth

The variation in use cases and locations of demand suggests that there is merit in maintaining the current flexibility on bandwidth (e.g. multiples of 10MHz bandwidth), even if the characteristics of 5G radio frequencies for the 3.8–4.2GHz band and the expected traffic volumes within localised solutions mean that most applicants will likely prefer using a wider bandwidth channel (e.g. 80MHz or 100MHz) as opposed to a narrower bandwidth of 20MHz or 40MHz.

6.3 Application and licence granting process

To support better efficiency in the use of the SAL framework, we think it is important to move the application process online. Better visibility for applicants of the likelihood of a successful application could also be beneficial, such as through an online tool providing visibility of other co-channel licences.

Our conclusion is that reducing application times and giving more visibility over the application process is more important in the short term than the development of a fully dynamic, DSA-type system. As discussed in Annex B.3, one of the motivations for developing a DSA-based system would be to enable opportunistic access to the spectrum whereby radio equipment can communicate with the database. However, since the expected evolution of use cases for the 3.8–4.2GHz band seems to be towards more bespoke private 5G networks and tailored FWA solutions, our conclusion is the current Ofcom-managed co-ordination process appears to be best suited to delivering this.

We note, as mentioned by several respondents to Ofcom's 'Call for inputs' consultation, that differing views on the benefits or otherwise of DSA-based solutions have already been considered by Ofcom. Whilst some stakeholders have indicated that a DSA-based solution could enable immediate authorisation and could also increase spectrum utilisation via opportunistic access, we note there would be a time lag (and high costs) involved in developing a full DSA process with geolocation and sensing, which does not address the short-term priority to increase the pace at which licences are granted. Several stakeholders expressed that the introduction of a full DSA system will significantly increase the uncertainty of spectrum access, which could have a negative impact on the quality of service provided from the local network.

We identified several other priorities for the licence granting process, including:

- Moving the application process to an online form rather than via email could be accompanied by creating user accounts, to simplify both application and licence payment processes. For example, this could allow Ofcom to implement single billing for SAL fees, covering all SALs per user in a single bill.

- Creating a visual and easily accessible tool giving visibility of co-channel licences already granted in a given location could enable applicants to have early visibility on whether their application is likely to be accepted and/or enable them to tailor applications accordingly

  - the online process could be enhanced to give applicants a provisional 'yes/no/subject to further co-ordination' indication for a requested licence to improve visibility of the process.

6.4 Summary of key recommendations

Figure 6.1 below summarises our recommendations for the SAL framework in descending order of priority.

Figure 6.1: Summary of improvement suggestions to the SAL framework [Source: Analysys Mason, 2023]

No.	Recommendations	Priority
1	Seek to increase rate of licence application granting and make the process more visible (such as by putting the application process online, providing an earlier indication of chances of applications being approved for given locations, and reducing timescales between application and approval). Appoint a single point of contact at Ofcom for licensing queries relating to SALs	High
2	Consider whether a high-level summary of existing low- and medium-power assignments can be made visible to applicants through an easy-to-view interface, to give greater visibility over availability of spectrum at given locations (such as via a map showing the location of currently approved licences)	High
3	Provide an online indication (e.g. yes/no/subject to further co-ordination) as to the status of applications, to give an idea to applicants of likelihood of application being approved	High
4	Include details of antenna pattern in the technical details requested from applicants so that directionality of antenna radiation can be incorporated into the co-ordination process	High
5	Consider clarifying technical conditions to enable use of AAS under the current medium-power licence	High
6	Improve the visibility of the 'exceptions process' (i.e. the co-ordination process undertaken by Ofcom to consider applications that depart from the standard conditions). Greater transparency to applicants on timescales for the process, and better dialogue over mitigation factors that might improve the success of co-ordination (e.g. antenna directivity, change in location, down-tilting, etc.) could be beneficial	High
7	Consider if medium-power licences can be applied for in non-rural postcode areas	Medium
8	Give flexibility to applicants to apply to use more than one base station in deployments at a given location under a medium-power licence (e.g. to provide coverage between buildings in a larger site)	Medium
9	Offer more flexible short-term licence durations for content production deployments and update the fee structure accordingly for shorter-duration licences to encourage efficient use of the spectrum	Medium
10	Examine how to maintain a level playing field for multiple applicants applying for a SAL to respond to the same customer need (e.g. in	Low

No.	Recommendations	Priority
	response to a customer who has issued a request for proposals via a competitive tender). Consider adding 'customer name' to the application so that Ofcom is able to identify where multiple applicants are applying for spectrum to respond to the same customer	
11	Continue to allow applicants to resolve co-ordination issues locally through suitable market means, such as synchronisation of TDD[64] timing using GPS[65]	Low

64 TDD: time division duplex.

65 GPS: global positioning system.

Annex A Interview summaries

We provide below a summary of the discussions held to inform our analysis. As agreed with interviewees, we have anonymised the names of interviewees and their organisations.

Interviewee 1

- The interviewee mentioned that the development cycle of 5G products for a new spectrum band takes time. In most cases, vendors will only develop products if the regulation is clear and a level of return on investment (based on scale and volume of demand) is anticipated. Therefore, the interviewee believes that new use cases for the 3.8–4.2GHz band will follow from a wider ecosystem for products becoming available. Clear regulatory certainty in Europe on the availability and conditions for use of the 3.8–4.2GHz band will help to build the ecosystem.

- It is understood from the interviewee that not all potential technologies that could be used in the 3.8–4.2GHz band fall within the purview of 3GPP's 5G standards. The interviewee cited the Digital Enhanced Cordless Telecommunications New Radio (DECT NR+) standard as being potentially deployable in this band. The interviewee is of the view that Ofcom could make the 3.8–4.2GHz band truly technology neutral, which would encourage more use cases to be developed. Whilst 3GPP's 5G technology can be used in IoT solutions, this is not the only solution for IoT connectivity and IoT use cases are also a potential market for alternative technologies such as DECT NR+.

- Moving forward, the interviewee believes that it is important to clarify objectives in developing this specific band, and whether the band could be opened for technologies with technical conditions that differ to those currently authorised.

- The interviewee also commented on the process of licence application. It was recommended that Ofcom should make the licence application process more automated. This includes allowing applicants to check the availability of spectrum in a given location through an online portal and apply for a licence, thus essentially removing the aspect of submitting applications in the form of e-mail. The interviewee recommended Ofcom should consider a database similar to CBRS in the USA. By automating the application process, the applicants would be able to apply for short-term licences quickly for 'pop-up' events, for example news broadcasting and live events, which are not typically known weeks in advance.

- The interviewee mentioned the possibility of categorising the applications for licences into different priority groups, which would allow certain users to have their licence application prioritised for more important use cases (e.g. emergency services). In addition, once the licence is assigned, it would be beneficial to keep the frequency protected at the location specified for the duration of the assignment, especially for the high-priority groups, to ensure quality of service.

Interviewee 2

- It was this interviewee's view that many industries are still conducting trials and participating in government-funded test beds to investigate the capabilities and benefits of deploying private 5G network technology. Only a number of industries have achieved some level of commercial success incorporating 5G technology into solving their business or operational needs. Notably, the ports industry has a good understanding of the benefits of private wireless networks and has successfully deployed private 5G networks for use cases that improve their efficiency through automation. However, many enterprises are still unclear of the business benefits or are in the process of determining the advantages that private 5G networks bring to their business.

- The interviewee envisaged a high demand for both indoor and outdoor private 5G equipment. For the latter, there is particularly strong demand for deployment in places such as oil refineries or outdoor spaces of factories/warehouses. It is often the case that both indoor and outdoor capabilities are required to allow seamless connection between the two environments and there is also a need to cover larger sites containing multiple buildings.

- Currently, the power limit of SALs is mainly determined based on postcodes, which presents a limitation over greater access to medium-power licences. Although Ofcom offers exemption for special cases with sufficient proof, it is typically a time-consuming process to obtain a medium-power authorisation in a non-rural postcode, leading to delays in being able to deploy. The interviewee is of the view that the current process could be considered as overly conservative regarding the granting of medium-power licences. It is suggested that a blanket prohibition of medium-power licence applications in urban postcodes should not be applied, but rather that applications for medium-power base stations in non-rural postcodes should be considered and only rejected if they have the potential to cause interference to nearby SAL systems, or to other existing uses (see Annex B.1).

- The interviewee recommended that Ofcom should consider developing an online portal that allows applicants to check the availability of spectrum in different locations before applying for a licence, which would streamline the application process and improve overall transparency. It was suggested that a more automated approval process could shorten the application process.

- The interviewee also noted inconsistencies regarding the allowed power limit of radio equipment. Under the low-power licence, the licensee is able to deploy multiple base stations within a 50 metre radius of the specified co-ordinate. As the licensee deploys multiple base stations, the EIRP level of the base stations on an aggregated level would be similar to that of a single base station on a medium-power licence. In some cases, it could be more effective and cost efficient to deploy a medium-power base station rather than multiple low-power ones. However, Ofcom generally does not allow medium-power licences to be assigned to urban postcodes, even for the aforementioned example.

- The interviewee thinks that Ofcom could further consider relaxing the power limits for certain use cases (e.g. FWA in rural areas), as these locations tend to be non-competitive areas (i.e.

areas where there is not strong demand for multiple SALs). If Ofcom dedicated one block of 100MHz to higher-power FWA use in rural locations, this could make FWA deployments more commercially viable, if the result is fewer base stations being needed and ability to reach more subscribers at a lower cost.

- Currently, the majority of 3.8–4.2GHz shared access licensees are holding licences with 100MHz bandwidth. The interviewee's view was that not all systems require a 100MHz bandwidth for their current use, but applicants may have applied for a larger bandwidth in anticipation of future capacity requirements, and due to the low annual licence fee.

Interviewee 3

- The main use cases that the interviewee sees for the 3.8–4.2GHz band currently are port operations and live video broadcasting content that can be uploaded to the broadcasting network in real time. The interviewee also found the 3.8–4.2GHz band to be attractive to deliver bespoke use cases with differing capacity requirements to those of consumer mobile broadband traffic in the public 5G networks, such as support for use cases requiring more uplink capacity.

- The interviewee considers that the demand for this band will increase as 5G standalone (SA) capability is implemented in public 5G networks, at which point more private 5G radio networks will be deployed, attached to a public 5G SA core. Users generally prefer the 100MHz bandwidth due to the capacity it offers and to its ability to meet end users' data rate requirements.

- The 3.8–4.2GHz spectrum band is also attractive for use in private 5G networks as synchronisation of frame structure is not required, meaning that individual solutions can be tailored with the appropriate uplink and downlink bandwidth to meet customer needs. Currently, this flexibility does not exist in public 5G networks and hence the 3.8–4.2GHz band is uniquely placed to address this requirement.

- The ecosystem for use of the n77 band is improving but presented some initial problems to the licence holders as some of the initially available products only support part of the band rather than the whole 3.8–4.2GHz band.

- The interviewee thinks the current co-ordination process is too lengthy and it is especially difficult to persuade Ofcom to issue medium-power licences in urban areas, even with evidence provided by the applicant to prove that it would not cause any interference. The interviewee is concerned that Ofcom's approach might be overly cautious rather than seeking to maximise use of the band.

- The interviewee advocates that frame synchronisation should be on a voluntary basis rather than a mandated one, which fits better with the original idea of making this band more flexible for different types of applications.

- The interviewee supported that the application process could be turned into an online one, rather than the current emailing system. This would mean that applicants can fill in the data on a

webpage and click a button to submit. Ideally, an online system could give applicants an instant co-ordination result, or at least provide a provisional answer. It causes business difficulties for an applicant to wait for at least six weeks for a decision as sometimes the applicant is bidding for a project and the timescale for submitting a bid is much shorter than the application processing time. Therefore it is important for the applicant to know whether they can get the licence in a much shorter time than the current processing time.

- The interviewee does not think that a full DSA approach is an optimal solution for the 3.8–4.2GHz band in the foreseeable future as most of the applications provided to the customers now require certainty over spectrum access, and a designated quality of service. The interviewee does not see any use cases that could require spectrum at a specific time but not the rest of the time, and hence the prospect of opportunistic access to a licensed SAL location does not seem to have merit. In addition, if a DSA solution is adopted and the dynamic database is outsourced to another company to charge users for access to the spectrum, the interviewee was concerned over transparency of the fee structure unless this was regulated by Ofcom (for example if the company that manages the database does not pay Ofcom for the spectrum in the first place and then determines its own fee structure for granting different applications).

- The interviewee would not oppose the implementation of further technology neutrality in the band if other users consider this is needed, with the main concern being this would make co-ordination even more difficult.

Interviewee 4

- The interviewee is currently using the 3.8–4.2GHz shared access band in its FWA deployments. The current co-ordination process for medium-power licences requires one licence application per mast site. The prospect of allowing a higher-power limit is highly attractive to the interviewee, as a lower number of masts would be needed to achieve higher coverage if high power is available.

- The interviewee suggested that FWA will remain an important use case for the 3.8–4.2GHz band to provide a viable wireless broadband connectivity solution for the most rural population and businesses in the UK, where deploying a fibre network is not commercially viable for the foreseeable future. The interviewee does not expect all of its FWA network to be fully replaced by fibre, since FWA is often used as a redundancy measure and an option to connect some subscribers even once fibre connections become available. The interviewee is of the view that the demand for licences will continue to increase for the FWA use case. The interviewee noted that the 26GHz band could also provide 5G FWA solutions in future, but that this does not provide an alternative to using the 3.8–4.2GHz band due to differences in propagation. Instead, the 26GHz band would be a complement rather than a substitute for the 3.8–4.2GHz use.

- The interviewee mentioned that the n77 band could become more congested as demand increases. A database with details of spectrum availability and locations was suggested as one of the possible solutions to increase visibility of current use. The interviewee noted that Ofcom

should have an online database that enables users to find out the availability of spectrum in a given location quickly before applying.

- The interviewee finds the SAL application process to be lengthy and complicated, and believes it should be made more "investment-friendly", allowing commercial operators bidding for Gigabit broadband projects to receive the result of their application quickly.

- The interviewee thinks that the vendor supply chain did not develop as quickly as expected, which affects wireless operators' ability to be as competitive as they hope to be. The UK market is pioneering in making the 3.8–4.2GHz band available for localised 5G use, thus off-the-shelf vendor equipment was initially not widely available and also requires a higher degree of customisation.

- The interviewee suggested that Ofcom should release a clear roadmap for the future development of the 3.8–4.2GHz band to provide a level of certainty to ensure investors' confidence. The interviewee expressed concerns around the viability of the business if Ofcom decides to remove the SAL framework at short notice, and emphasised the importance of providing guarantee of continued spectrum access to existing licensees if required.

Interviewee 5

- The interviewee mentioned that there is typically no boilerplate proposition for private 5G network deployment, but a more tailored and collaborative approach with individual customers is needed, to design and deploy private mobile networks based on the bespoke requirements requested.

- To date, this interviewee has mostly deployed standalone private mobile networks tailored to the needs of the intended customers. The interviewee suggested that the future roadmap for private 5G network deployment will likely see the introduction of hybrid capability, where private mobile networks will share some infrastructure with public mobile networks and that private 5G wireless networks may be combined with network slices from a public 5G core network to provide wider area coverage.

- The interviewee thinks that there will be steady growth in terms of SAL demand for private 5G network deployment and also believes that FWA is a strong proposition to make use of the 3.8–4.2GHz SAL, provided that there is sufficient bandwidth to achieve higher data rates. The interviewee also mentioned this could be achieved by making mmWave spectrum available in the SAL framework for outdoor deployments.

- The interviewee is of the view that there is a lack of transparency and limited updates provided from Ofcom on SAL application processing. The interviewee noted that no advice is provided by Ofcom during the application process, and a decision would only be made five to six weeks later:

    – the interviewee's view is that the long decision-making timeline is negatively affecting applicants, especially from a competitiveness perspective

  - businesses are often competing against other enterprises for the same project on a rigid project timeline, and getting a timely response to a licence application is of particular importance for project execution and success of tender applications.

- The interviewee suggested that Ofcom could streamline the application process through a simple online portal that showcases categories of likely response (e.g. red, amber, green) to applications for locations, based on currently deployed systems. An appointed single point of contact at Ofcom would be beneficial.

- From this interviewee's perspective, a full dynamic database/system for spectrum co-ordination and use in the 3.8–4.2GHz band is not necessary in the short term, but a transparent online portal where users can easily determine the availability of spectrum in the location of interest is more desirable.

- The interviewee suggested that Ofcom could consider introducing administered incentive pricing (AIP) to reflect the opportunity cost of deploying medium-power licences in urban areas (thus foreclosing potential for low-power licences to be accommodated).

Interviewee 6

- The interviewee mentioned that their equipment has low-power characteristics and does not currently support the entire 3.8–4.2GHz band. The company aims to follow market trends and different customer requirements, which will drive its product evolution strategy.

- The interviewee suggested that the current technical conditions for the SAL in the UK could limit the ability to fulfil the ambition of deploying 5G networks in a variety of industries. The view of this interviewee was that the current SAL framework could limit the deployment of many bespoke use cases, such as mission-critical applications, automation and transportation, and smart cities, due to compatibility issues between currently available equipment and the current technical limits for SAL use (specifically, that use of massive MIMO is not compatible with current power limits and deployment of medium-power licences in urban postcodes is generally not allowed).

- With the evolution of 5G antenna technologies such as AAS over the past few years, the interviewee recommended that Ofcom should revisit the SAL framework published in 2019. The interviewee suggested that Ofcom should give flexibility to accommodate the requirements of different solutions, and revise the SAL framework to accommodate applications using AAS. Enterprises would then be able to quickly deploy their network using off-the-shelf 5G products without having to re-design the equipment to fit Ofcom's conditions as this would incur high investment costs. This would encourage the adoption of this spectrum. The interviewee suggested that the technical framework that the German regulator BNetzA has published in relation to local network usage for private companies in the 3.7–3.8GHz band is a useful reference in relation to authorisation of AAS.

- Regarding whether there is merit in introducing a DSA approach, the interviewee does not recommend a system where all radio equipment is required to communicate with a database, as this would require significant development both of database solutions and radio equipment, plus development of co-ordination conditions. The other challenge with a dynamic system is to ensure that that users of private 5G networks can be provided with a guaranteed quality of service within their licensed area. For example, use cases such as management of seaport operations or any mission-critical applications require guaranteed access to spectrum, which would be difficult to guarantee in a dynamic spectrum management system if there was the prospect of other users accessing spectrum in the same licensed location on an opportunistic basis. The interviewee is of the view that Ofcom should move towards an online application process for SAL applications, given the current lengthy processing time.

- The interviewee supports the "use it or lose it" approach to licence granting, but considers that Ofcom should extend the time before the licence is revoked. From the interviewee's experience, the process of deploying test lab equipment in the UK has taken up to 12 months in some cases.

- The interviewee hopes that the use of the 3.8–4.2GHz band for private 5G networks can ideally be harmonised on a near-global basis and, if not, on a regional basis (e.g. in Europe). This would encourage further development of the ecosystem and adoption by a wider range of global industries.

Interviewee 7

- From the interviewee's perspective, the company hopes that the 3.8–4.2GHz band can support further adoption of private 5G network solutions, and that demand for these solutions will increase. The interviewee suggested that the SAL framework should look into optimising the power level and geographical use of the spectrum to encourage more users to adopt these solutions.

- There are two technical deployment conditions that the interviewee thinks are important to the future development of the SALs:

  – the first is the opportunity to allow for higher power levels than what is currently available for SALs in the UK. The interviewee suggested that Ofcom had taken a conservative approach to restricting power limits that may result in spectrum access being denied, and this should be further considered as the framework evolves, taking account of the volume of use and the types of demand
  – the second is the approach to co-ordination among the SAL licensees, which concerns the risk of interference as the number of private network deployments increases. The interviewee suggested that it would be important to keep under review whether more intensive use of parts of the band in future might give rise to increased levels of interference. This is especially important for the upper part of the 3.8–4.2GHz band which is already used for radio altimeters and at airports.

- The interviewee also mentioned that if the market signals demand for higher-bandwidth requirement, there should be discussions to enable higher bandwidth to accommodate use cases needing higher throughput, e.g. VR/AR or video surveillance applications.

- The interviewee suggested that Ofcom is in the best position to offer a co-ordinated approach to manage SAL spectrum. The interviewee recommended that Ofcom should consider a process to manage applicants that own or have applied for SAL spectrum in the past, so that the applicants that are regular users do not need to repeat the lengthy application process multiple times.

- The interviewee did not think there was a need to change the technical conditions in the SAL framework to accommodate other wireless technologies (e.g. DECT NR+) on the assumption that other technologies that would be compatible with using the 3.8–4.2GHz band might be accommodated within the existing technical conditions for use of the band.

Interviewee 8

- The interviewee has been actively applying for and using SALs in the 3.8–4.2GHz band, especially low-power licences, for content production. They have been running trials using the band for live broadcasting of large events at selected locations across the UK.

- One reason for using SALs for video content production use cases is that compared to using a traditional programme making and special events (PMSE) video assignment, there is scope via the SAL to use uplink capacity for video upload from video cameras whilst using downlink capacity for wireless communications (e.g. camera control communications). If using PMSE assignments, then separate frequencies and solutions would be needed for camera control.

- Whilst initial trials of 5G for audio applications highlighted issues with latency of the connection, more recent developments have indicated that audio use via 5G is also possible.

- The interviewee is particularly interested in short-term licences due to the nature of some forms of content production, such as news broadcasting, which normally does not last for a long period of time (e.g. hours to days). The interviewee suggested that Ofcom should treat this type of licence application on a case-by-case basis based on the duration of licence requested, rather than applying the assessment metrics for other SAL applications that are intended for longer-term deployment.

  – the interviewee believes that granting short-term licences will help to use and then return the spectrum quickly (rather than holding onto licences that were only required for a matter of days). This could encourage more efficient use of spectrum.

- The interviewee mentioned that the current SAL application process is lengthy, which is not ideal considering the unpredictable nature and duration of the "on-demand" content production sector. Whilst some content production licences are held for a longer period (e.g. at media locations), others are only required for very short periods. Currently, the length of time needed for the licence to be granted significantly exceeds the amount of time that the licence will be in

use. The interviewee suggested that Ofcom should adopt a licence application process similar to that of the current PMSE licensing scheme, which has a dedicated site and application tool. Some of the characteristics that the interviewee would expect from a more automated application tool for SALs are as follows:

  - capability to automatically assess and calculate basic network usage around the location for which a licence has been applied for
  - in some cases where an automated response is not issued, application can be escalated to relevant personnel to be processed quickly
  - applicants should be allowed to submit details on a more granular level to enable Ofcom to conduct a more holistic assessment of the licence applications, so that if an exemption is required it can be granted without delay.

- The interviewee mentioned that the current process does not give strong confidence in SAL applications being accepted due to lack of clarity concerning other SALs in the surrounding area and lack of visibility over the co-ordination process that is being applied. Greater certainty of licence applications being successful would be highly beneficial to licensees in terms of project planning and cost management.

- The interviewee believes that mandated co-ordination of the form used for licence applications covering longer-term deployments is not required if licences are needed for very short periods.

- The interviewee recommended that Ofcom should make the assessment process for exemption clearer, which would help remove ambiguity in the licence application process. This may encourage more use cases to adopt SALs.

- Provided spectrum masks and interference conditions can be complied with, there may also be the possibility to allow use of different technologies (e.g. DECT NR+). This would help fulfil Ofcom’s aim of technology neutrality in spectrum assignment.

- The interviewee commented that, as an organisation also holding satellite Earth station licences, the protection distances applied to the Earth stations are currently more than sufficient. There could be scope for these protection distances to be reviewed.

- The interviewee recommended that Ofcom should release clearer information on the SAL fee structure for short-term licences, as they believe the fee structure should reflect Ofcom’s goal of encouraging more efficient spectrum use. The interviewee suggested that the fee structure should be related to the administrative cost and the duration of the licence.

Annex B Additional research and data analysis

The below provides further supporting analysis based on Ofcom's WTR and other sources.

B.1 Locations of existing usage for fixed links and permanent Earth stations

There are currently ten fixed-link licences issued in the 3.8–4.2GHz band, which are mainly located around London and in the South East region (see Figure B.1 below). All the fixed-link licences use 30MHz bandwidth. The number of licences per centre frequency can be found in Figure B.2 below.

Figure B.1: Map of existing fixed-link licences in the 3.8–4.2GHz band [Source: Analysys Mason based on Ofcom, 2023]

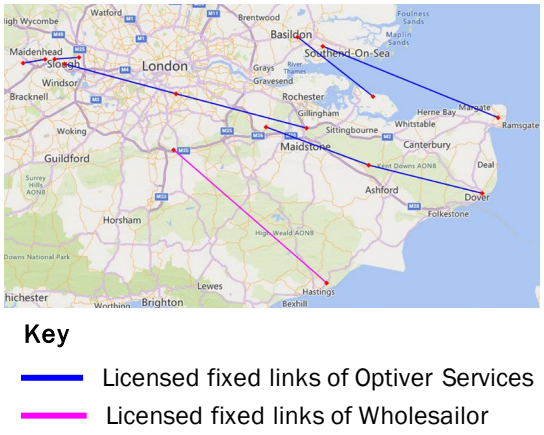
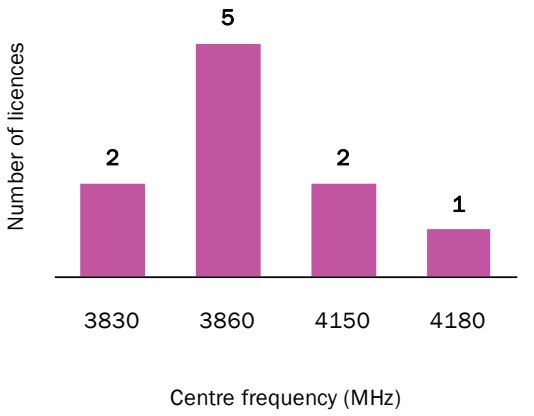


Figure B.2: Number of fixed-link licences per centre frequency [Source: Analysys Mason based on Ofcom, 2023]



Besides SALs and fixed links, the 3.8–4.2GHz band also accommodates some satellite uses for permanent Earth stations. Figure B.3 illustrates the permanent receiving-only Earth stations whose centre frequency falls within the 3.8–4.2GHz band.

Figure B.3: Map of permanent receiving-only Earth stations with centre frequency falling in the 3.8–4.2GHz band [Source: Analysys Mason based on Ofcom's Space Spectrum Strategy,[66] 2023]

B.2 Frequency distribution of current SALs and fixed links

The bandwidths allowed for SALs in the 3.8–4.2GHz band include 10MHz, 20MHz, 30MHz, 40MHz, 50MHz, 60MHz, 80MHz and 100MHz. Figure B.4 to Figure B.9 below show the number

66 Data sourced from Ofcom's spectrum licensing database. See https://www.ofcom.org.uk/consultations-and-statements/category-1/space-spectrum-strategy/interactive-data

of licences for each bandwidth per centre frequency[67] with the number of licences for all bandwidths per centre frequency summarised in Figure B.10.

Figure B.4: Number of SALs with 20MHz bandwidth per centre frequency [Source: Analysys Mason based on Ofcom, 2023]

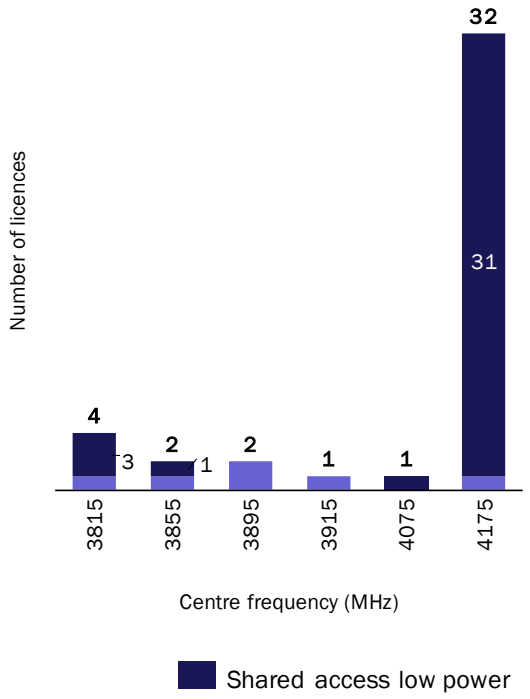
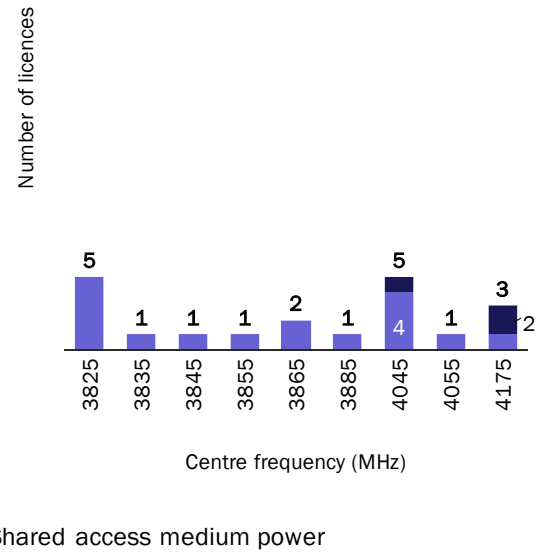


Figure B.5: Number of SALs with 40MHz bandwidth per centre frequency [Source: Analysys Mason based on Ofcom, 2023]



67 There is only one shared access medium-power licence with 10MHz bandwidth, of which the centre frequency is 4070MHz. There is also one shared access medium-power licence with 30MHz bandwidth, for which the centre frequency is 3880MHz. These two licences are not shown separately but included in Figure B.10.

Figure B.6: Number of SALs with 50MHz bandwidth per centre frequency [Source: Analysys Mason based on Ofcom, 2023]

Figure B.7: Number of SALs with 60MHz bandwidth per centre frequency [Source: Analysys Mason based on Ofcom, 2023]

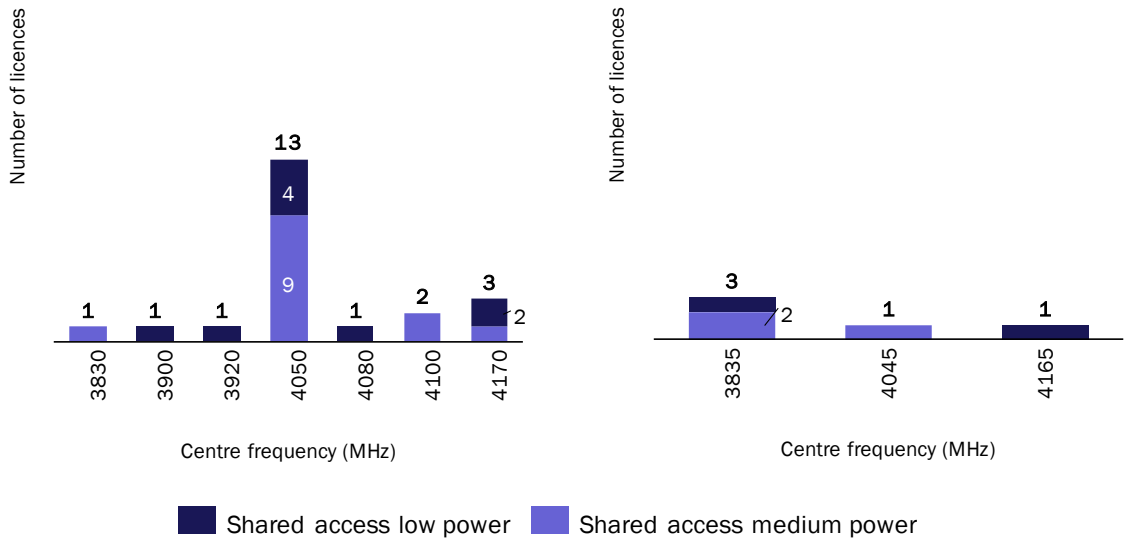


Figure B.8: Number of SALs with 80MHz bandwidth per centre frequency [Source: Analysys Mason based on Ofcom, 2023]

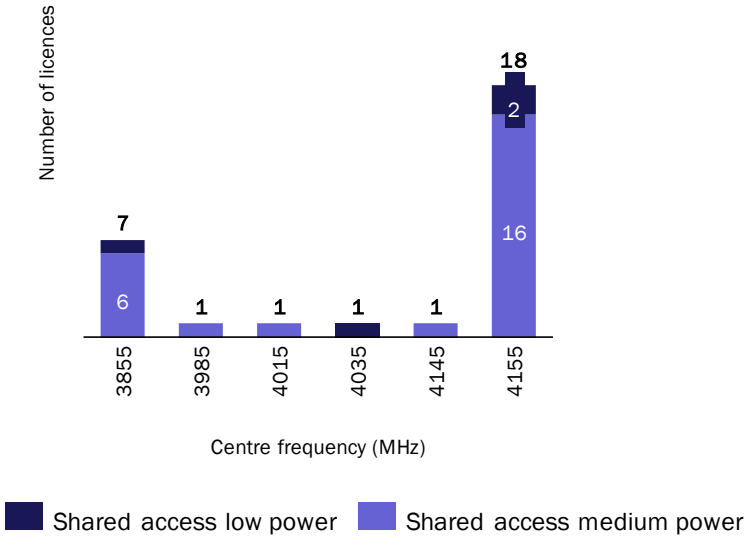


Figure B.9: Number of SALs with 100MHz bandwidth per centre frequency [Source: Analysys Mason based on Ofcom, 2023]

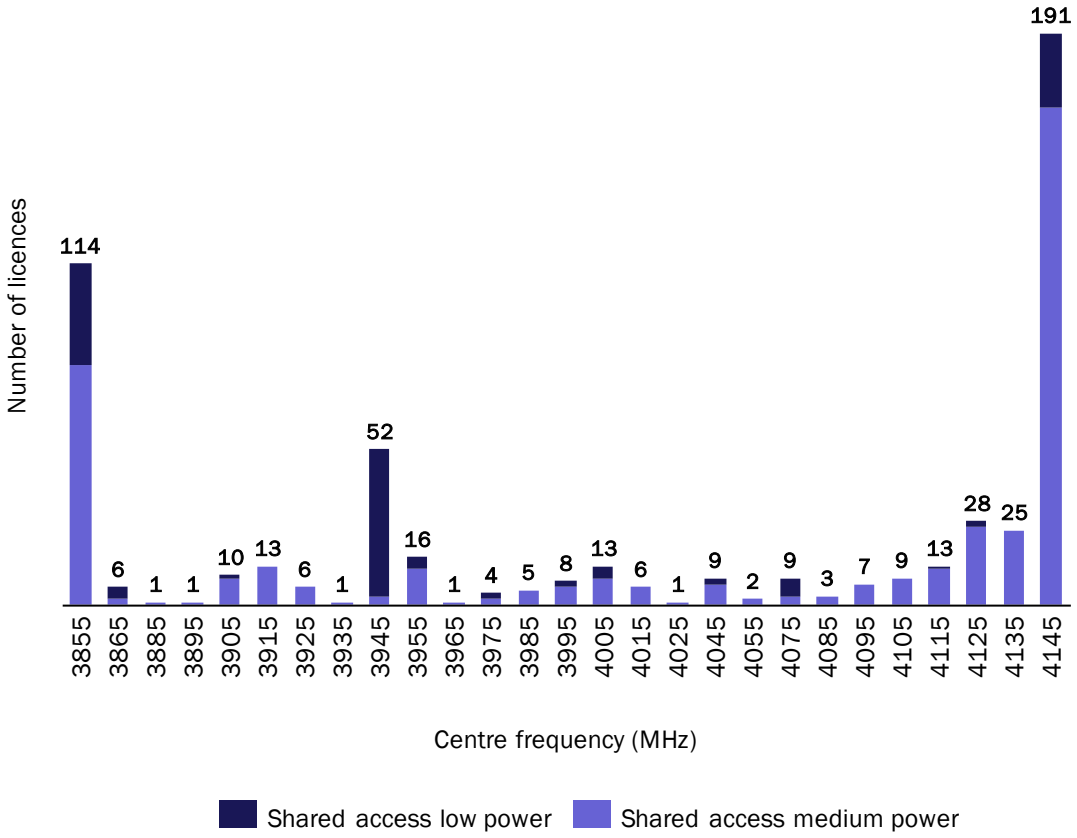
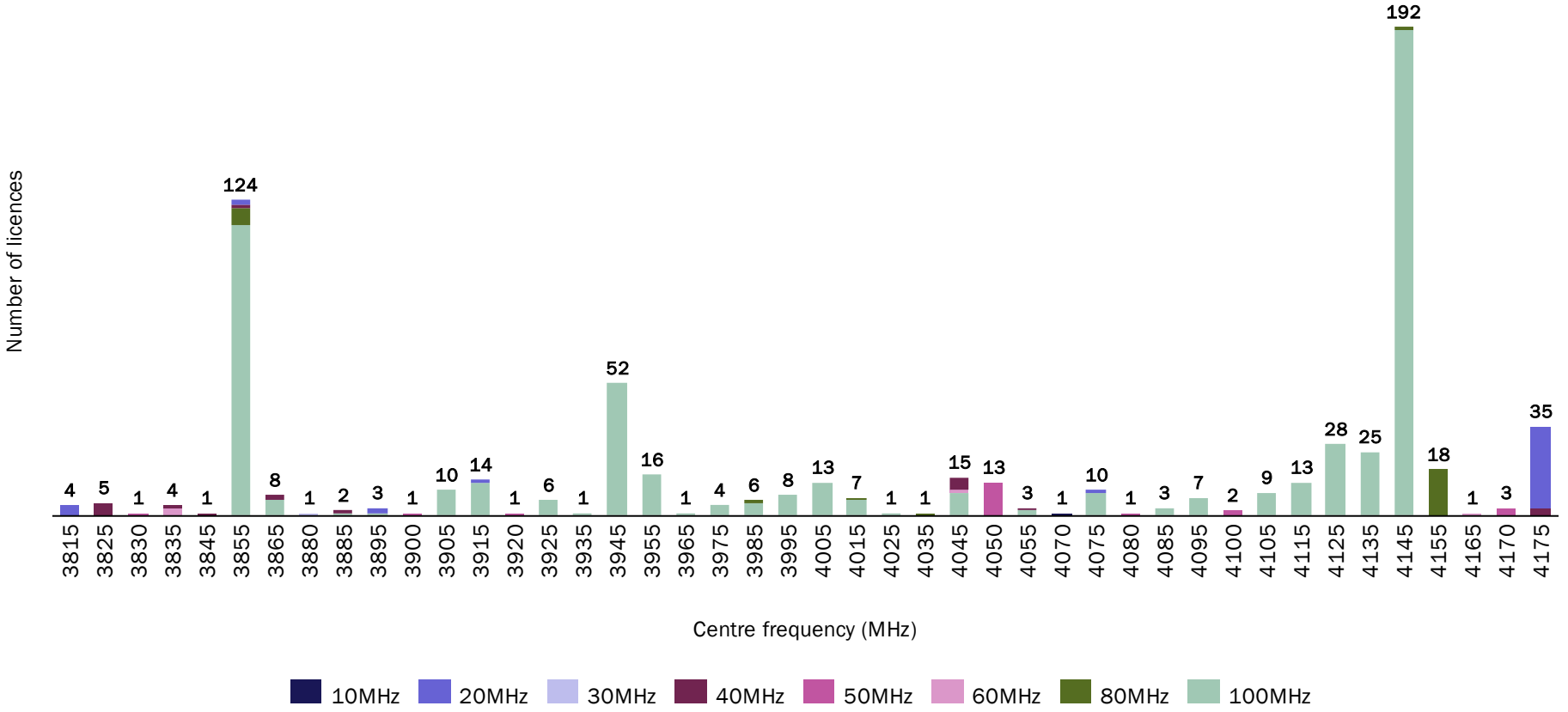


Figure B.10: Number of SALs in the 3.8–4.2GHz band per bandwidth per centre frequency [Source: Analysys Mason based on Ofcom, 2023]



B.3 Considerations on dynamic spectrum access

In the original issuance of the SAL framework, Ofcom indicated that a full DSA approach could be considered at some point in the future if beneficial to enable the spectrum frequencies to be used more effectively and efficiently. As of today, the main commercially implemented DSA solution globally in the 3.5GHz band is the Citizen Broadband Radio Service (CBRS) in the USA. The CBRS is a USA-specific implementation that has been designed to account for the need to accommodate incumbent defence use within the 3.5GHz band. The CBRS approach consists of a 'spectrum access system' (SAS) that incorporates dynamic databases to manage operation across three tiers of use:[68]

- **Tier 1 – incumbents access**: this tier is used by high-powered federal (defence) authorised users, and by commercial fixed satellite service (space-to-Earth) Earth stations and legacy wireless broadband licensees (for a fixed period, before these licences are revoked). These incumbent uses are protected by geographical exclusion zones
- **Tier 2 – priority access**: this tier consists of 70MHz of spectrum, divided into priority access licences (PALs). PALs were auctioned by the Federal Communications Commission (FCC) in 2021 as ten-year renewable licences on a regional basis (up to seven 10MHz lots were auctioned per region). To prevent interference with Tier 1, priority access licensees comply with transmission power limits, which limits use of the band to smaller-cell deployments
- **Tier 3 – general authorised access (GAA)**: the entire 150MHz (3.55–3.7GHz) of the CBRS band can be used through the general access tier in locations where frequencies are not being used by either of the other two tiers.[69] GAA users must not cause harmful interference to Tier 1 or Tier 2 users and must accept interference from the uses in the other tiers. GAA users also have no expectation of interference protection from other co-frequency GAA users.

A DSA-based solution is also being implemented in the USA in the 6GHz band.

We note the regulator in Saudi Arabia is also introducing an automatic frequency co-ordination system in the 6GHz band.[70]

68 See https://www.fcc.gov/wireless/bureau-divisions/mobility-division/35-ghz-band/35-ghz-band-overview

69 Tier 3 is often referred to as unlicensed use, but users must meet the FCC's technical, financial, character and citizenship qualifications to be eligible. See https://www.fcc.gov/wireless/bureau-divisions/mobility-division/35-ghz-band/35-ghz-band-overview

70 For example, see https://wifinowglobal.com/news-and-blog/world-first-saudi-regulator-citc-successfully-demonstrates-standard-power-6-ghz-wi-fi-with-afc/