Call for Input: Potential spectrum bands to support utilities sector transformation

Consideration of bands at 400 MHz, 450 MHz, 700 MHz, 800/900 MHz and 1900 MHz

Call for Input:

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Contents

Section

Annex

1. Overview

1.1 This document provides information about potential candidate spectrum bands that might be suitable to support future operational communications by the utilities sector, and seeks stakeholder inputs.

1.2 A wide range of communication services, including wireless communications, are used by the utilities sector to support the efficient and reliable provision of electricity, gas and water services to people and businesses in the UK. For example, they enable remote monitoring and control of infrastructure across the UK (sometimes in remote locations), to identify and deal with faults and plan maintenance.

1.3 The utilities sector expects to see growth in its communication requirements in future, with the biggest changes in the electricity sector which is transforming to support net zero. A number of technology and network solutions could play a role; one option being advocated by the energy industry is a new private communication network (using 4G/LTE or 5G technologies). This would require access to suitable spectrum in part or all of the UK.

1.4 There is not yet a confirmed plan for how to meet the sector's future communication requirements, or whether access to new spectrum might be required to realise this. While Ofcom's role is not to determine the most appropriate operational solution, we consider it is important to develop a shared understanding across stakeholders of the advantages and disadvantages of potential candidate bands. This will support an informed debate and provide additional evidence so that we can move forward more swiftly with a consultation on specific proposals if needed.

What information we are providing and what we are seeking views on – in brief

In this document we identify five potential candidate spectrum bands for future use by utilities operational communication networks in some or all of the UK:

- **400 MHz**: up to 2x3 MHz in 410-412 MHz paired with 420-422 MHz, and 412-414 MHz paired with 422-424 MHz.
- **450 MHz**: up to 2x5 MHz within 450-470 MHz, part or all of 451-456 MHz paired with 461-466 MHz or 452.5-457.5 MHz paired with 462.5-467.5 MHz.
- **700 MHz**: up to 2x3 MHz in 733-736 MHz paired with 788-791 MHz.
- **800/900 MHz**: up to 2x3 MHz in 876-880 MHz paired with 921-925 MHz.
- **1900 MHz**: up to 15 MHz (unpaired) in 1900-1920 MHz.

For each band, we provide **information** and seek **input** on the following factors:

- Current use of the band.
- Future demand from existing and alternative spectrum users.
- Potential equipment availability.
- Technical constraints on using the band for a private network.
- Actions involved in enabling use of the band for a private network.
- Costs associated with deploying a private network.

1.5 At this stage we are not proposing which candidate spectrum band might be most appropriate, if a private network were required, or making any proposals to change the use of any of the bands discussed. Some of the bands discussed are already heavily used by other users, delivering significant benefits for people and businesses in the UK. This call for input provides an open process for current and future users of the bands to provide their views together with the utilities sector, potential private network providers, equipment manufacturers and other interested parties.

1.6 If in future we propose to make changes to the use of these (or other) bands, this would be subject to our usual consultation process, including impact assessment, in line with our statutory duties and regulatory principles. In developing any proposals for specific bands, two important considerations, among others, would be whether there is competing demand for spectrum and the benefits that any existing users of spectrum are delivering to people and businesses in the UK. In addition, we would expect to take account of the spectrum implications of any relevant decisions by government bodies and other regulators with responsibilities for the utilities sector.

1.7 This call for input closes on 7 September 2023. We will publish an update on our next steps by Q4 2023/24.

The overview section in this document is a simplified high-level summary only. The full document sets out the information and questions that we are seeking stakeholder input on.

2. Introduction

2.1 This call for input (CFI) discusses and seeks input on five potential candidate spectrum bands (i.e. sets of frequencies) that we consider could be suitable to support the future operational communication needs of the utilities sector.

The purpose of this CFI

2.2 Some parties within the utilities industry are advocating for the use of private wide area network(s)[1] using mobile broadband (4G/LTE or potentially 5G) technologies (referred to as a 'private network' throughout this document) to support their future operational communications. While there may be other options for meeting their communication needs, this type of private network, if confirmed, could require access to additional spectrum.

2.3 The purpose of this document is to prepare for an outcome where such a private network is required, by developing a shared understanding across stakeholders of the potential candidate spectrum bands. This will support an informed debate involving all interested parties and provide additional evidence so that we can move forward more swiftly with a consultation on specific proposals, if needed.

2.4 For each candidate spectrum band, we set out its technical and regulatory characteristics, and what might be involved in enabling use of that band for a private network (section 9 summarises this information for all bands).

2.5 We are seeking input from a range of stakeholders - current and future users of the bands, the utilities sector, potential private network providers, equipment manufacturers and other interested parties - on the suitability, costs and benefits of using these (and any other) bands for a private network for utilities. We anticipate that this will help utilities stakeholders to compare and better understand the advantages and/or disadvantages of different spectrum solutions. We also want to understand the future demand for these bands from other stakeholders, including both incumbents and other potential new users. This will assist us in developing any future spectrum proposals, if required, in due course.

2.6 Where relevant, we have considered the potential for candidate spectrum bands to be used in different parts of the UK given differences in spectrum use, as it may be possible to use a different band in Northern Ireland (NI) than Great Britain (GB).

2.7 This document does **not** seek to:

- **Determine whether a private network is required** to meet utilities' future connectivity requirements, which lies outside Ofcom's remit.
- **Identify the most suitable spectrum band** for use by utilities for a private network, or make proposals in relation to any of the bands discussed, including how we would authorise any new user(s) of the band. These matters would be subject to a future consultation, in line with our statutory duties and regulatory principles.

[1] There are a number of potential models for one or more private networks, which could differ according to which utilities sectors would be using the network and the geographic area covered by each network.

Spectrum access is a critical ingredient for wireless communication

2.8 The radio spectrum is a valuable and finite natural resource and demand is increasing as new wireless technologies and systems are created, and existing users transform the way they use spectrum. In line with our statutory duties (see annex 1) and our 2021 spectrum management strategy, one of our aims is to ensure that key sectors with specialised requirements are able to access the right wireless communications or spectrum for them.

2.9 We have a role to ensure that spectrum is used optimally across the UK as a whole, and we track the changing wireless communication and spectrum needs of key sectors to identify when we may need to take action to support those changing needs. The utilities sector (electricity, gas and water) is one such sector undergoing significant change, and we have been engaging with them to understand what these changes might mean for spectrum use.

2.10 Other government bodies and regulators have responsibilities for policies and regulations affecting the sector, including those influencing its future communication requirements and investment in communication networks and services (as set out in annex 6). We would take account of the spectrum implications of any relevant decisions by these bodies in our future work.

Utilities use a wide range of communication services to support efficient and reliable services

2.11 The electricity, gas and water sectors all use a wide range of operational communication requirements, which typically include the following broad categories:

- data communications used to monitor and control their infrastructure at fixed sites throughout the country, which can sometimes be in remote locations;
- fixed voice and data communications to people at key sites;
- mobile voice and data communications for their field workforce; and
- video (CCTV) monitoring at key sites.

2.12 Utilities also need to communicate during emergency situations, including where there has been a prolonged loss of power, for example following severe storms where electricity, gas and/or water supplies have been disrupted, so that supply is restored as soon as possible.[2]

2.13 To meet these operational communication requirements, these sectors employ a mix of public communication services, including public mobile networks and the public switched telephone network (PSTN) copper telephone network, as well as a range of private communication services using wired (i.e. copper and fibre) and wireless technologies. Wireless technologies include point to point wireless fixed links, narrowband private mobile radio (PMR), and scanning telemetry networks that provide monitoring and control services (e.g. SCADA[3]).

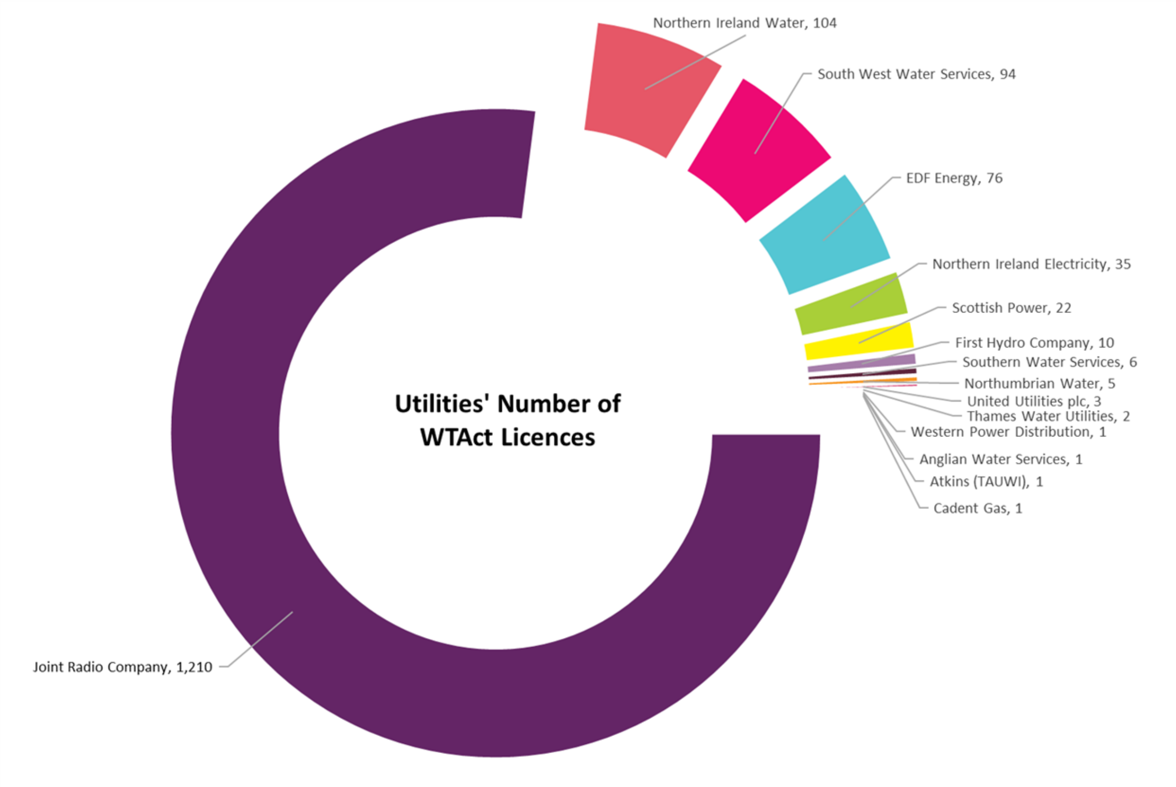
[2] For example see the final report of the Energy Emergencies Executive Committee Storm Arwen Review, June 2022

[3] Supervisory control and data acquisition (SCADA) systems in the electricity sector monitor voltage, current, temperature levels and switch positions throughout the network, and offer the ability to reconfigure the network remotely.

2.14 In future the utilities sector is likely to continue using some of these existing technologies without requiring new spectrum or needing to move (some or all) existing requirements to a private network. However, the PSTN copper network and 2G / 3G mobile networks are reaching the end of their lifespans and so alternative solutions will need to be identified.

2.15 Spectrum licences[4] currently held by utilities licensees are shown in figure 2.1.

Figure 2.1: Utilities licensees and licence numbers (all licence types)



The electricity sector's operational communication needs are growing as it transforms to meet the net zero emissions goal

2.16 All utilities expect their operational communication requirements to increase going forward. Of these, the most significant changes are expected to be in the electricity sector. A key factor driving these changes is the digitalisation of the sector[5], seen as critical to reaching the UK's target of net zero carbon emissions by 2050 (and to decarbonise the UK power system by 2035).[6] The net zero target is driving two fundamental shifts in how power is generated and used:

- further growth in sustainable generation, including many more wind and solar farms which are individually smaller in capacity but larger in number and spread over a wider geographic area (including remote locations) compared to traditional power stations; and

[4] Includes business radio, fixed wireless access, fixed links, scanning telemetry, shared access, and innovation and research.
[5] Policy paper: Energy Digitalisation Taskforce report: joint response by BEIS, Ofgem and Innovate UK, July 2022
[6] Net zero strategy, October 2021

- increased overall demand driven by electrification of the economy, including the shift to electric vehicles[7] and transition to low-carbon heating, for example through domestic gas boilers being replaced with heat pumps powered by electricity.[8]

2.17 Based on initial discussions with electricity industry stakeholders, the Department for Energy Security and Net Zero and Ofgem, we understand that the most significant changes in communication requirements for the electricity sector arise from:

- **Strengthening and expanding the electricity network** to deal with increased demand for electricity (e.g. from electric vehicles and the electrification of heating). Where new electricity network infrastructure is needed to support increased electrical loads these will benefit from operational connectivity to enable remote monitoring and control of equipment. The benefits include allowing assets to be used more intensively, identifying and resolving faults, and identifying the need for upgrades.[9]
- **Growing complexity in balancing supply and demand** on the electricity grid because of many new sources of electrical demand (e.g. electric vehicles) and a greater proportion of generation from intermittent renewable sources (e.g. solar, wind). Intelligent shifting of demand away from peak periods will reduce the overbuild of energy infrastructure, and allow for more effective network planning. There is ongoing work to refine these communication requirements, including by Ofgem[10] and the Department for Energy Security and Net Zero.[11]
- **Arrangements for restoring the national electricity network** following a complete power outage (previously known as 'black start'[12]). Greater reliance on renewable energy sources distributed across the country can complicate these arrangements, and revised procedures could have greater communication requirements than today.

2.18 Our current understanding is that control of electrical devices 'behind the meter'[13] (e.g. electric vehicle chargers, heat pumps) will rely on existing communication networks and so will not contribute to new spectrum demand.[14]

These future communication needs may require additional spectrum access

2.19 A range of technologies and networks could in principle deliver these future needs, each with different potential spectrum requirements. This includes using public mobile networks, satellite (in particular for connecting remote sites), shared private networks used by multiple

[7] Government takes historic step towards net-zero with end of sale of new petrol and diesel cars by 2030
[8] Heat pump investment roadmap, April 2023
[9] Electricity networks strategic framework: enabling a secure, net zero energy system
[10] Ofgem Call for Input: the future of distributed flexibility, March 2023
[11] Digital spine feasibility study, March 2023
[12] National Grid: Black start guide
[13] 'Behind the meter' refers to anything on the energy users' side of the electricity meter as opposed to the electricity network side. This includes energy smart appliances that can respond to price and/or other signals by changing their electricity consumption, and local generation such as home solar panels.
[14] Delivering a smart and secure electricity system (consultation July 2022, Government response March 2023) – page 42 of the consultation states that "Government does not expect to prescribe a local or wide-area communications network for ESAs (energy smart appliances)".

operators[15] and hybrid networks using wired and wireless solutions (such as fixed links and shared access spectrum at 3.8-4.2 GHz).

2.20 The Energy Network Association (ENA), who represent the electricity distribution network operators (DNOs)[16] and Joint Radio Company (JRC), an industry owned consultancy holding spectrum licences used by the UK energy industry, have advocated for a private network using mobile broadband (4G/LTE or potentially 5G) technologies. The ENA[17] have said that although some of its future requirements could be met using public networks, they could not all be met for critical electricity network operations. It highlighted the need for high levels of resilience, including sufficient back-up power to enable communication during prolonged power outages. However, other stakeholders[18] have indicated alternative solutions to a private network could also be adopted by the utilities.

2.21 Our understanding is that the gas and water sectors are less likely to require additional spectrum for a private network, although it is possible they would use one if it were deployed. The gas sector mostly uses the PSTN copper network for operational monitoring and is expected to migrate to alternative wired or wireless solutions when the PSTN is no longer available. Water infrastructure is currently connected using commercial wired and wireless networks[19] for leak detection, and water pressure and quality monitoring.

2.22 If it was determined that a private network was necessary for the utilities sector, there could be a number of different solutions depending on the scope of communication services that it would need to carry.[20] It could also be a single uniform network or a hybrid network combining multiple technologies. These factors would determine the amount of spectrum which might be needed for the network to operate and how this might vary by location.

> Question 1: Have we correctly identified the key changes in the utilities sector that could lead to additional spectrum requirements?
>
> Question 2: What alternative communication solutions might play a role in meeting the future operational communication needs of the utilities sector, alongside or instead of additional spectrum for a private network?

[15] Multiple users with specialised communication needs (e.g. supporting critical infrastructure which might not be best served over public networks) could come to an arrangement to share a private network, or a third party might develop such a network to serve those users. Users might come from across the utilities sector (electricity, gas, water) and potentially from other sectors such as rail and the emergency services. This might change the profile of demand for spectrum (e.g. the bandwidth needed or preference for specific bands), and/or increase the benefits from making spectrum available to these users.

[16] DNOs are the companies that run the regional electricity distribution networks that connect the high voltage transmission grid to homes, businesses, and industrial electricity users.

[17] Energy Networks Association - position statement of strategic telecommunications group

[18] See responses to 1900 MHz consultation by BT, Satelliot, and Vodafone.

[19] For example using commercial NB-IoT (narrowband internet of things) and LoRaWAN networks.

[20] Future networks are also likely to have different requirements and different available solutions in different locations (e.g. depending on the bandwidth required and whether assets are fixed or mobile).

Relationship to other Ofcom work

2.23 There are linkages between our work examining spectrum for the utilities sector and other work underway across Ofcom. We explain these below.

Proposal to allocate spectrum to the Police Service of Northern Ireland (PSNI)

2.24 Two of the bands we consider in this CFI overlap with bands that we recently consulted on for use by the PSNI in NI (the PSNI consultation[21]). The existing PSNI communications network has limited data capability, and our proposals were aimed at supporting the PSNI transition to modern mobile technology enabling fast, safe and secure communications for the emergency services in NI. We proposed making 2x3 MHz of the 700 MHz band (733-736 MHz paired with 788-791 MHz) and 2x4 MHz of the 800/900 MHz band (876-880 MHz paired with 921-925 MHz), currently unallocated in NI, available for use by the PSNI.

2.25 Following a review of responses to our PSNI consultation, in April 2023 we advised that we would seek more information on demand for these bands in this CFI before proceeding. This could have implications for our future work as discussed at paragraph 6.13.

Proposal to reallocate 1900 MHz band

2.26 We recently consulted on a third band discussed in this CFI, regarding the future of the unpaired 1900-1920 MHz band (the 1900 MHz consultation[22]). We considered that current use of the band may not be optimal because there could be other higher value users of the spectrum, including national infrastructure uses focused on public safety, such as rail and utilities. Due to potential complexities in achieving optimal use through trading, we considered it may be more appropriate for us to intervene to achieve optimal use of the spectrum by revoking the existing licences and reallocating the spectrum.

2.27 Our 1900 MHz consultation recently closed, and we are currently considering stakeholder responses (and will do so alongside responses to this CFI) before proceeding. This could have implications for our future work on this band, as discussed at paragraph 8.14.

Switch off of the PSTN and 2G/3G networks

Migrating the PSTN to VoIP services

2.28 The PSTN is being decommissioned, and traditional landline phone services are being replaced with voice over IP services (VoIP). BT has taken the decision to retire the PSTN by the end of December 2025 and other communication providers using the same technology as BT are following a broadly similar timescale. The process of PSTN switch off is being led by industry and has already started.[23] We have an ongoing monitoring programme, and rules and guidance to ensure customers are not subject to undue disruption and are protected from harm during this transition, including during a power outage.

[21] Spectrum for the PSNI: introducing new digital services, September 2022
[22] Exploring future use of the unpaired 2100 MHz (1900-1920 MHz) spectrum, March 2023
[23] Future of voice

2.29 Migrating to VoIP impacts equipment used by the utilities sector, such as telemetry, remote monitoring equipment and alarms. This equipment may have to be reconfigured or replaced when the PSTN is retired and in some cases connected to a new power source as, unlike the PSTN, wired or wireless connections rely on a mains power connection to work. Utilities users of the PSTN will need to work with communication providers to manage the transition to VoIP and identify equipment that needs reconfiguring/replacing.

Migrating 2G/3G to 4G/5G services

2.30 In late 2021, mobile operators confirmed in a joint statement with DCMS that they do not intend to offer their 2G and 3G networks past 2033 at the latest. Ofcom does not have a formal regulatory role in the switch off process, however earlier this year we set out our expectations of mobile providers for 2G/3G switch off, to ensure they make every effort to identify services which currently rely on 2G/3G networks, including smart meters and monitoring systems used by utilities. We expect mobile operators to work with industry to help raise awareness so that relevant suppliers have sufficient time to update their devices and ensure continuity of service. We also published a 2022 consumer guide to 2G/3G switch off which provides further background information.

Structure of the rest of this document

2.31 The rest of this document is set out as follows:

- Section 3 provides a general structure for the spectrum bands we consider in this CFI and discusses the capacity various bandwidths could support and the coverage of different frequencies;
- Sections 4-8 examine each of the potential candidate spectrum bands; and
- Section 9 summarises our key findings on the potential suitability of each spectrum band detailed in sections 4-8, including an illustrative view of the potential timing for each band’s availability;
- Section 10 explains our next steps, and how we intend to take the findings from this CFI forward.

3. Overview of our approach in this CFI

3.1 This section sets out the **potential candidate spectrum bands** for a private network for the utilities sector, and the **factors we examine** for each band in sections 4-8. We also discuss two important cross cutting factors relevant to all bands, **capacity** and **coverage**.

Spectrum bands we are considering

3.2 The five potential candidate spectrum bands we are considering (listed in table 3.1 below), were identified on the basis that they could support:

- **bandwidths of at least 2x1.4 MHz paired spectrum or at least 5 MHz unpaired spectrum**. Electricity sector stakeholders have said they anticipate needing to connect a large number of assets, and that existing narrowband systems may not scale well to these new demands, so using mobile broadband technologies (i.e. 4G/LTE or 5G) is strongly preferred. These technologies typically support a minimum channel size of 2x1.4 MHz or 5 MHz unpaired;
- **a broad ecosystem of devices suitable for utilities**. For example, if mobile broadband or similar technologies are already deployed at scale in other countries (preferably for utilities applications) in a given band, or have the potential to be, this will likely drive down the cost of equipment in the UK; and
- **wide area (national) coverage.** Utilities infrastructure requiring connectivity (e.g. electricity substations) is present throughout the country, sometimes in remote locations. In some cases we consider spectrum bands only potentially available only in NI.

3.3 Throughout this CFI, we refer to these specific frequencies by the spectrum band listed.

Table 3.1: Summary of potential candidate spectrum bands

Spectrum band	Frequencies under consideration (MHz)	Relevant LTE band(s)	Potential bandwidth available
400 MHz – NI only	410-412 MHz uplink paired with 420-422 MHz downlink, and 412-414 MHz uplink paired with 422-424 MHz downlink	LTE band 87	Up to 2x3 MHz FDD
450 MHz	Within 450-470 MHz, part or all of 451-456 MHz / 461-466 MHz **or** 452.5-457.5 MHz /462.5-467.5 MHz	LTE bands 72 and 31	Up to 2x5 MHz FDD
700 MHz PPDR	733-736 MHz paired with 788-791 MHz	LTE band 28	Up to 2x3 MHz FDD
800/900 MHz – NI only	876-880 MHz paired with 921-925 MHz	None at present	Up to 2x3 MHz FDD
1900 MHz[24]	1900-1920 MHz	LTE band 39	Up to 15 MHz TDD

[24] The 1900 MHz band is referred to as the 'unpaired 2100 MHz spectrum' in our 1900 MHz consultation.

3.4 Note that although we refer to the specific subset of 2x3 MHz in the 700 MHz band as the '700 MHz PPDR[25] band' for simplicity, this does not preclude it from being used for non-PPDR applications.

> Question 3: Are there any other spectrum bands we should consider for use by utilities?

Information provided for each band

3.5 For each band we provide information on several factors that could influence the band's suitability for future use by utilities:

a) **Current and potential future use of the band -** including the current and adjacent band users, how they are authorised and, where possible, information on the nature and intensity of use.

b) **Characteristics of the band –** including:

- **Harmonisation and equipment ecosystem:** If a spectrum band is identified by international regulatory recommendations, decisions of the ITU[26] and/or regional bodies (including CEPT[27], the relevant body for the UK), then this can support the emergence of a global device ecosystem. As noted above, this can help ensure there is a ready supply of compatible terminals for UK utilities at reasonable cost, including routers, modules and antennas.[28] In some cases the existence of an equipment ecosystem for non-utilities applications (e.g. PPDR) could provide a basis for developing equipment that is suitable for the utilities sector.
- **Coexistence constraints**: The presence of existing spectrum users, either within the band being considered or adjacent to it, may create constraints on any new user(s). This arises from the need to appropriately protect existing users from harmful interference, or because of incoming interference from existing users into new users.

c) **What needs to happen to enable use by a private network** (e.g. undertaking technical work or resolving policy issues) - Technical actions could include further study of coexistence constraints, potentially moving or retuning users to a different frequency, or coordinating with them to avoid harmful interference. These technical actions may also depend on policy or other actions, such as consulting on potential changes to use of the band.

d) **Costs associated with deploying a private network for utilities –** We qualitatively discuss three key cost categories associated with deploying a private network[29] which are driven by the particular spectrum band:

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[25] Public protection and disaster relief

[26] International Telecommunication Union

[27] CEPT is the European Conference of Postal and Telecommunications Administrations. Its main role is to establish a European forum for promoting harmonisation to facilitate interoperability and enable economies of scale to be realised.

[28] Our research in this CFI is supported by GAMBoD (the GSA analyser for mobile broadband data), as at June 2023.

[29] These costs include radio sites that might be built, investments that might be needed to ensure a modern and resilient core network, and equipment costs (that could benefit from a harmonised ecosystem or could be bespoke).

- **sites:** coverage of a band will affect the number of base stations needed and the required initial investment;[30]
- **equipment:** costs are driven by the scale of the equipment ecosystem; and
- **migration:** some additional costs may be borne by a number of parties if action is required to migrate existing users from the band.

3.6 Our preliminary cost assessment takes account of a high level assessment of the coverage of different frequencies (see below) and information currently available to us about the availability of equipment. For the purposes of this document, we have not sought to assess the opportunity cost of making each band available for use by utilities.

Illustrative timing of availability

3.7 We also give a high level preliminary view of the potential timing for each band's availability in the summary table in section 9. This is driven by the work identified under (c) to enable use of the band, i.e. timeframes for developing equipment, technical coexistence studies, our policy considerations, authorisation changes and/or any necessary migration planning and implementation including consultation(s) on any specific proposals. Timescales are broadly driven by whether there are existing users and/or competing demands for the band. If there are no existing users, a band may be available within 5 years once it has been confirmed as a band we will focus on, but is likely to take longer if there are existing users.

- **If there were no existing users and no competing demand from other potential users:** we could typically authorise such bands fairly swiftly. If there were no established equipment ecosystem then the timescale for use of the band would then be dependent on manufacturers developing suitable equipment.
- **If there were no existing users but there is competing demand from other potential users**, and band sharing arrangements were not agreed: timing would typically affected by the additional complexity of determining the appropriate mechanism for who will get a licence, potentially taking account of any wider social value of spectrum use, and then implementing that mechanism.
- **If there were existing users**: timing would typically be affected by the process for assessing the feasibility of using the band i.e. whether existing users can coexist with the potential new user or would need to be migrated to new frequencies (or cleared from the band), and if so, whether the costs and benefits of migrating/clearing users are proportionate:
  - Where, following consultation we determine that users should be migrated, there would be a period of transition, including notice to affected parties.
  - Where, following consultation we determine that users should be cleared, we are required to give five years notice of revocation although in certain cases or specific locations it may be possible to expedite this process, for example through agreements with licensees.

[30] While coverage may be the main driver for site costs in some cases (e.g. when there is sufficient bandwidth available), in other cases capacity could be the main driver of site costs (e.g. in the future if more terminals need to be connected).

- In this case, prospective new users may get certainty of future access ahead of the spectrum actually becoming available, depending on the timing of the authorisation process.

Bandwidth that could support a private network for utilities

3.8 The bandwidth, or amount of spectrum available is a key determinant of what services[31] can be provided using that spectrum, though the minimum bandwidth that utilities require for any private network has not yet been determined. This is influenced by the communication demands for a private network, the number of utilities sites being connected, the density of base stations serving those sites, and whether alternative networks are being used at some locations, all of which have significant uncertainty at this stage. Indeed, it is possible that different bandwidths will be needed at different locations.

3.9 Given this uncertainty, we consider three bandwidths in this CFI that are indicative of those that could be used to meet the utilities sector's future operational communication needs, and are also supported by a wide range of broadband technologies[32], including 4G/LTE:

- **1.4 MHz**: for bands supporting 2x1.4 MHz FDD[33];
- **3 MHz**: for bands supporting 2x3 MHz FDD, and broadly equivalent to the capacity of bands supporting 5 MHz TDD[34] (assuming an uplink dominant frame structure); and
- **5 MHz**: for bands supporting 2x5 MHz FDD, and broadly equivalent to the capacity of bands supporting 10 MHz TDD.

3.10 Industry have suggested that at least 2x3 MHz would be required.

Illustrative capacity of different bandwidths

3.11 We have modelled the potential capacity of these different bandwidths to deliver communication services from a single base station sector and found that:

- all bandwidths, including the smallest bandwidth (2x1.4 MHz), could support hundreds of data connections and tens of simultaneous voice calls; and
- a video service could be hard to provide across very large cells in all the bandwidths we studied. It may be easier to provide video to fixed locations (e.g. for CCTV at a substation) than to support a mobile video service (e.g. to field engineers).

3.12 Further details of our capacity analysis are provided at annex 7.

[31] Services include **data** communications for monitoring and control of infrastructure, **voice calls** supporting utilities' mobile workforce, and **video streams** to support video calls or remote CCTV monitoring of key sites.
[32] These technologies include 3GPP LTE and its derivatives including LTE-M. We note that the minimum bandwidth for 5G NR technology is currently 5 MHz, however, we understand that 3GPP is working towards developing standards supporting smaller bandwidths to support sectors including utilities.
[33] frequency-division duplexing uses separate frequency bands to transmit and receive.
[34] time-division duplexing uses the same frequency band to both transmit and receive, assigning alternative time slots for transmit and receive operations.

Question 4: Do you have any comments on the three bandwidths we have considered that might be necessary to support a private network for utilities? Please reference our capacity analysis in annex 7 where relevant.

Coverage implications of frequency bands

3.13 All potential spectrum bands considered in this CFI can be used to provide the wide area coverage which a private network for utilities is likely to require when using high power base stations. However, radio signals at lower frequencies can serve a bigger coverage area than higher frequencies, which can have consequences for the number of base stations needed to provide coverage in an area and hence deployment costs. For example, one of the claimed benefits of the 400 MHz and 450 MHz bands for utilities is superior coverage.[35]

3.14 To provide indicative coverage capabilities of each band we modelled coverage for a single base station in a range of terrain types to understand more about the extent to which frequency might affect coverage area and the number of electricity substations covered. The key findings from our coverage analysis are that:

- **Coverage at 450 MHz is marginally better than that at 700 MHz**: We found that a 700 MHz base station could cover around 90% of the area that an equivalent 450 MHz base station covers. However, a small increase in the transmit power at 700 MHz could result in coverage broadly equivalent to that of 450 MHz.[36]
- **Coverage at 450 MHz is greater than that at 1900 MHz**, but there is less difference in hilly areas: We found that the area that a base station using the 1900 MHz band was able to cover was around 40% of the area that the equivalent 450 MHz base station covers when in a flat area, but this increases to around 50% in a hilly area.[37]

3.15 This analysis was not a full area coverage planning exercise, so cannot be used to directly assess the relative number of base stations that would be necessary for coverage when considering each frequency band. Nonetheless it provides initial indications of the different band coverage properties. Further details of our coverage analysis are set out in annex 8.

Question 5: Do you have any comments on our approach to examining each potential candidate spectrum band, including the factors relevant to assessing suitability, and the capacity and coverage analysis provided in annexes 7 and 8?

[35] EUTC Spectrum position paper: spectrum needs for utilities (2021)
[36] By increasing the transmit power of a 700 MHz base station by 3 dB, we found that coverage at 700 MHz was greater than the lower power 450 MHz base station in all the types of terrain considered. We therefore infer that a 700 MHz base station transmitting with a power of 0 to 3 dB more than an equivalent 450 MHz base station could have broadly equivalent coverage to a 450 MHz base station. Any increase in base station power limits may have consequences for coexistence so this would also need to be taken into account.
[37] Compared to higher frequencies, lower frequencies improve coverage in hilly areas less than in flat areas because terrain blocks radio signals in hilly areas and the greater terrain diffraction at lower frequencies only partially mitigates this.

4. 400 MHz - in Northern Ireland only

Summary

4.1 In this document, the "400 MHz band" refers to:

Frequencies under consideration (MHz)	Relevant LTE band(s)	Potential bandwidth
410-412 MHz uplink paired with 420-422 MHz downlink (lower pair); and 412-414 MHz uplink paired with 422-424 MHz downlink (upper pair)	Band 87 (410-415 MHz uplink / 420-425 MHz downlink)	Up to 2x3 MHz FDD

4.2 The 400 MHz band is potentially available in NI only, owing to the need to protect the radar at RAF Fylingdales. The feasibility of this band and amount of spectrum which might be available would primarily depend on (i) accessing spectrum currently held by Arqiva/Airwave, and (ii) finding a way to share with PSNI's use of the 400 MHz band, or its migration out of the band. We would also need to confirm technical requirements to protect the Fylingdales radar and other Ministry of Defence (MOD) use. This band is likely to offer a good equipment ecosystem and comparatively lower deployment costs.

Current and potential future use of the 400 MHz band in NI

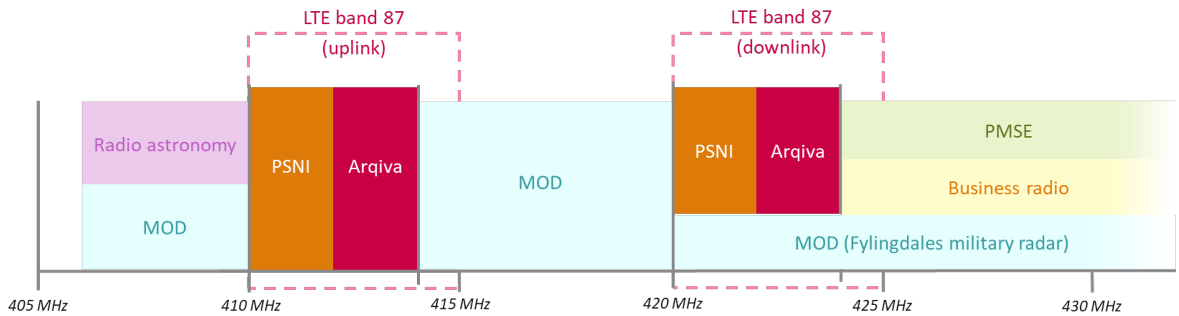
4.3 Figure 4.1 shows how the 400 MHz band and adjacent frequencies are currently configured in NI:

- The **lower 2x2 MHz** of paired spectrum, **410-412 MHz and 420-422 MHz** has some limited use by the PSNI for emergency services in NI, using TETRA (a narrowband PMR technology).[38]
- The **upper 2x2 MHz** of paired spectrum, **412-414 MHz and 422-424 MHz** was awarded nationally to Arqiva in 2006 and traded in 2008 to include Airwave as a co-licensee.[39] Specific use under the licence is a commercial decision for the licensees. In GB we understand it is used to support smart meters and the emergency services. However, the band is not used for these purposes in NI and therefore we understand may have limited or no use in NI.

4.4 The RAF Fylingdales radar operates in 420-450 MHz and is therefore co-channel with the (downlink) of both lower and upper pairs of the 400 MHz band.

[38] The Department of Health and Social Care (DHSC) has responsibility for these frequencies across the whole of the UK.
[39] Arqiva uses the licence to provide two-way low bandwidth data communications between smart meters and energy suppliers in parts of GB. Airwave uses the licence to support its TETRA network and the ambulance service in GB (Airwave was acquired by Motorola Solutions in 2016).

Figure 4.1: Current use of the 400 MHz band



4.5 The adjacent users of the 400 MHz band are as follows:

- Radio astronomy operating in the frequencies below at 406.1-410 MHz; the UK hosts some important radio astronomy sites in GB[40] but we are not aware of any sites in NI.
- The MOD has allocations of spectrum at 406-410 MHz, 414-420 MHz (for fixed and mobile applications) and 420-450 MHz (supporting Fylingdales radar and other military use).
- Business radio and programme making and special events (PMSE)[41] operating in the frequencies above at 425-450 MHz.
- There are also short range devices (SRDs) and amateur radio (above 430 MHz).[42]

Characteristics of the 400 MHz band in NI

Harmonisation and equipment ecosystem

4.6 Spectrum for LTE band 87 has already been allocated in several countries, and consultations are underway to do so in others.[43] In Bahrain and the Republic of Ireland (referred to as Ireland in this CFI), the 400 MHz band has been specifically designated for utilities use.[44] Although availability of compatible equipment is at an early stage, we understand an increasing range of equipment is being made available.

Coexistence constraints – co-channel

4.7 **RAF Fylingdales radar:** spectrum deployments in 420-450 MHz must coordinate to ensure that signal power levels at the radar from narrowband systems (up to 25 kHz) do not exceed required thresholds. Previous measurements have found that broadband systems are likely

[40] The UK carries out MERLIN observations, pulsars and mapping radio sources in this band at six locations (Cambridge, Darnhall, Defford, Jodrell Bank, Knockin, and Pickmere) See Ofcom Space science and meteorology spectrum allocations.
[41] PMSE use covers **talkback** (communications for instructions to production crew or presenters); **audiovisual links** (typically supporting live reporting or to connect speakers at events); **audio distribution systems** (providing local enhancements such as relaying a referee's microphone or description services for the visually impaired); and **remote monitoring and control** (used for camera control and telemetry).
[42] SRDs use 433.05-434.79 MHz and amateur radio uses 430-440 MHz on a secondary basis across the UK, so we have not studied the coexistence implications on their use further, especially as SRDs operate on a non-interference, non-protection basis, and amateur radio must not cause interference to other users.
[43] Botswana, Argentina, Cambodia, Denmark, Greece have allocated band 87 for LTE, while consultations are taking place to do so in the US, Brazil, Norway, Tunisia, and Saudi Arabia.
[44] 410-413 MHz /420-423 MHz was awarded for utilities smart grid use in Ireland in 2019 and ESB Networks has recently announced it is deploying an LTE private network with Nokia there.

to have a greater impact than narrowband systems on the Fylingdales radar performance. International studies also suggest that it may be that an exclusion zone from radars of more than 400 km is required for broadband systems.[45] Therefore we consider that a private network using the 400 MHz band could be possible in NI but will not be in the vast majority of GB.

4.8 **PSNI / emergency services TETRA:** a broadband private network is unlikely to be able to operate in exactly the same area as the incumbent PSNI TETRA use but co-ordination / sharing arrangements could be explored.

Coexistence constraints – adjacent spectrum

4.9 We do not anticipate there to be any coexistence constraints on a broadband private network in NI arising from the need to protect radio astronomy[46], or for business radio, PMSE and other narrowband users.[47]

4.10 We would need to examine with MOD how it uses 406-410 MHz, 414-420 MHz and 420-450 MHz, to understand whether interference from adjacent band users might arise.

Enabling use of the 400 MHz band in NI for a private network

4.11 Access to 2x1.4 MHz would require access to either the lower or upper pair in the 400 MHz band; 2x3 MHz would require access to both pairs to create contiguous spectrum.

4.12 **Accessing the lower pair (410-412 MHz/420-422 MHz):** The feasibility of accessing the lower pair will depend on finding a way to share or coordinate with the PSNI's use of the 400 MHz band, or whether the PSNI might potentially cease using this band in the future.

4.13 **Accessing the upper pair (412-414 MHz/422-424 MHz):** The feasibility of accessing the upper pair would depend on the nature of co-channel use by existing licensees (Arqiva / Airwave). Access could be established through commercial arrangements, for example through spectrum trading.[48]

4.14 **Accessing either or both lower and upper pairs:** In addition to the specific actions for the lower and upper pairs noted above, we would also need to work with the MOD to understand what technical conditions or coordination requirements might be necessary to protect the Fylingdales radar, and any other MOD use of 406-410 MHz, 414-420 MHz and 420-450 MHz.

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[45] ECC Report 240: Compatibility studies regarding broadband PPDR and other radio applications in 410-430 MHz and 450-470 MHz and adjacent bands

[46] ECC Report 283 considers how minimum frequency separation and separation distances can ensure coexistence between radio astronomy and new broadband services in the 400 MHz band, should any issues arise.

[47] ECC Decision (19)02: Land mobile systems in the frequency ranges 68-87.5 MHz, 146-174 MHz, 406.1-410 MHz, 410-430 MHz, 440- 450 MHz and 450-470 MHz, annexes 1 and 2

[48] These licences are tradeable. We would also need to consider technical licence variations where these might be necessary to enable use by the desired technology, so that it can coexist with other users, given UK Interface Requirement 2065 currently limits technologies using carriers greater than 2x1 MHz bandwidth.

Costs associated with deploying a private network for utilities using the 400 MHz band in NI

4.15 The distinguishing cost factors for using the 400 MHz band are:

- **Sites:** potentially the lowest build costs due to its coverage characteristics (see paragraph 3.14). However, depending on the bandwidth available, some additional build might be needed to ensure sufficient capacity.
- **Equipment:** network equipment would benefit from an international ecosystem (see paragraph 4.6) likely resulting in lower equipment costs compared to bands requiring bespoke equipment.
- **Migration:** it is currently uncertain whether existing users would need to migrate out of the band and the costs associated with that.

Question 6: Do you have any comments on our overview of the 400 MHz band in NI? Please consider the specific factors we have discussed in your response.

5. 450 MHz – in Great Britain and Northern Ireland

Summary

5.1 In this document, "the 450 MHz band" relates to:

Frequencies under consideration (MHz)	Relevant LTE band(s)	Potential bandwidth
450-470 MHz	LTE band 72 (451-456 MHz uplink /461-466 MHz downlink); and LTE band 31 (452.5-457.5 MHz uplink / 462.5-467.5 MHz downlink)	Up to 2x5 MHz FDD

5.2 This band is heavily used across the UK, delivering important benefits for several sectors. There would be significant challenges and costs in making it available for a private network, owing to extensive current use and the UK's band plan, which differs from many other European countries. It would also likely take longer to make available than other bands. Even so, we are including it in our considerations as it is likely to offer a good equipment ecosystem (because of its adoption in other countries) with comparatively lower deployment costs, and it is seen an 'anchor band' for wireless communications in the energy sectors in Europe.[49]

5.3 There are different options to make spectrum available in this band. We would need to establish both the technical feasibility and costs and benefits of these, which range from a limited partial replan (e.g. to release 2x1.4 MHz) to a full replan to align the UK's use with other European countries. The potential benefits and impacts would be likely to vary significantly across these options. The options would require significant study before any proposals could be made for consultation.

Current and potential future use of the 450 MHz band

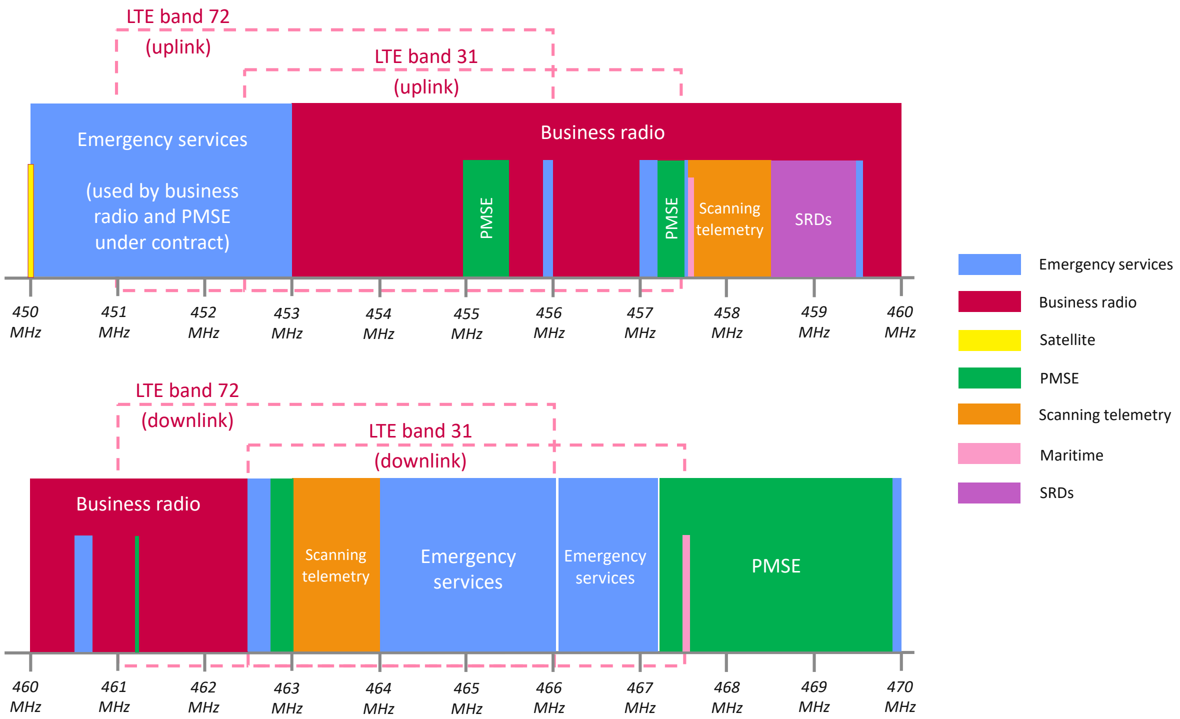
5.4 The 450 MHz band is predominantly used by narrowband systems in the UK. It is used intensively, across many different users: business radio; PMSE; emergency services; scanning telemetry; licence exempt SRDs; maritime onboard ships; and satellite (earth to space) use by space operation service and space research service (as shown in figure 5.1).

5.5 The UK's band plan for the 450 MHz band uses a reversed uplink and downlink ("the UK band plan") when compared with the band plan used by many other European countries ("the

[49] For example see EUTC response to Ofcom's consultation on the future use of the unpaired 2100 MHz (1900-1920 MHz) spectrum

harmonised band plan").[50] This means that UK base stations transmit in frequencies used for receiving in the rest of Europe, and continental base stations transmit in frequencies used for receiving in the UK, which can result in interference caused to the south and east of the UK during certain periods of weather.[51]

Figure 5.1: Current use of the 450 MHz band in the UK



Summary of current users

5.6 **Business radio:** use of 453-462.5 MHz (and 450-453 MHz under contract) supports 12.5 kHz channels for PMR communications across many industries including retail (shopping precincts), transport (buses and taxis), security, factories, construction and utilities. Almost 40,000 licences are authorised in this band, across five licence types.[52]

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[50] CEPT Recommendation T/R 25-08: Planning criteria and cross-border coordination of frequencies for land mobile systems in the range 29.7-470 MHz. Also sets out the band planning and guidance for 450 MHz cross-border coordination.
[51] Certain atmospheric conditions give rise to anomalous propagation effects such as 'ducting'. The effect of continental interference was considered in our 2017 UHF strategy review. ECC Recommendation T/R 25-08 provides the basis for cross-border coordination of frequencies for land mobile systems in the 450 MHz band.
[52] The breakdown of business radio licences in February 2023 was: (i) 13,212 **technical assigned licences**, which authorise using a particular frequency within a stated coverage area; (ii) 131 **area defined licences**, which authorise exclusive use of a frequency within a defined area (from 50km^2 to UK wide); (iii) 9264 **simple site light licences**, for localised voice and paging systems for small/ specific sites using base station and antenna; (iv) 15,581 **simple UK light licences** for device-to-device communications without using a base station (several frequencies); and (v) 1233 **suppliers light licences** used for hire, service and repair of radio equipment.

5.7 **PMSE:** currently has significant use across 450-470 MHz. In 2022, over 47,000 PMSE assignment allocations were made in the 450 MHz band. In 2015 we recognised PMSE use of the 450 MHz band as strategically important[53].

5.8 **Emergency services**: consists of police, fire and rescue services, and HM Prison and Probation Service use of dedicated emergency services frequencies in the 450 MHz band[54] UK wide. Services are currently transitioning to a new emergency services network (ESN)[55], and as a result, some of these frequencies may become available for civil use in the future.

5.9 **Scanning telemetry** uses a SCADA network in 457.5-458.5 MHz paired with 463-464 MHz for monitoring and controlling safety critical gas, electricity and water plant equipment.

5.10 **Licence exempt SRD** use of 458.5-459.5 MHz (in the UK only) is for applications including industrial/commercial telemetry and telecommand, model control, vehicle and fixed alarms, and medical and biological applications.[56]

5.11 **Maritime** use of 457.5-457.6 MHz paired with 467.5-467.6 MHz relates to an international allocation for on board ships communications.[57]

5.12 **Satellite** use of 449.75-450.25 MHz is an international allocation supporting space services[58] for which there are a small number of earth stations in use (transmission only).

5.13 The adjacent users of the 450 MHz band are as follows:

- Business radio, PMSE and MOD operating in the frequencies below at 425-450 MHz.
- Digital terrestrial television (DTT) operates above at 470-694 MHz using a mixed network of high power and smaller in-fill transmitters. These frequencies are also available to PMSE licensees for wireless microphones and similar uses.

Characteristics of the 450 MHz band

Harmonisation and equipment ecosystem

5.14 The harmonised technical conditions for broadband use of 450 MHz band were agreed in ECC Decision (19)02. A 3GPP ecosystem for LTE equipment has developed in the 450 MHz band[59], including terminal equipment which can be used to provide connectivity for utilities. LTE

[53] Our 2015 PMSE spectrum review noted the potential loss of access to this band would be disruptive to the sector's ability to support large or major events. Previously, our 2010 statement on PMSE future spectrum access also set out some security of tenure provisions for PMSE access until August 2021 or on five years' notice, whichever is later, including in relation to access to parts of the 450 MHz band (though this does not include access to 450-453 MHz). This was subject to the legitimate rights of primary and adjacent spectrum users and our acting in the interests of national security or to comply with an international obligation of the UK or a Direction by the Secretary of State. We said that non-PMSE use of this spectrum would need to be justified on the grounds of delivering greater benefit to society, and we would take the views of affected stakeholders into account in our decisions.

[54] See page 2 of the emergency services frequency allocation table for a list of frequencies used.

[55] Emergency Services Network: overview, 2023

[56] UK Interface requirements 2030 – licence exempt short range devices

[57] UK Interface requirement 2035 – for maritime UHF on-board communication systems and equipment. Allocated under footnote 5.287 of the ITU Radio Regulations.

[58] Footnote 5.286 of the ITU Radio Regulations, states it may be used for the space operation service (Earth-to-space) and the space research service (Earth-to-space), subject to agreement obtained under provision No.9.21.

[59] There are currently 44 devices supporting LTE band 72 and 235 devices supporting LTE band 31 (mostly routers and modules), and these continue to increase year on year.

networks using band 72 or band 31 (which align with the harmonised band plan) are being adopted widely throughout Europe and other parts of the world, including specifically for utilities use, and more countries are consulting on proposals to do so.[60]

5.15 In this section we assume that a private network in the 450 MHz band would wish to use the same equipment ecosystem already developed for the harmonised band plan in order to take advantage of the existing device ecosystem.

Coexistence constraints – co-channel

5.16 **Incumbent narrowband users:** we consider that a broadband private network is unlikely to be able to coexist co-channel in the same area as these existing users (including business radio, emergency services and PMSE). Further, opportunities for geographic sharing are likely to be limited, since a private network requires wide area coverage.[61]

5.17 Ireland's configuration of the 450 MHz band is aligned to the UK band plan, so a UK private network using the harmonised band plan would require careful coordination, particularly at the border with NI.

Coexistence – Adjacent spectrum users

5.18 **Narrowband users**: The coexistence issues for narrowband users operating in a reverse configuration - including **business radio, PMSE, emergency services, scanning telemetry** – would depend on whether the band were fully replanned to align all narrowband users with the harmonised band configuration. These are discussed in the following subsection on enabling access for a new private network. We do not anticipate any coexistence constraints on a broadband private network arising from other narrowband users, **maritime** and **satellite**, as they operate using the harmonised band plan.

5.19 **DTT:** We consider that coexistence between a private network in the 450 MHz band and DTT is likely to be possible.[62]

5.20 **Fylingdales radar:** There is no coordination requirement in place for current narrowband spectrum use above 450 MHz with the Fylingdales radar operating in 420-450 MHz. However, previous measurements found that broadband systems in the adjacent 450 MHz band could have an impact on the radar's performance, although to a lesser degree than co-channel use at 400 MHz. Therefore, we would need to manage coexistence with broadband systems in the 450 MHz band which are near to the radar.

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[60] According to GAMBoD, LTE networks have already been deployed in LTE bands 72 or 31 in Germany, Netherlands, Brazil, Hungary, Poland and Sweden. France is consulting on allowing LTE use of the 450 MHz band.

[61] ECC Report 292: Current use, future opportunities and guidance to administrations for the 400 MHz PMR/PAMR frequencies, see Executive summary.

[62] ECC Report 240 found that an out-of-band emissions limits on broadband base stations and a frequency separation of up to 3 MHz between the broadband downlink and DTT could enable coexistence. A3.2 of ECC Decision (19)02 defines the harmonised technical conditions for an appropriate out-of-band emissions limit on the broadband base station downlink.

Enabling use of the 450 MHz band for a private network

5.21 Given its current heavy use, any use of the 450 MHz band for a private network would require significant replanning and have an impact on existing users, at least some of which would need to migrate to alternative frequencies if these could be identified. The UK's reversed band plan compared to many other European countries introduces additional complexity. Before any proposals could be made for consultation, the technical feasibility, and cost and benefits of any changes, including the impact on existing users, would need to be carefully assessed.

5.22 We last reviewed our framework for managing the UHF bands (410-470 MHz) in 2017 (the UHF review[63]). At that point we decided not to undertake a full replan of the 450 MHz band to align with the harmonised band plan on proportionality grounds, and said that we would not consider the issue again "unless there is a significant and material change to the spectrum environment". We consider that it might now be appropriate to revisit the question of fully replanning to align with the harmonised band plan, in view of changes to the spectrum environment in the past six years and anticipated further changes. These include digitalisation of equipment, changes in demand and technology options for incumbent services (such as push-to-talk over public mobile networks or Wi-Fi), increasing demand for utilities communications and the growing ecosystem of equipment suitable for the utilities sector in this band.

5.23 If replanning the band were to be considered there are two high level approaches that could be taken:

- **Partial replan: Migrating some incumbent narrowband users** to clear part of the band for a private network, and retaining the current UK band plan for remaining adjacent narrowband users. This might be the least intrusive approach for releasing 2x1.4 MHz, and in principle could release up to 2x5 MHz (although the replanning involved might then be closer to a full replan).
- **Full replan: Replanning all incumbent narrowband users** to align with the harmonised band plan, leaving part of the band clear (i.e. from 2x1.4 MHz to 2x5 MHz) for a private network. This is the approach that was discussed in our 2017 UHF review.

5.24 We would also consider coexistence with the Fylingdales radar operating below 450 MHz.

Partial replan considerations: Migrating some incumbent co-channel users and retaining the current UK band plan for adjacent users

5.25 Under this approach, existing narrowband users that would be co-channel with the new private network would need to migrate to alternative frequencies, as they could not coexist with a private network. We would aim for remaining adjacent narrowband users to remain in their current configuration where possible.

[63] 2017 Strategic Review of UHF bands 1 and 2

5.26 The impact on incumbent users would be determined by a number of factors, including the total amount of spectrum to be cleared and the frequencies chosen. An illustrative example of a scenario in which 2 x 1.4 MHz is required is shown on the following page.

Technical considerations

5.27 The amount of spectrum that would need to be cleared would be determined by not only the required bandwidth but also any additional spectrum required for there to be sufficient frequency separation between the new broadband private network and incumbent narrowband users. This might be required to manage the risk of interference between the uplink of incumbent narrowband users and the downlink of the broadband private network, and vice versa, which would otherwise be immediately adjacent in frequency. As set out in annex 9, if needed, this frequency separation may need to be up to 2 MHz.

5.28 The private network would likely also require additional base station filtering on both the uplink and the downlink. We would need to do further work to determine the filtering requirements and the necessity and size of any frequency separation.

5.29 If frequency separation was necessary, then the resulting gap (between the incumbent narrowband users and the broadband private network) could be used by narrowband users, such as business radio users, opting to use equipment configured for the harmonised band plan. Figure 5.2 provides an illustration, for the upper part of the band, of the changes in alignment and use for partial replans with and without frequency separation. This is a highly simplified view (not to scale) to illustrate the concepts rather than a detailed band plan.

Figure 5.2: Simplified Illustration of partial replan concept with and without frequency separation (showing upper part of band)

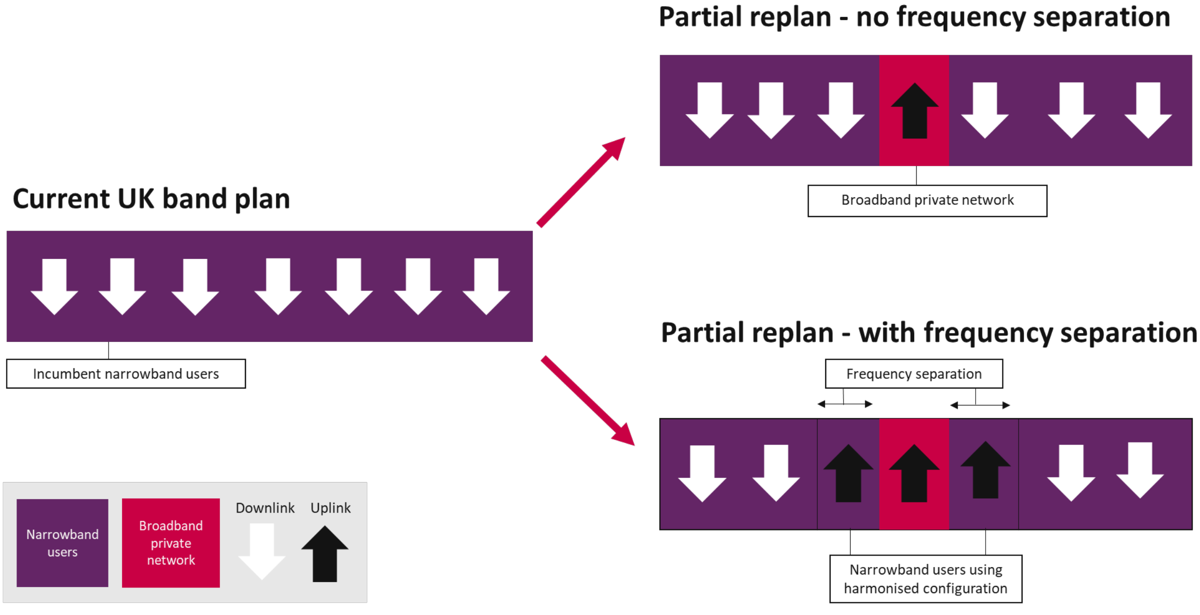


Illustration of how potential incumbent users might be affected by a partial replan

The specific types and numbers of incumbent users impacted by a partial replan of the 450 MHz band would depend on how much bandwidth were being released for the private network, the extent of any frequency separation and whether LTE band 72 or LTE band 31 was to be used. In table 5.1. we provide examples of the specific frequency ranges that might need to be cleared to use LTE band 72, depending on these factors.[64]

Table 5.1: Examples of spectrum that might need to be cleared for a partial replan to enable a private network in LTE band 72

Frequency separation required	Private network bandwidth		
	2x1.4 MHz	2x3 MHz	2x5 MHz
None	451-452.4 MHz /461-462.4 MHz	451-454 MHz /461-464 MHz	451-456 MHz /461-466 MHz
1 MHz	450-453.4 MHz /460-463.4 MHz	450-455 MHz /460-465 MHz	450-457 MHz /460-467 MHz
2 MHz	450-454.4 MHz /460-464.4 MHz	450-456 MHz /460-466 MHz	450-458 MHz /460-468 MHz

To illustrate the potential impact on various incumbent users, we consider the example where the private network uses 2x1.4 MHz in LTE band 72 and there is no frequency separation required (orange cell in table 5.1). In this scenario the incumbent users would lose access to 451-452.4 MHz and 461-462.4 MHz:

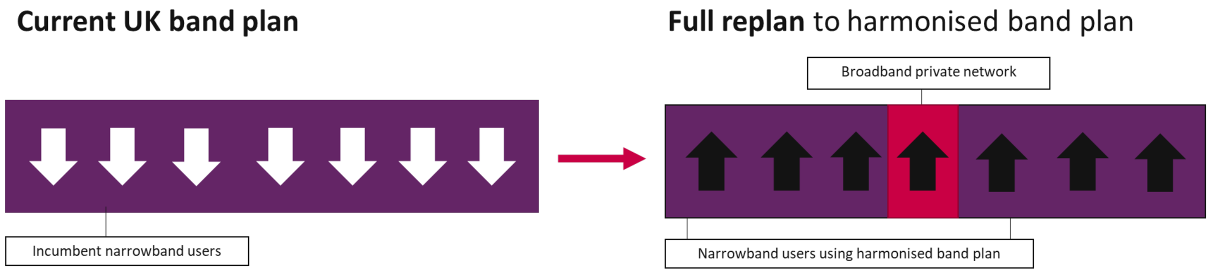
- **Business radio users.** This example might affect around 3700 business radio licences[65], based on licensing data from June 2023. This is less than 10% of business radio licences across the 450 MHz band. To assess this example more fully we would need to do further work on whether there is an alternative frequency range that those users could migrate to and how, including whether existing equipment could be retuned. We understand that most existing business radio equipment can be retuned between UHF 1 (425-450 MHz) and UHF 2 (450-470 MHz).
- **PMSE users.** This example could impact around 7% of PMSE assignments based on 2022 licensing data[66]. To assess this more fully we would need to do further work to determine whether this use could be accommodated in alternative frequencies, and the extent to which existing equipment can be retuned.
- **Emergency services.** To assess the impact of this example more fully we would need to discuss plans for future emergency services use of the 450 MHz band with the Home Office.

[64] The specific frequencies shown also assume (for 2x1.4 MHz and 2x3 MHz) that the frequencies used for the private network start at the bottom of LTE band 72, i.e. starting from 451 MHz / 461 MHz.
[65] 3741 business radio licences were on issue in June 2023 within 461-462.4 MHz. Of these, 2446 were technically assigned licences; 62 were area defined licences; and 1233 were suppliers light licences. There was no use in 451-452.4 MHz.
[66] 3203 PMSE assignments were made within 451-452.4 MHz and 461-462.4 MHz in 2022, out of total of 47,000 across the whole band.

Full replan considerations: Replanning all incumbent narrowband users to align with the harmonised band plan

5.30 Under this approach, all narrowband users in the 450 MHz band (including business radio, PMSE, emergency services, scanning telemetry but excluding maritime and satellite) would be replanned from the current UK band plan, to operate in the harmonised band plan, while releasing spectrum (up to 2x5 MHz) suitable for a private network. Figure 5.3 provides a highly simplified illustration of the concept of a full replan for the upper part of the band (again this is to illustrate the concept rather than a detailed band plan).

Figure 5.3: Illustration of concept of full replan (showing upper part of band)



5.31 This would be a very significant replanning exercise impacting a large number of narrowband users who would need to change their use of the band, including using different frequencies, changing uplink and downlink direction and potentially accessing less spectrum overall. Further technical analysis would be required to determine the feasibility of such a change, such as whether equipment can be retuned. We would also need to take account of potential future changes in incumbent demand, and consider how to minimise the disruption and the net cost of such a replan.

5.32 As a result of such a replan, broadband systems and adjacent narrowband users operating would both be operating in line with harmonised band plan and so no additional technical conditions, including filtering and frequency separation, would be required.[67] This would also remove the existing risk of interference (resulting from the current reversed band configuration) from continental use of this band into narrowband users in the UK.

Costs associated with deploying a private network for utilities using the 450 MHz band

5.33 The distinguishing cost factors for using the 450 MHz band are:

- **Sites:** we would expect the lowest initial build costs due to its coverage characteristics (see paragraph 3.14). However, depending on the bandwidth available, some additional build might be needed to ensure sufficient capacity.

[67] Annex 3 of ECC Decision (19)02

- **Equipment:** as in the 400 MHz band, it is likely that network equipment using this band would benefit from an international ecosystem (see paragraph 5.14) resulting in lower equipment costs when compared to bands that would require bespoke equipment.
- **Migration:** as noted above the 450 MHz band is currently intensively used across the UK and there could be significant costs incurred by some or all existing users if they were migrated within or out of the band.[68] We expect the key cost drivers for any resulting migration plan could include:
  - existing users' future demand for the spectrum (for example, given potential changes in technology options for incumbent services – see paragraph 5.22);
  - the bandwidth required for utilities (which impacts the number of existing users that would need to be moved);
  - the users impacted (e.g. PMSE or business radio) as they could face different costs;
  - which bands existing users could be migrated to;
  - the extent to which existing equipment and base stations could be retuned (as this is much cheaper than replacing equipment); and
  - the retune and replacement costs of existing equipment and base stations.

Question 7: Do you have any comments on our overview of the 450 MHz band in GB and NI? Please consider the specific factors we have discussed (including the coexistence analysis in annex 9) in your response.

Question 8: Do you consider that changes in the spectrum environment for the 450 MHz band mean that there is a case for re-examining whether this band should be reconfigured in the UK to align with the harmonised band plan?

[68] A study undertaken by PA Consulting in June 2004 estimated the cost of a band reversal for the 450 MHz band would be between £260m and £310m. However, we note that this cost range is not necessarily appropriate as: (a) it assessed band reversal of the UHF 2 band while migration costs could require moving a proportion of users in this band, and (b) the estimate was based on costs, use, and the ability to retune in 2004 which may no longer be applicable, given they are nearly two decades old.

6. 700 MHz – in Great Britain and Northern Ireland

Summary

6.1 In this document, "the 700 MHz PPDR band" relates to:

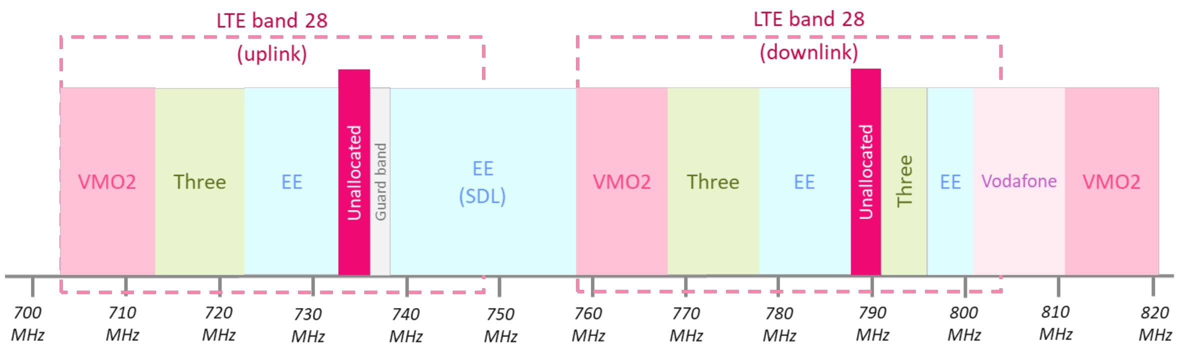
Frequencies under consideration (MHz)	Relevant LTE band(s)	Potential bandwidth
733-736 MHz (uplink) paired with 788-791 MHz (downlink)	Band 28 (703-748 MHz uplink / 758-803 MHz downlink)	Up to 2x3 MHz FDD

6.2 The 700 MHz PPDR band could potentially be available for use in GB and NI, subject to resolving potential coexistence challenges with adjacent supplementary downlink (SDL) mobile spectrum and developing a suitable equipment ecosystem. However, there are a number of potential future users of the band including the PSNI.

Current and potential future use of the 700 MHz PPDR band

6.3 Figure 6.1 shows how the wider 700 MHz band (694-821 MHz) is currently configured in the UK. The 700 MHz PPDR band (shown in red) is currently unallocated and lies adjacent to previously awarded spectrum for mobile, including the 'centre gap' 700 MHz SDL band (738-758 MHz) held by EE. Mobile operators also hold spectrum in adjacent bands; the blocks immediately adjacent to the 700 MHz PPDR band are held by EE (723-733 MHz and 778-788 MHz) and Three (791-796 MHz).[69]

Figure 6.1: Current use of the 700 MHz PPDR band



[69] The other mobile licensed spectrum in adjacent bands is held by: Virgin Media O2 (703-713 MHz, 758-768 MHz, 811-821 MHz), EE (796-801 MHz), Three (713-723 MHz and 768-778 MHz) and Vodafone (801-811 MHz).

6.4 We are aware of several potential users of the 700 MHz PPDR band. We recently consulted on making it available in NI for use by the PSNI to support its future communication needs. Some respondents[70] to our PSNI consultation signalled the potential for utilities to also use the 700 MHz PPDR band across the UK, potentially in a shared capacity with PSNI in NI. There is also potential Home Office interest in using this band in GB for ESN ancillary requirements. Competing demand could have implications for our future work on this band, as discussed below.

Characteristics of the 700 MHz PPDR band

Harmonisation and equipment ecosystem

6.5 The 700 MHz PPDR band has been harmonised by CEPT for PPDR[71]. There is planned use for PPDR networks, and some limited rollout, across Europe in this band.

6.6 While LTE band 28 is popular worldwide with a mature LTE equipment ecosystem[72], the subset of 700 MHz PPDR frequencies lacks dedicated LTE equipment. An ecosystem for devices tailored for PPDR use is expected to develop following harmonisation.[73] We are not aware of any other countries looking to use the 700 MHz PPDR band for utilities.

Coexistence constraints

6.7 There are no co-channel coexistence constraints as the 700 MHz PPDR band is currently unused.

6.8 For adjacent spectrum below 733 MHz and either side of 788-791 MHz, we consider that the European harmonised technical conditions would ensure coexistence between a private network in 700 MHz PPDR spectrum and adjacent users.

6.9 However, use might potentially be constrained due to the risk of interference from SDL transmissions in the 700 MHz SDL band, especially in urban areas where demand for SDL is likely to be greatest. We considered this in our PSNI consultation and found that:

a) the risk of interference from PPDR handset transmissions to SDL reception is low; but

b) there is the potential for interference from SDL base station transmissions to PPDR base station receivers, where they are deployed within a few km of each other, and we explored some options[74] to mitigate these interference risks.

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[70] See PSNI consultation responses from JRC, NIE Networks, NI Water, and Westica.

[71] See ECC Decision (16)02: Harmonised technical conditions and frequency bands for the implementation of broadband public protection and disaster relief systems, and EC Implementing Decision 2016/687: Harmonisation of the 694-790 MHz frequency band for terrestrial systems capable of providing wireless broadband electronic communications services and for flexible national use in the Union

[72] The number of devices supporting LTE band 28 has grown from 215 in 2015 to 4544 in 2023.

[73] Nokia's response to the PSNI consultation noted that it has recently developed a 4G base station that supports the 700 MHz PPDR band. It also referred to recent deployment in this band in France and Spain for critical uses.

[74] See paragraphs 2.16-2.18 and 2.19-2.24 of the PSNI consultation.

Enabling use of the 700 MHz PPDR band for a private network

6.10 Enabling use of this band would require steps to mitigate the risk of interference from SDL to utilities base stations. Prospective users would need to engage with the 700 MHz SDL band licensee (currently EE) to understand the potential for technical and commercial arrangements to manage the risk of interference from SDL base stations in that band. As discussed in our PSNI consultation there are a number of site engineering techniques that the SDL user could employ[75]; utilities users would need to deploy base stations that are sufficiently resilient to SDL transmissions, including using sufficient filtering as well some of the site engineering techniques.

6.11 In addition, an equipment ecosystem suitable for utilities use would need to be developed, driven by industry working with manufacturers.

6.12 If there were potential competing demand from multiple users for this band, then this would need to be resolved, for example through sharing arrangements between these users or through us undertaking further work (and an appropriate process) to determine the band's optimal use.

6.13 In NI, these actions are closely linked to our PSNI consultation process. Following our review of responses, we updated stakeholders in April that we would use this CFI to seek more information before deciding what to do with this band. While no decisions have yet been taken and are subject to further consultation, one potential outcome of our work could mean the band would be allocated in NI to PSNI (potentially enabling shared use with others). In this scenario, the 700 MHz PPDR band might only be available in GB for utilities.

Costs associated with deploying a private network for utilities using the 700 MHz PPDR band

6.14 The distinguishing cost factors for using the 700 MHz PPDR band are:

- **Sites:** there would likely be limited additional sites needed, thus limited incremental network build costs, when compared to the 450 MHz band as 700 MHz provides similar coverage (see paragraph 3.14).
- **Equipment:** there would likely be significantly higher equipment costs for bespoke equipment because (globally) there are no other utilities users of this band (see paragraph 6.6). This could be a more significant factor than the limited additional site costs.

> Question 9: Do you have any comments on our overview of the 700 MHz band in GB and NI? Please consider the specific factors we have discussed in your response.

[75] Including increasing the antenna downtilt; changing antenna azimuth; and/or lowering transmitter power levels.

7. 800/900 MHz – in Northern Ireland only

Summary

7.1 In this document "the 800/900 MHz band" refers to:

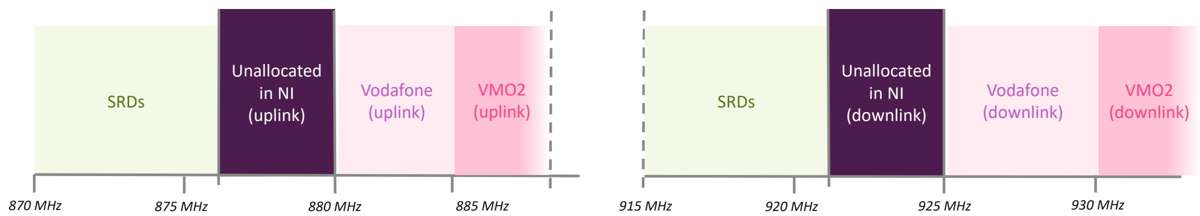
Frequencies under consideration (MHz)	Relevant LTE band(s)	Potential bandwidth
876-880 MHz uplink paired with 921-925 MHz downlink	None, at present	Up to 2x3 MHz FDD

7.2 The 800/900 MHz band is potentially available in NI only, as this band is already fully used by GSM-R[76] in GB (as explained below). Given the band is unused in NI and that we have identified no significant coexistence constraints, it could be made available relatively quickly following our usual process to authorise the band. However, we recently consulted on making this band available for use by the PSNI so would need to manage the potential for competing demand and determine the optimal use. Industry would need to work with manufacturers to develop an ecosystem for suitable terminal equipment.

Current and potential future use of the 800/900 MHz band in NI

7.3 Figure 7.1 shows how the 800/900 MHz band is currently configured in NI. The 2x4 MHz of spectrum we are considering in this CFI (shown in purple) is currently unused in NI. Although the 800/900 MHz band is harmonised across Europe for GSM-R, the railway operator in NI (NI Rail) does not use GSM-R technology.[77] In GB, this band is licensed to Network Rail for operational communications across its railway network.

Figure 7.1: Current use of the 800/900 MHz band in NI



7.4 We recently consulted on making the 800/900 MHz band available in NI for use by the PSNI as part of its future communication needs. Some respondents to our PSNI consultation indicated that the utilities sector could also potentially use this band (see footnote 70), which could have implications for our future work on this band, as discussed below.

7.5 The adjacent users of the 800/900 MHz band are as follows:

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[76] Global System for Mobile Communications-Railway
[77] Instead, NI Rail uses a mix of other spectrum and technology for its communication needs including the current PSNI Barracuda network. We understand that this arrangement between the PSNI and NI Rail is expected to continue.

- SRDs operate in the spectrum below (870-876 MHz and 915-921 MHz) on a non-interference basis with no protection from other licensed users of the frequency bands; typical uses include telemetry, telecommand, alarms, and RFID (radio frequency identification).
- Mobile operators (Vodafone and Virgin Media O2 (VMO2)) use the spectrum above 925 MHz for mobile networks. Vodafone holds the immediately adjacent licence at 880.1-885.1 MHz paired with 925.1-930.1 MHz.

Characteristics of the 800/900 MHz band in NI

Harmonisation and equipment ecosystem

7.6 The 800/900 MHz band is harmonised by CEPT for railway mobile radio (RMR)[78], which includes GSM-R and FRMCS[79], to meet rail's growing data needs. As the band is still widely used for GSM-R, there is not yet a wider broadband device ecosystem for this band, and we are not aware of any other countries looking to use the 800/900 MHz band for utilities.

Coexistence constraints

7.7 There are no co-channel coexistence constraints on using the 800/900 MHz band in NI as it is currently unused there.

7.8 We expect no constraints for future high power use given that CEPT Report 80[80] notes that broadband technologies which comply with the technical conditions set out in that report would be compatible with adjacent mobile users without the need for a guard band.

7.9 We also consider that a private network can coexist with adjacent SRD use in 874-876 MHz and 915-921 MHz based on ECC Report 313[81].

Enabling use of the 800/900 MHz band in NI for a private network

7.10 There are two key challenges to enabling use of this band for a private network for utilities.

7.11 The key technical issue is that an equipment ecosystem suitable for utilities use in this band would need to be developed, driven by industry working with manufacturers.

7.12 The key policy issue is whether there is competing demand for the band in NI (from PSNI and utility users), and if there is, how that competing demand is resolved. One approach would be for those parties to develop a way to share access to the spectrum. Alternatively, if that did not happen and competing demand remained, we would need to carry out further work

[78] In 2020, CEPT harmonised an additional 2x 1.6 MHz of spectrum (874.4-876/ 914.4-921 MHz) for RMR. See ECC Decision (20)02: Harmonised use of the paired frequency bands 874.4- 880.0 MHz and 919.4-925.0 MHz and of the unpaired frequency band 1900-1910 MHz for Railway Mobile Radio (RMR) and EC Implementing Decision (EU) 2021/1730: Harmonised use of the paired frequency bands 874,4-880,0 MHz and 919,4-925,0 MHz and of the unpaired frequency band 1900-1910 MHz for railway mobile radio

[79] Future rail mobile communication system)

[80] CEPT Report 80: Channelling arrangements and least restrictive technical conditions suitable for ECS including 5G terrestrial wireless systems in the 900 MHz and 1800 MHz frequency bands (see section 3.3.6).

[81] Technical study for co-existence between RMR in the 900 MHz range and other applications in adjacent bands

to determine the optimal use of the band. No decisions have yet been taken and are subject to further consultation.

Costs associated with deploying a private network for utilities using the 800/900 MHz band in NI

7.13 The distinguishing cost factors for using the 800/900 MHz band are similar to 700 MHz:

- **Sites:** there would likely be limited additional sites needed, thus limited network build costs, when compared to the 450 MHz band as the 800 / 900 MHz band provides similar coverage (see paragraph 3.14).
- **Equipment:** there would likely be significantly higher equipment costs for bespoke equipment because (globally) there are no other utilities users of this band (see paragraph 7.6). This could be a more significant factor than the limited additional site costs.

> Question 10: Do you have any comments on our overview of the 800/900 MHz band in NI? Please consider the specific factors we have discussed in your response.

8. 1900 MHz – in Great Britain and Northern Ireland

Summary

8.1 In this document "the 1900 MHz band" refers to:

Frequencies under consideration (MHz)	Relevant LTE band(s)	Potential bandwidth
1900-1920 MHz	Band 39 - 1880-1920 MHz	Up to 15 MHz TDD (unpaired)

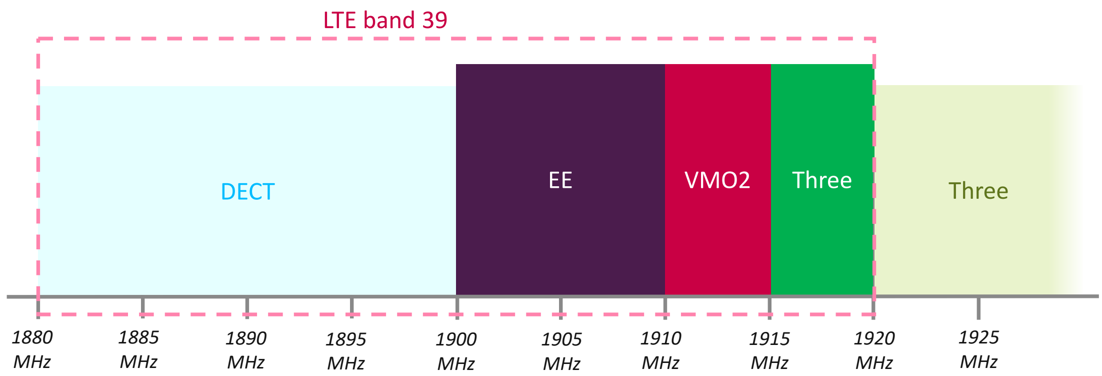
8.2 The 1900 MHz band could be available for use across the UK. We recently consulted on future use of this band, to ensure optimal use of this spectrum and potentially make it available for higher value potential users (such as the utilities sector, rail and the ESN gateway[82]). We consider that use for a private network would be limited to 1900-1915 MHz. The key factors influencing its availability for a private network for the utilities are:

- Ofcom's decision following the 1900 MHz consultation and any subsequent proposals to make the band available to new users;
- the potential for competing demand from other users and scope for sharing; and
- industry developing an equipment ecosystem.

Current and potential future use of the 1900 MHz band

8.3 Figure 8.1 shows how the 1900 MHz band is currently licensed in the UK. Three mobile operators currently hold licences in the unpaired 1900 MHz band: EE, VMO2 and Three.[83]

Figure 8.1: Current use of the 1900 MHz band



[82] The ESN gateway is a niche application providing a coverage extension to ESN devices on an ad hoc/temporary basis when the emergency services need to respond in an area or location beyond the normal coverage of EE's macro network, or within a building where the signal level from the network is insufficient to support reliable communications.
[83] Following the award in 2000, spectrum holdings for each mobile operator are: EE (10 MHz at 1899.9-1909.9 MHz), VMO2 (5 MHz at1909.9-1914.9 MHz) and Three (5.1 MHz at 1914.9-1920 MHz).

8.4 The 1900 MHz band has remained unused for mobile services in the UK since its award in 2000[84], and 1900 MHz licensees have indicated they have no plans for future wide area mobile use in this band in the foreseeable future.[85] In 2017, EE requested a variation to its 1900-1910 MHz licence to support an ESN gateway, but it has not yet been deployed.

8.5 We recently consulted on future use of the 1900 MHz band, to ensure optimal use of this spectrum and potentially make it available for higher value users. In addition to the utilities sector, rail and the ESN gateway were identified as potential future users:

- For **rail**, 1900-1910 MHz has been harmonised at a European level for FRMCS (a 5G new radio (NR) technology), to support critical new applications and interoperability requirements (such as automatic train operation, remote control of engine, train integrity and sensing).
- For the **ESN gateway,** we said 1915-1920 MHz may be an option, subject to further work on the technical and practical implications.

8.6 The adjacent users are:

- digital enhanced cordless telecommunications (DECT) equipment used at 1880-1900 MHz; and
- FDD mobile uplink above 1920 MHz (relates to all mobile operators, but the immediately adjacent user is Three).

Characteristics of the 1900 MHz band

Harmonisation and equipment ecosystem

8.7 In 2020, CEPT harmonised 1900-1910 MHz for RMR (including FRMCS) under ECC Decision (19)02 on a non-exclusive basis.

8.8 While the wider LTE band 39 has a mature device ecosystem globally, the specific frequencies we are considering lack dedicated LTE equipment outside of China. Prototype future rail equipment operating in the 1900 MHz band is being developed and tested with planned European trials based on upgraded 5G equipment around 2024.

Coexistence constraints – co-channel

8.9 The 1900 MHz band is licensed for mobile services but remains unused. There is potential for it to be used for the ESN gateway, however that would be unlikely to be able to coexist co-channel in the same geographical areas with a private network.

[84] CEPT studied the 1900 MHz band in 2015 and reported that although licensed in many countries, it has remained unused in Europe since being awarded (in some countries licences have already been surrendered.

[85] In response to our July 2021 consultation on annual licences fees for 2100 MHz spectrum, the views of BT (parent company of EE), VMO2 and Three can be found on our website.

Coexistence constraints – adjacent spectrum

8.10 As discussed at paragraph 3.12 of our 1900 MHz consultation, our view is that:

- high power mobile use in 1900-1915 MHz (i.e. that would be suitable for a private network for utilities) should be able to coexist with the adjacent spectrum users (DECT below 1900 MHz and the public mobile networks above 1920 MHz).
- use in the 1915-1920 MHz band would need to be at low power to be able to coexist with mobile use above 1920 MHz. This power constraint would make 1915-1920 MHz unsuitable for wide area coverage.

8.11 Both of these findings assume the mobile base station receivers above 1920 MHz have sufficient selectivity, or geographical separation from use below 1920 MHz, to prevent them being blocked by future services in 1900-1920 MHz.[86]

Enabling use of the 1900 MHz band for a private network

8.12 To ensure coexistence between users and prevent adjacent mobile base station receivers above 1920 MHz being blocked by future high and low power services in 1900-1920 MHz those receivers will need to have sufficient selectivity. This may involve mobile operators making modifications to base station equipment where those base stations are close to new high power deployments in 1900-1915 MHz.

8.13 In addition, an equipment ecosystem suitable for utilities use would need to be developed, driven by industry working with manufacturers.

8.14 Policy issues for the 1900 MHz band are closely linked to our 1900 MHz consultation process, seeking to determine optimal use of this band. We are currently considering responses to this consultation and expect to reach a conclusion on optimal use (and how best to achieve it) in early 2024. Should we decide to revoke these licences, licensees would be given five years' notice, and a consultation on reallocating the spectrum would follow.

8.15 Any future work on reallocating the spectrum would need to take account of competing demand for access to the 1900 MHz band from rail, utilities and the ESN gateway (and/or others), and the potential for sharing of spectrum or networks between such users, in order to determine the optimal use of the band.

Costs associated with deploying a private network for utilities using the 1900 MHz band

8.16 The distinguishing cost factors for using the 1900 MHz band are:

- **Sites**: a larger investment in base stations would be required due to the relative coverage characteristics of this band when compared to lower frequency bands (see paragraph

[86] ECC Report 314 considered coexistence between FRMCS at 65 dBm/10 MHz in 1900-1910 MHz with adjacent services. The report noted that mobile base station receivers above 1920 MHz could be at risk of being blocked by nearby FRMCS base stations and that one way that this risk could be mitigated was by improving the selectivity of mobile base stations above 1920 MHz as specified in ETSI TS 103 807.

3.14). This would also mean higher operating costs due to a greater number of base stations. However, we note that this higher upfront build for coverage would provide additional network capacity if that were necessary.

- **Equipment:** in addition, the equipment costs would likely be significantly higher due to the need for bespoke equipment in a band where there are limited mobile users and not yet any utilities users (see paragraph 8.8).

Question 11: Do you have any comments on our overview of the 1900 MHz band in GB and NI? Please consider the specific factors we have discussed in your response.

9. Summary of suitability for each band, including illustrative timing

Band / bandwidth	Equipment ecosystem	What needs to happen to enable use for a private network	Preliminary view of associated costs	Illustrative timing for accessing the band
400 MHz (NI only) – up to 2x3 MHz FDD	• Widely available (and increasing) LTE and utilities specific equipment	• **To access lower 2x2 MHz pair** - share / coordinate with PSNI's current limited use, otherwise depends on whether PSNI ceases using the band in future • **To access upper 2x2 MHz pair** - commercial arrangements (i.e. through spectrum trading or leasing) with current licensees (Arqiva/Airwave) • **To access either or both lower and upper pairs** - work with MOD to understand arrangements necessary (if any) to protect Fylingdales radar, and other MOD use	• Lowest site build costs • Lower equipment costs • Uncertain if any migration costs	• **Lower pair** - <5 years if able to share, or if PSNI ceases use • **Upper pair** - <5 years if agree commercial access with Arqiva/Airwave
450 MHz – up to 2x5 MHz FDD	• Widely available (and increasing) LTE and utilities specific equipment	• Consider changes to the spectrum environment since 2017 • Comprehensively assess technical feasibility, cost and benefits of any proposed replan, including the implications for existing users • Consider coexistence arrangements for adjacent Fylingdales radar • **For partial replan** – migrate some narrowband users. Study extent of filtering and frequency separation required • **For full replan** – replan all narrowband users to align with harmonised band plan	• Similar site and equipment costs as 400 MHz band • Significant costs from migrating (some or all) incumbent users	• >5 years for band availability depending on scale and complexity of replan • Certainty of access to the band could be <5 years
700 MHz PPDR – up to 2x3 MHz FDD	• PPDR device availability increasing but not yet any utilities specific equipment	• Prospective users of band and SDL licensee (EE) to identify commercial and/or technical opportunities for mitigating interference risks, including utilities base stations resilience to SDL transmissions • Utilities to work with manufacturers to develop suitable equipment • Resolve any potential competing demand for the spectrum through sharing arrangements or an Ofcom process to determine optimal use	• Limited increase on the lowest site build costs of 400/450 MHz bands • Higher bespoke equipment costs	• <5 years as no incumbent users
800/900 MHz (NI only) – up to 2x3 MHz FDD	• No 4G/LTE or 5G. Harmonised for GSM-R / FRMCS	• Utilities to work with manufacturers to develop suitable equipment • Resolve any potential competing demand for the spectrum through sharing arrangements or an Ofcom process to determine optimal use	• Similar to 700 MHz	• <5 years as no incumbent users
1900 MHz – up to 15 MHz TDD	• Limited LTE equipment (not utilities specific) • 1900-1910 harmonised for FRMCS	• Mobile base station receivers above 1920 need sufficient selectivity • Utilities to work with manufacturers to develop suitable equipment • Subject to the outcome of our 1900 MHz consultation, potential process to revoke existing licensees and subsequently reallocate spectrum, taking account of any potential for competing demand and sharing between new users.	• Highest initial site build and operating costs • Higher bespoke equipment costs	• >5 years. If licences are revoked, subject to reallocation process, potential to deploy within 5 year notice period if spectrum unused

Question 12: Which band(s) do you consider we should examine further with a view to developing consultation proposals to enable their use in a private network, if this were needed? Please reference the factors we have considered where appropriate and provide separate answers for GB and NI if relevant.

10. Next steps

Our approach to managing responses to this CFI

10.1 We welcome stakeholder responses on the issues raised in this CFI. The consultation period closes on 7 September 2023.

10.2 We intend to use those responses to inform our understanding of the advantages and/or disadvantages of potential candidate spectrum bands for the utilities sector. We are also seeking to confirm the demand for these bands from all stakeholders – utilities, incumbents and other potential new users – to inform our understanding of competing demand and any future spectrum authorisation proposals.

10.3 As set out in paragraphs 2.24 and 2.26, we are concurrently examining some of these spectrum bands in other work, notably the 700 and 800/900 MHz bands in NI and the 1900 MHz band across the UK. We intend to consider responses to other relevant consultations alongside responses to this CFI, to coordinate our spectrum approach and ensure that competing demands are fully understood.

10.4 We aim to provide an update for stakeholders including a summary of responses to this CFI, and our anticipated next steps, by Q4 2023/24.

Our future work

10.5 How we move forward, including whether and when we undertake further study of specific bands and potentially bring forward authorisation proposals, will be informed by responses to this CFI and continuing engagement with stakeholders, government and utilities regulators. We will also engage with neighbouring administrations where there could be cross border coordination considerations, in particular in relation to NI.

We will continue to engage with government and utilities regulators on utilities' operational requirements

10.6 The Department for Science, Innovation and Technology (DSIT) is the department responsible for spectrum policy, so we will continue to engage with them as we progress our work. DSIT play an important role in cross-government coordination on spectrum matters, including for NI. We will also continue to engage with devolved governments in the rest of GB.

10.7 Before moving forward with any specific spectrum proposals we expect to take account of relevant decisions by the Department for Energy Security and Net Zero and Ofgem in GB (and DfE and the Utility Regulator in NI). This is because:

- the need for spectrum will depend on whether investment in a private network is supported by those bodies; and

- the bandwidth needed for such a private network will depend on the services which are considered essential to be carried on that network (i.e. could not be carried on alternative networks, including public mobile networks).

10.8 We expect both points to be informed by the outcome of the technical evaluation project led by the Department for Energy Security and Net Zero, discussed in paragraph A6.3.

Band specific next steps

10.9 While it is too early to determine definitive band specific actions or their timing, where we consider appropriate to consider specific bands in more detail, the 'Enabling use for a private network' section under each band in sections 4-8, provides a guide to the type of further work we (and others) might need to undertake, and illustrative timing for each band's availability, as summarised in section 9. In general, this reflects that the simplest and quickest bands to progress are those where there are no existing users and no competing demands for future access. We would also encourage stakeholders to consider what role they might play in progressing some of these actions.

We would consult on any specific future proposals

10.10 In developing proposals for specific bands, two important considerations would be whether there is competing demand for spectrum and the benefits that existing users of spectrum are delivering to people and businesses in the UK. Any further work to develop proposals to authorise spectrum would be in line with our statutory duties (as set out in annex 1) and take account of our 2021 spectrum management strategy.

A1. Legal framework

A1.1 This annex explains our legal framework, derived from our duties and powers under both the Communications Act 2003 (the 2003 Act) and the Wireless Telegraphy Act 2006 (the 2006 Act). It also provides an overview of the main legislative provisions relevant to wireless telegraphy licensing and proposed variations. It is not a full statement of all the legal provisions which may be relevant to our functions and wireless telegraphy licensing.

Ofcom's duties when carrying out spectrum functions

A1.2 In carrying out our spectrum functions we have a duty under section 3 of the 2006 Act to have regard, in particular, to:

- the extent to which the spectrum is available for use, or further use, for wireless telegraphy;
- the demand for use of that spectrum for wireless telegraphy; and
- the demand that is likely to arise in future for such use.

A1.3 We also have a duty to have regard, in particular, to the desirability of promoting:

- the efficient management and use of the spectrum for wireless telegraphy;
- the economic and other benefits that may arise from the use of wireless telegraphy;
- the development of innovative services; and
- competition in the provision of electronic communications services.

Ofcom's general duties

A1.4 Our principal duty under section 3(1) of the 2003 Act, when carrying out our functions, is:

- to further the interests of citizens in relation to communications matters; and
- to further the interests of consumers in relevant markets, where appropriate by promoting competition.

A1.5 In doing so, we are also required by section 3(2) to secure (among other things):

- the optimal use of spectrum, and
- the availability throughout the United Kingdom of a wide range of electronic communications services.

A1.6 Section 3(3) provides that in performing our duties, we must have regard to the principles of transparency, accountability, proportionality and consistency, as well as ensuring that its actions are targeted only at cases in which action is needed.

A1.7 Section 3(4) also requires us to have regard to the following matters (among others):

- the desirability of promoting competition in relevant markets;
- the desirability of encouraging investment and innovation in relevant markets;

- the different needs and interests, so far as the use of the electro-magnetic spectrum for wireless telegraphy is concerned, of all persons who may wish to make use of it; and
- the different interests of persons in the different parts of the United Kingdom, of the different ethnic communities within the United Kingdom and of persons living in rural and in urban areas.

Ofcom's power to revoke or vary spectrum licences

A1.8 Our powers to carry out our spectrum functions are set out in the 2006 Act. Such powers include, under sections 9 and 10, the general power to revoke or vary any wireless telegraphy licences. Schedule 1 of the 2006 Act sets out a process for revoking or varying wireless telegraphy licences.

A1.9 We have a duty set out in section 9(7) of the 2006 Act to ensure that wireless telegraphy licence conditions are objectively justified in relation to networks and services to which they relate, non-discriminatory, proportionate and transparent.

A1.10 We have a broad discretion under paragraph 6 of Schedule 1 of the 2006 Act to vary licences, subject to certain limitations. However, this process does not apply to a proposed licence variation that is made at the request or with the consent of the licensee.

Impact assessment

A1.11 Section 7 of the Communications Act requires us to assess and publish the likely impact of implementing a proposal which would be likely to have a significant impact on businesses or the general public, or when there is a major change in Ofcom's activities. As a matter of policy Ofcom is committed to carrying out and publishing impact assessments in relation to the great majority of our policy decisions, although the form of that assessment will depend on the particular nature of the proposal.

A1.12 Ofcom is an evidence-based organisation and welcomes responses to this consultation. We note that this document is not yet making firm proposals, only seeking input. We have therefore not undertaken an impact assessment in this document.

Equality impact assessment

A1.13 Section 149 of the Equality Act 2010 (the 2010 Act) imposes a duty on Ofcom, when carrying out its functions, to have due regard to the need to eliminate discrimination, harassment, victimisation and other prohibited conduct related to the following protected characteristics: age; disability; gender reassignment; marriage and civil partnership; pregnancy and maternity; race; religion or belief; sex and sexual orientation. The 2010 Act also requires Ofcom to have due regard to the need to advance equality of opportunity and foster good relations between persons who share specified protected characteristics and persons who do not.

A1.14 Section 75 of the Northern Ireland Act 1998 (the 1998 Act) also imposes a duty on Ofcom, when carrying out its functions relating to NI, to have due regard to the need to promote equality of opportunity and regard to the desirability of promoting good relations across a range of categories outlined in the 1998 Act. Ofcom's Revised NI Equality Scheme explains how we comply with our statutory duties under the 1998 Act.

A1.15 To help us comply with our duties under the 2010 Act and the 1998 Act, we assess the impact of our proposals on persons sharing protected characteristics and in particular whether they may discriminate against such persons or impact on equality of opportunity or good relations. We fulfil these obligations by carrying out an Equality Impact Assessment ('EIA'), which examines the impact our policy is likely to have on people, depending on their personal circumstances. EIAs also assist us in making sure that we are meeting our principal duty of furthering the interests of citizens and consumers, regardless of their background and identity.

A1.16 We do not consider this document has equality implications under the 2010 Act or the 1998 Act.

A2. Responding to this CFI

How to respond

A2.1 Ofcom would like to receive views and comments on the issues raised in this document, by 5pm on Thursday, 7 September 2023.

A2.2 You can download a response form from https://www.ofcom.org.uk/consultations-and-statements/category-1/potential-spectrum-bands-to-support-utilities. You can return this by email or post to the address provided in the response form.

A2.3 If your response is a large file, or has supporting charts, tables or other data, please email it to utilitiesnetwork@ofcom.org.uk, as an attachment in Microsoft Word format, together with the cover sheet.

A2.4 Responses may alternatively be posted to us, marked with the title of this CFI:

Potential spectrum bands for Utilities
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A2.5 We welcome responses in formats other than print, for example an audio recording or a British Sign Language video. We will publish a transcript of any audio or video responses we receive (unless your response is confidential). To respond in BSL:

- send us a recording of you signing your response. This should be no longer than 5 minutes. Suitable file formats are DVDs, wmv or QuickTime files; or
- upload a video of you signing your response directly to YouTube (or another hosting site) and send us the link.

A2.6 We do not need a paper copy of your response as well as an electronic version. We will acknowledge receipt of a response submitted to us by email.

A2.7 You do not have to answer all the questions in this CFI if you do not have a view; a short response on just one point is fine. We also welcome joint responses.

A2.8 It would be helpful if your response could include direct answers to the questions asked in this CFI. The questions are listed at annex 5. It would also help if you could explain why you hold your views, and what you think the effect of Ofcom's proposals would be.

A2.9 If you want to discuss the issues and questions raised in this CFI, please contact the team by email to Utilities@ofcom.org.uk.

Confidentiality

A2.10 Consultations are more effective if we publish the responses before the consultation period closes. In particular, this can help people and organisations with limited resources or familiarity with the issues to respond in a more informed way. So, in the interests of transparency and good regulatory practice, and because we believe it is important that everyone who is interested in an issue can see other respondents' views, we usually publish responses on the Ofcom website at regular intervals during and after the consultation period.

A2.11 If you think your response should be kept confidential, please specify which part(s) this applies to, and explain why. Please send any confidential sections as a separate annex. If you want your name, address, other contact details or job title to remain confidential, please provide them only in the cover sheet, so that we do not have to edit your response.

A2.12 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and try to respect it. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A2.13 To fulfil our pre-disclosure duty, we may share a copy of your response with the relevant government department before we publish it on our website.

A2.14 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's intellectual property rights are explained further in our Terms of Use.

Next steps

A2.15 Following this consultation period, Ofcom plans to publish an update by Q4 2023/24.

A2.16 If you wish, you can register to receive mail updates alerting you to new Ofcom publications.

Ofcom's consultation processes

A2.17 Ofcom aims to make responding to a consultation as easy as possible. For more information, please see our consultation principles in annex 3.

A2.18 If you have any comments or suggestions on how we manage our consultations, please email us at consult@ofcom.org.uk. We particularly welcome ideas on how Ofcom could more effectively seek the views of groups or individuals, such as small businesses and residential consumers, who are less likely to give their opinions through a formal consultation.

A2.19 If you would like to discuss our consultation processes more generally, please email us at corporationsecretary@ofcom.org.uk, or write to:

Corporation Secretary
Ofcom
Riverside House
2a Southwark Bridge Road
London SE1 9HA

A3. Ofcom's consultation principles

Ofcom has seven principles that it follows for every public written consultation:

Before the consultation

A3.1 Wherever possible, we will hold informal talks with people and organisations before announcing a big consultation, to find out whether we are thinking along the right lines. If we do not have enough time to do this, we will hold an open meeting to explain our proposals, shortly after announcing the consultation.

During the consultation

A3.2 We will be clear about whom we are consulting, why, on what questions and for how long.

A3.3 We will make the consultation document as short and simple as possible, with an overview of no more than two pages. We will try to make it as easy as possible for people to give us a written response.

A3.4 We will consult for up to ten weeks, depending on the potential impact of our proposals.

A3.5 A person within Ofcom will be in charge of making sure we follow our own guidelines and aim to reach the largest possible number of people and organisations who may be interested in the outcome of our decisions. Ofcom's Consultation Champion is the main person to contact if you have views on the way we run our consultations.

A3.6 If we are not able to follow any of these seven principles, we will explain why.

After the consultation

A3.7 We think it is important that everyone who is interested in an issue can see other people's views, so we usually publish the responses on our website at regular intervals during and after the consultation period. After the consultation we will make our decisions and publish a statement explaining what we are going to do, and why, showing how respondents' views helped to shape these decisions.

A4. Consultation coversheet

BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

Please tick below what part of your response you consider is confidential, giving your reasons why

Nothing

Name/contact details/job title

Whole response

Organisation

Part of the response

If there is no separate annex, which parts? ____

____

If you want part of your response, your name or your organisation not to be published, can Ofcom still publish a reference to the contents of your response (including, for any confidential parts, a general summary that does not disclose the specific information or enable you to be identified)?

DECLARATION

I confirm that the correspondence supplied with this cover sheet is a formal consultation response that Ofcom can publish. However, in supplying this response, I understand that Ofcom may need to publish all responses, including those which are marked as confidential, in order to meet legal obligations. If I have sent my response by email, Ofcom can disregard any standard e-mail text about not disclosing email contents and attachments.

Ofcom aims to publish responses at regular intervals during and after the consultation period. If your response is non-confidential (in whole or in part), and you would prefer us to publish your response only once the consultation has ended, please tick here.

Name Signed (if hard copy)

A5. List of CFI questions

A5.1 We invite responses to the following questions we have asked in this CFI:

Question 1: Have we correctly identified the key changes in the utilities sector that could lead to additional spectrum requirements?

Question 2: What alternative communication solutions might play a role in meeting the future operational communication needs of the utilities sector, alongside or instead of additional spectrum for a private network?

Question 3: Are there any other spectrum bands we should consider for use by utilities?

Question 4: Do you have any comments on the three bandwidths we have considered that might be necessary to support a private network for utilities? Please reference our capacity analysis in annex 7 where relevant.

Question 5: Do you have any comments on our approach to examining each potential candidate spectrum band, including the factors relevant to assessing suitability, and the capacity and coverage analysis provided in annexes 7 and 8?

Question 6: Do you have any comments on our overview of the 400 MHz band in NI? Please consider the specific factors we have discussed in your response.

Question 7: Do you have any comments on our overview of the 450 MHz band in GB and NI? Please consider the specific factors we have discussed (including the coexistence analysis in annex 9) in your response.

Question 8: Do you consider that changes in the spectrum environment for the 450 MHz band mean that there is a case for re-examining whether this band should be reconfigured in the UK to align with the harmonised band plan?

Question 9: Do you have any comments on our overview of the 700 MHz band in GB and NI? Please consider the specific factors we have discussed in your response.

Question 10: Do you have any comments on our overview of the 800/900 MHz band in NI? Please consider the specific factors we have discussed in your response.

Question 11: Do you have any comments on our overview of the 1900 MHz band in GB and NI? Please consider the specific factors we have discussed in your response.

Question 12: Which band(s) do you consider we should examine further with a view to developing consultation proposals to enable their use in a private network, if this were needed? Please reference the factors we have considered where appropriate and provide separate answers for GB and NI if relevant.

A6. Relationship to work of other bodies with a utilities remit

A6.1 While Ofcom has the role to ensure that spectrum is used optimally across the UK as a whole, other bodies have responsibilities for policies and regulations affecting the utilities sector, including those influencing its future communication requirements and investment in communication networks and services. There are different levels of devolution for energy and water matters in each part of the UK, so the bodies differ in different parts of the UK, as set out below.

A6.2 **DSIT** is the government department responsible for spectrum policy. DSIT play an important role in cross-government coordination on spectrum matters, including for NI.

Energy policy

A6.3 The **Department for Energy Security and Net Zero** (DESNZ) owns energy policy more widely across the UK and its priorities include delivering security of energy supply, achieving net zero carbon dioxide emissions by 2050[87], keeping consumer bills low and seizing the opportunities of net zero to lead the world in new green industries. It is currently undertaking a technical evaluation project looking at the technical viability and financial costs of a range of communication options, supporting the use cases for the energy sector as it transitions to net zero, including the potential requirement for a private network.

- In NI, energy policy is devolved to the NI Executive, and the **Department for the Economy** (DfE) is responsible for NI's energy strategy[88].
- In Scotland, the **Energy and Climate Change Directorate** has responsibility for some devolved energy matters.

A6.4 **Ofgem** is the energy regulator for GB (for gas and electricity), and in NI the **Utility Regulator** is responsible for regulating the electricity, gas, water and sewerage industries. Where there is a need for the energy sector to invest in new infrastructure, i.e. communication infrastructure agreed by government (DESNZ in GB and DfE in NI), then these regulators have a role to ensure the efficiency of any costs incurred and to determine how those costs are recovered by energy companies through price controls.

- In NI, the Utility Regulator has said that Northern Ireland Energy (NIE) Network's investment plan for the "RP7" price control review (covering 1 April 2025 to 31 March 2031) should include the delivery of communication networks to support system monitoring, control and data acquisition[89]. We understand this plan was submitted in

[87] In Scotland, the net zero target is 2045.
[88] Energy strategy action plan 2023
[89] See "System monitoring, control and data acquisition" in NIE networks RP7 price control: our approach July 2022

March 2023 and that the Utility Regulator expects to publish a draft determination on RP7 in November 2023.

- In GB, Ofgem set the RIIO-ED2 price control[90] for DNOs running from 1 April 2023 to 31 March 2028. The price control can be adjusted through a re-opener mechanism to allow for changing circumstances during the price control period. This includes a "digitalisation re-opener"[91] which we understand could be used for additional investment in telecoms networks by the DNOs.

Water policy

A6.5 The responsibility for the water sector in the UK is devolved. Overall responsibility rests with the **Department for Environment, Food and Rural Affairs** (Defra) in England, the **Energy and Climate Change Directorate** in Scotland, the **Department for Climate Change** in Wales, and **Department for Infrastructure** in NI.

A6.6 The relevant economic regulatory bodies are **Ofwat** (the Water Services Regulation Authority) for the water and sewerage sectors in England and Wales, and the **Water Industry Commission Scotland** (with the **Utility Regulator** also performing this function in NI). As discussed earlier in this CFI, we understand that the water industry in GB is not currently seeking access to new spectrum to meet its operational communication needs, so discussions with these bodies are yet to take place.

[90] RIIO-ED2 sets the outputs that the 14 electricity DNOs need to deliver for their consumers and the associated revenues they are allowed to collect for the five-year period from 1 April 2023 to 31 March 2028.
[91] Ofgem Re-opener guidance and application requirements document, February 2023

A7. Spectrum capacity scenarios model

A7.1 This annex explains how we have calculated the spectrum capacity scenarios for a utilities network using a range of bandwidths, and is structured as follows:

- a high level description of the model we used;
- the parameters for our calculations, including the capacity of a base station sector, the services considered and data rates assumptions, and our assumptions on spectral efficiency; and
- the results of our analysis, and how we are interpreting them.

Description of the model

A7.2 We have used the following equation to calculate the number of communication services which could be supported by a single base station sector.:

Equation 1: Spectrum capacity model

$$Number\ of\ services = \sum \frac{Spectrum\ \times Spectral\ efficiency}{Service\ required\ data\ rate}$$

where

Spectrum	The spectrum available to support communication services in hertz (Hz)
Service required data rate	The data rate required to support communication services in bits per second (bps)
Number of services	The number of communication services that can be supported
Spectral efficiency	The maximum data rate that can be carried in one hertz, in bits per second per hertz (bps/Hz)
Σ	The sum of the number of communication services that can be supported for each type of communication service

Uplink capacity calculations and bandwidth scenarios

A7.3 We considered the following three bandwidths for uplink capacity calculations which could be supported in the potential candidate spectrum bands identified in this CFI. We chose a range of bandwidths that are indicative of those that could be used by a utilities network and are also supported by broadband technologies including 4G/LTE:

- **1.4 MHz**: for a 2x1.4 MHz FDD spectrum configuration
- **3 MHz**: for a 2x3 MHz FDD configuration. This could also be broadly equivalent to a 1x5 MHz TDD configuration with an uplink dominant frame structure.
- **5 MHz:** for a 2x5 MHz FDD configuration. This could also be broadly equivalent to a 1 x 10 MHz TDD configuration.

A7.4 We calculate the uplink capacity for each bandwidth scenario per base station sector using equation 2 below. *Spectrum* and *spectral efficiency* are as defined in equation 1 and *uplink capacity* refers to the capacity of a single base station sector in bps.

Equation 2: Uplink capacity

$$Uplink\ capacity = Spectrum \times\ Spectral\ efficiency$$

Services and data rate assumptions

A7.5 We considered three types of services that might be supported by a utilities network:

- data communications for monitoring and control of infrastructure;
- voice calls, for example to support communications with the utilities mobile workforce; and
- video streams, for example to support video calls or remote CCTV monitoring of key sites.

A7.6 We considered a range of data rates that might be needed to support each service. The data rate range assumptions (in bits per second (bps) or kilobits per second (kbps)) are set out in table A7.1 below, with sources where available, along with considering whether the assumption is a peak or average.

Table A7.1: Data rate assumptions for example services

Example service	Data rate range	Notes
Data monitoring and control	600 to 1,280 bps	The higher number in the range is from JRC's WPD Next generation wireless telecoms analysis report, where 25 measurements of 6144 bits[92] each are averaged over 120 seconds = 1280 bps. The lower number in the range is based on our own judgement, considering lower resolution analogue measurements.[93] Both numbers are average data rate requirements which assume that packet transmissions from separate terminals can be scheduled perfectly and are tolerant to a few milliseconds of delay.
Voice calls	8 to 32 kbps	We have used 8 kbps (lower quality) and 32 kbps (higher quality) as representative of the bit rate range for speech codecs.[94] As it is unlikely that voice calls will be in continuous use 24 hours a day, these date rate requirements are peak data rates for concurrent calls.

[92] JRC base the 6144 bits on 1024 bits (or 128 bytes) per analogue measurement, with an extra allowance for encoding (2x), security (2x) and digital measurements (1.5x).
[93] We derived our value considering 25 measurements of 2880 bits each over 120 seconds = 600 bps; where 2880 bits is based on 20 measurement parameters of 16 bits each (320 bits) plus a 20 byte IP header (160 bits, since 1 byte = 8 bits) which adds up to 480 bits, that is then multiplied by six for encoding, security and other overheads i.e. 2880 bits in total.
[94] For example, 3GPP's enhanced voice services (EVS) codec ranges from 5.9 to 128 kbps depending on the audio quality desired and bandwidth available (see ETSI EVS codecs)

Example service	Data rate range	Notes
Video streams	400 to 1,000 kbps	We consider that 400 to 1,000 kbps[95] could be appropriate for most video streaming applications like video calling or CCTV. We note that the data rates may be higher or lower than the range we have indicated for some specialist video streaming applications.[96] For video calls these are peak rates, assuming that video calls will not be used continuously. For CCTV which continuously streams at mainstream[97] quality, these data rate requirements are average data rates because the video stream will be always required.[98]

Spectral efficiency assumptions

A7.7 We understand that the data traffic flow for utilities is likely to be greater in the uplink than the downlink because the use cases typically continuously stream data to a central monitoring location. We have considered 3GPP technical report 37.910 which gives an uplink data rate of 3.36 bps/Hz (average) and 0.07 bps/Hz (5th percentile[99]) LTE FDD in a rural, low mobility, large cell configuration with 10 MHz bandwidth.[100]

A7.8 Taking this large potential range of spectral efficiencies into account, we have considered that a utilities network might be sparser (i.e. deploying fewer, larger cells) than a conventional mobile network.[101] This means that there could be a large number of service connections, for example electricity substations, at the edges of cells. We have therefore conservatively assumed an average uplink spectral efficiency of 0.4 bps/Hz across the cell i.e. closer to the 0.07 bps/Hz 5th percentile figure than the 3.36 bps/Hz average figure.

Results

A7.9 We have used our model to consider the uplink capacity of a base station sector and the number of services that could be supported by a sector in our “central case”. We have then

[95] For example, 480p video using the H264 video codec requires around 1,000 kbps, while 240p (H264) video requires around 400 kbps.

[96] For example, 8K video might require 8,000 kbps, a CCTV substream might only require 200 kbps and a “talking heads” video conference call might require less than 150 kbps (see https://www.cctvcameraworld.com/watching-security-cameras-slow-internet-connection/ and Ultra-low bitrate compression of talking-head videos via text).

[97] The mainstream is the full high definition resolution video stream that a camera can produce. The substream is a lower resolution stream that can be used for fluid remote viewing or a low overhead continuous stream for recording.

[98] When considering CCTV that only streams at mainstream quality when motion is detected or uses some other trigger for mainstream quality streaming then these data rate requirements are peak data rates for concurrent video streams.

[99] The cell edge user spectral efficiency is defined as 5% point of the cumulative distribution function (CDF) of the normalised user throughput.

[100] 3GPP technical specification 37.910, see table 5.4.2.3.3-2

[101] JRC’s report assumes that base stations might have a coverage radius of 10 km (see page 11). This is larger than the cells typically used in public mobile networks, for example, 3GPP’s low mobility, large cell scenario in 3GPP TS 37.910 (see section 5.4) assumes a 6 km inter-site distance.

examined the capacity which might be available to edge-of-cell users in very large cells and also the capacity of a cell which is in an area where a high capacity is required.

Central case results

A7.10 We present our results for the central case considering that each cell might need to support several hundreds of data terminals[102], several concurrent voice calls with any remaining capacity available for video. We considered this for a range of possible data rates and present our results below in Table A7.2 and Figures A7.1 and A7.2.

Table A7.2: Number of services that could be supported by a base station sector

Example service	Lower service data rate requirement assumptions for each bandwidth			Higher service data rate requirement assumptions for each bandwidth		
Data rate requirements	**Data: 0.6kbps** **Voice: 8 kbps** **Video: 400 kbps**			**Data: 1.28 kbps** **Voice: 32 kbps** **Video: 1000 kbps**		
Bandwidth (*MHz*)	**1.4**	**3**	**5**	**1.4**	**3**	**5**
Sector Capacity (*Mbps*)	**0.56**	**1.2**	**2**	**0.56**	**1.2**	**2**
Data monitoring and control ***No. of connections***	600	800	800	312	687	531
Voice calls ***No. of concurrent transmissions***	25	40	40	5	10	10
Video streams ***No. of concurrent transmissions***	0	1	3	0	0	1

[102] From JRC's report, we calculated an average 270 substations could be covered by each base station sector in the south west and midlands network that JRC modelled. We calculated this from tables 2.3 and 2.4: 64,683 total substations covered by 242 total sectors is an average of 267 substations per sector.

Figure 7.1: Number of services that could be supported by a base station sector (lower service data rate requirement)

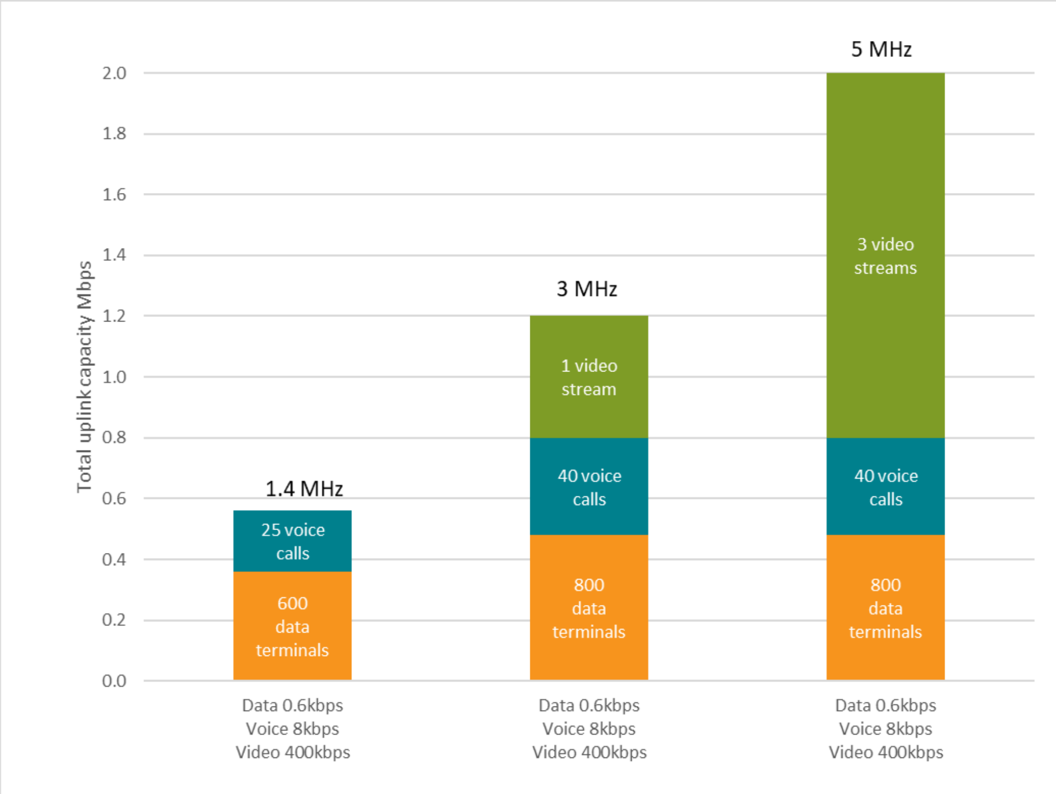
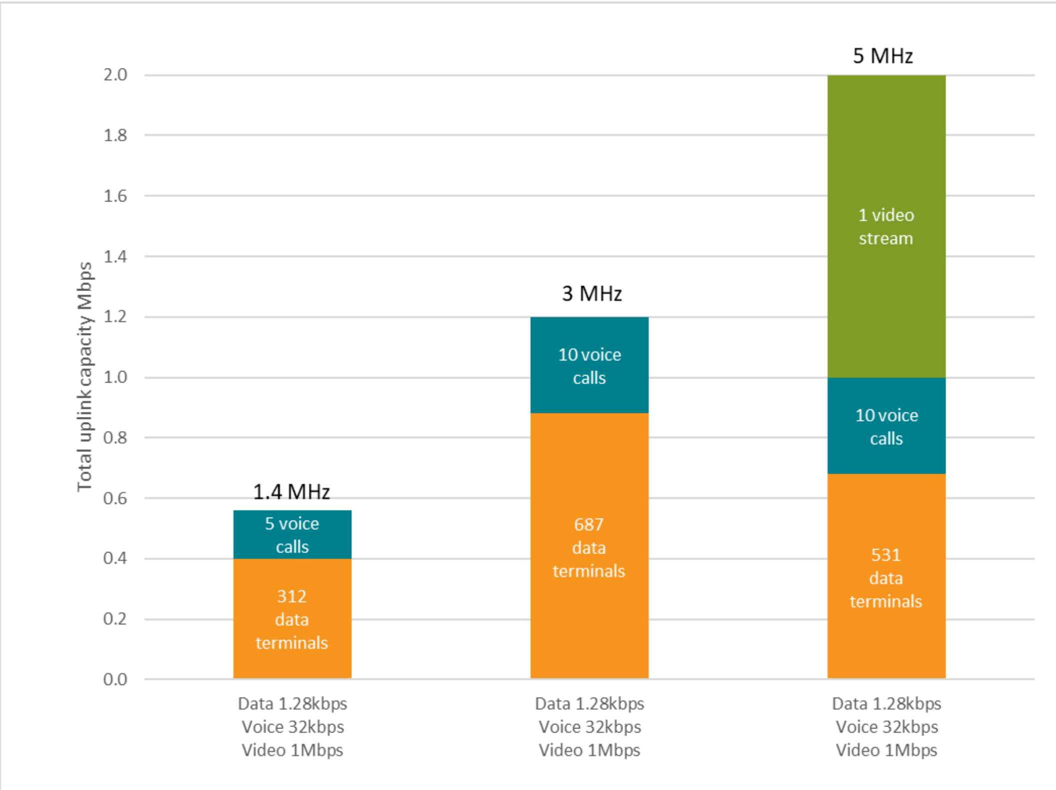


Figure 7.2: Number of services that could be supported by a base station sector (higher service data rate requirement)



Further uplink capacity scenarios

A7.11 Uplink spectral efficiency is the value which has the greatest potential variability in our uplink capacity model. To make sure we have taken into this account, we have considered two scenarios where the uplink spectral efficiency is likely to vary from the central case we have considered above. Uplink spectral efficiency may be lower than in our central case when serving terminals which are at the edge-of-cell in very large cells and uplink spectral efficiency may be higher when a network is carefully planned to provide greater capacity in an area.

Planning for edge-of-cell services

A7.12 Some services, particularly mobile services, can require a minimum uplink data rate in the whole area covered by a cell, including at the cell edge where the uplink signal can be difficult for the base station to receive. We have therefore considered which example services might be supported right to the cell edge.

A7.13 We consider that 0.07 bps/Hz is relevant for cell-edge users because this is the 5th percentile spectral efficiency figure for large cells as discussed above. We consider the extent to which a single stream for each example service could be supported at this spectral efficiency and found the following results for spectrum requirements (as summarised in table A7.3 below):

- An edge-of-cell data terminal could require 0.018 MHz of spectrum, which can be supported in all three bandwidths we are considering (i.e. 1.4 to 5 MHz).
- Similarly, for an edge-of-cell high quality voice call, the spectrum required, 0.457 MHz, is within the range of all of the bandwidths we are considering.
- For an edge-of-cell video stream, the uplink data rate required (5.7 to 14.3 MHz) exceeds the uplink capacity available in all three of the bandwidth scenarios we are considering.

Table A7.3: Spectrum required to support one stream for each example service at the cell edge

Example service	Data rate (kbps)	5th percentile spectral efficiency (bps/Hz)	Spectrum required (MHz)
Data terminal	1.28	0.07	0.018
Higher quality voice	32	0.07	0.457
Lower quality video	400	0.07	5.70
Higher quality video	1000	0.07	14.30

A7.14 Our results show that data terminals and voice calls could be supported at the edge-of-cell for all three bandwidth scenarios. However it might be difficult for a private network to guarantee coverage for video streaming across the whole of a large cell. This might be acceptable for a CCTV service because it may be possible to design the network so that sites requiring CCTV are never at the edge-of-cell. Video calling is a mobile service and field teams might require video calling capability anywhere in a cell, including at locations which are at the edge-of-cell where it could be hard to guarantee a video service.

Planning for high capacity areas

A7.15 Wireless networks can be planned to provide greater uplink capacity in areas where such capacity is needed. This can be achieved by increasing the density of base station deployments in an area or through careful planning of base station locations so that high data requirement services, like video for CCTV, are not needed at the edge-of-cell where uplink spectral efficiency would be at its lowest. We have used 3.36 bps/Hz for average uplink spectral efficiency (see *Spectral Efficiency Assumptions*) which we consider is relevant for areas where a high capacity is required.

A7.16 Assuming that video streaming dominates the data requirement, because video streaming requires a data capacity which is much greater than that of data terminals or voice calls, the number of concurrent video streams that could be carried under the high capacity areas scenario are shown in table A7.4 below. As a comparison, we added the number of concurrent video streams that could be supported in our central case scenario (i.e. uplink spectral efficiency = 0.4 bps/Hz), also assuming that all of the capacity available is used to provide video services. We observe that careful planning of base station locations could allow for high data requirement services like video streaming to be provided to several sites across a limited area.

Table A7.4: Number of video streams that could be supported by a base station sector

Capacity scenario for concurrent video streams	Lower service data rate requirement assumptions for each bandwidth scenario			Higher service data rate requirement assumptions for each bandwidth scenario		
	1.4 MHz	3 MHz	5 MHz	1.4 MHz	3 MHz	5 MHz
Uplink capacity (*Mbps*)	4.7	10.1	16.8	4.7	10.1	16.8
High capacity areas *No. concurrent video streams*	11	25	42	4	10	16
Central case results *No. concurrent video streams*	1	3	5	0	1	2

Study limitations

A7.17 We have modelled the uplink capacity of a single base station sector. An area capacity analysis would require a detailed planning exercise to understand whether the network capacity was sufficient to support the communication services required by users across a wide area.

A7.18 Future technology developments may help reduce the data rate requirements of services (e.g. edge computing reducing the data transmitted by using intelligent sensors to only send useful processed information rather than all the data).

Interpreting our analysis

A7.19 The results show that a range of monitoring and control of data, voice calls and video streams can be accommodated in 1.4, 3 and 5 MHz of spectrum. Data and voice services can be supported across large cells considering all three bandwidths, but video may be harder to support everywhere.

A7.20 For an edge-of-cell video stream, the uplink data rate required exceeds the uplink capacity available in all of the spectrum scenarios we have considered. This means that it might be difficult for a dedicated utilities network to guarantee video streaming coverage across the whole of each cell. This might be acceptable for CCTV which is installed in a fixed locations and so a dedicated network can be designed so that sites which require CCTV are never at the edge-of-cell. However, it might be more difficult to guarantee video calling across the coverage area of a cell because field teams might need to work at locations which are at the edge-of-cell.

A8. Coverage analysis

A8.1 This annex considers the coverage that could be provided using three of our potential candidate spectrum bands, and is set out as follows:

- a description of the methodology we used;
- a coverage area analysis comparing the area and number of electricity substations served by a single base station at different frequency bands and in different terrain; and
- a sensitivity analysis to examine the impact on coverage by: (a) increasing terminal height; and (b) using higher power in the 700 MHz band.

Methodology

A8.2 We used coverage prediction software HTZ Communications to consider the coverage that could be provided using three frequencies centred on: 450 MHz, 700 MHz and 1900 MHz. We selected these frequencies because we consider they are representative of all the potential candidate spectrum bands considered in this CFI.[103] The parameters used in our coverage predictions are shown in table A8.1 below.

Table A8.1: Parameters set in coverage prediction software (HTZ Communications)

Parameter	Values
Transmit centre frequency (MHz)	450 / 700 / 1900
EIRP (dBm)	50
Height of base station (m)	30
Height of terminal (m)	2
Antenna pattern	Omni-directional
Propagation model	ITU-R 1812-6
RSRP threshold[104] (dBm)	-115
Environmental noise (dB)	7 (450 MHz) 3 (700 MHz) 0 (1900 MHz)

A8.3 We have taken the EIRP, height of base station and height of receiver s from JRC's WPD Next generation wireless telecoms analysis report. We also assume that coverage is

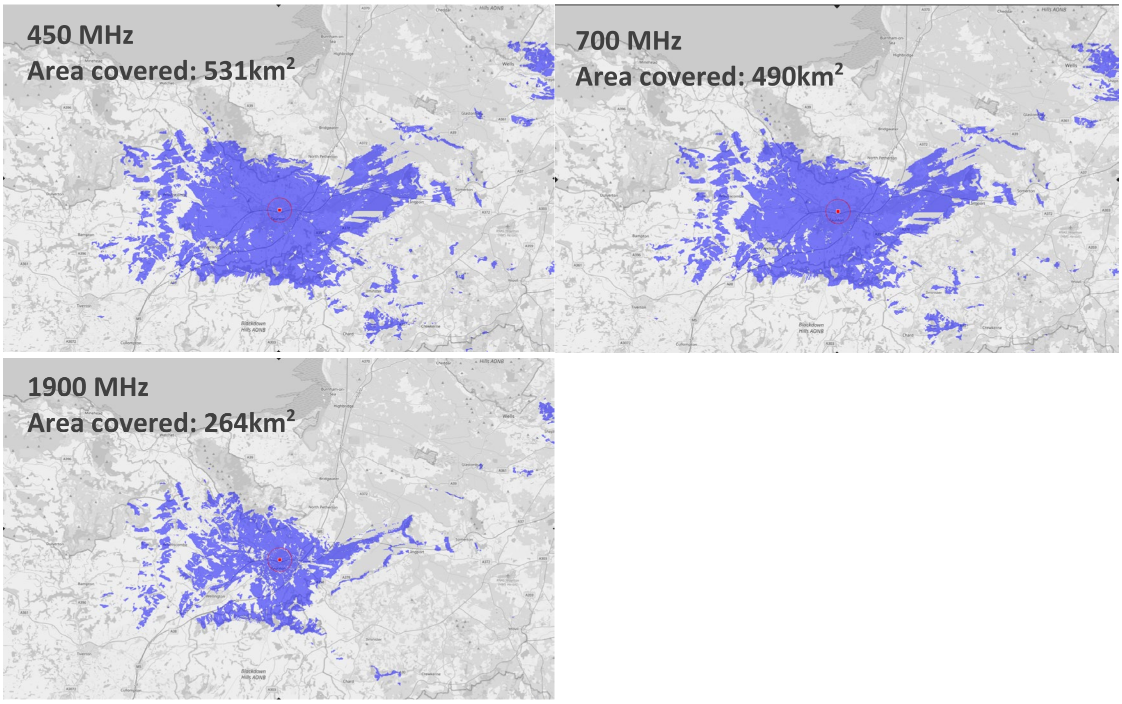
[103] For example, coverage modelled at 450 MHz is also likely to be representative of the coverage which can be achieved at 400 MHz because the frequency separation between these two bands is small. Similarly, coverage modelled at 700 MHz is likely to be similar to the coverage which can be achieved at 800/900 MHz.
[104] Reference signal received power threshold, which determines the area covered by an LTE cell site for a given minimum service.

reciprocal and that a terminal which is in the coverage range of a base station downlink is also in the uplink coverage range. The locations of the base stations and substations used in this study were obtained from National Grid's open datasets (April 2023)[105]. The locations of base stations used in this study were found by looking at the primary substations in each area and considering sites which might give the best coverage (e.g. those primary substations at the top of hills).

Coverage results

A8.4 Figures A8.1 to A8.3 illustrate the coverage maps at 450 MHz, 700 MHz and 1900 MHz bands in different terrains: urban, hilly and flat terrain respectively, with terminal height of 2m. The areas in blue represent the predicted coverage area and the red dots show the location of the base station.

Figure A8.1: Comparison of coverage in urban terrain (base station location: Taunton, Somerset)



[105] Primary substation location (easting / northings) and Distribution substation location (easting / northings)

Figure A8.2: Comparison of coverage in hilly terrain (base station location: near Ebbw Vale, Gwent)

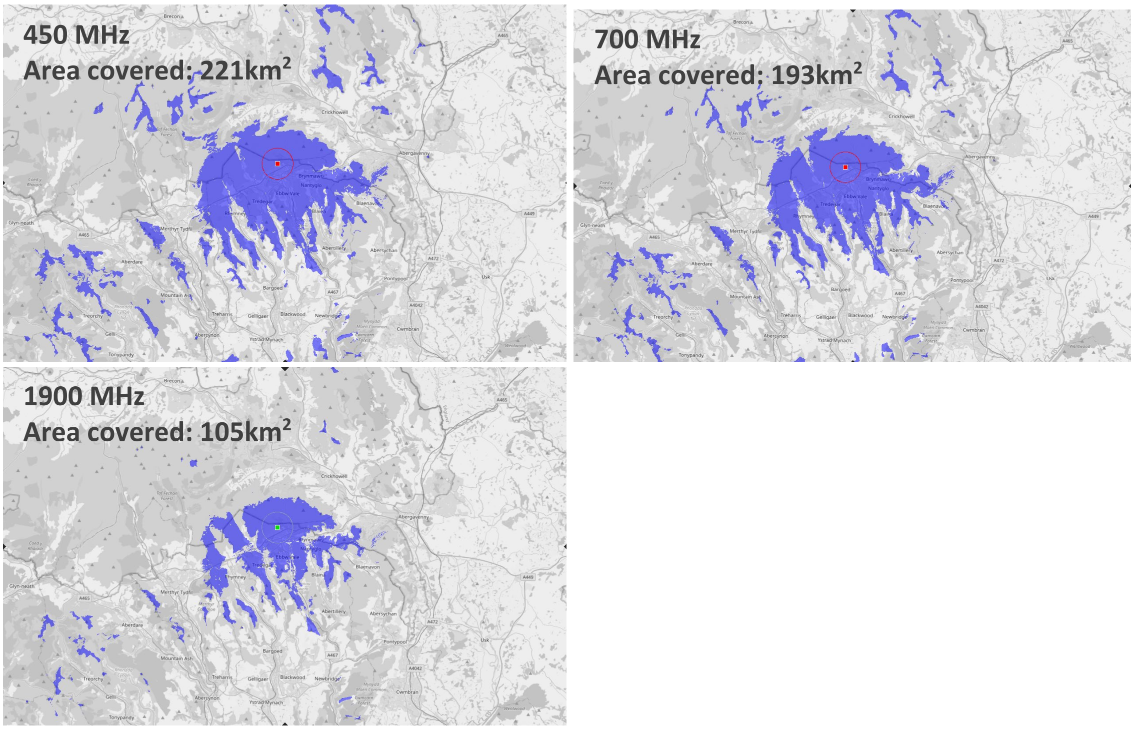
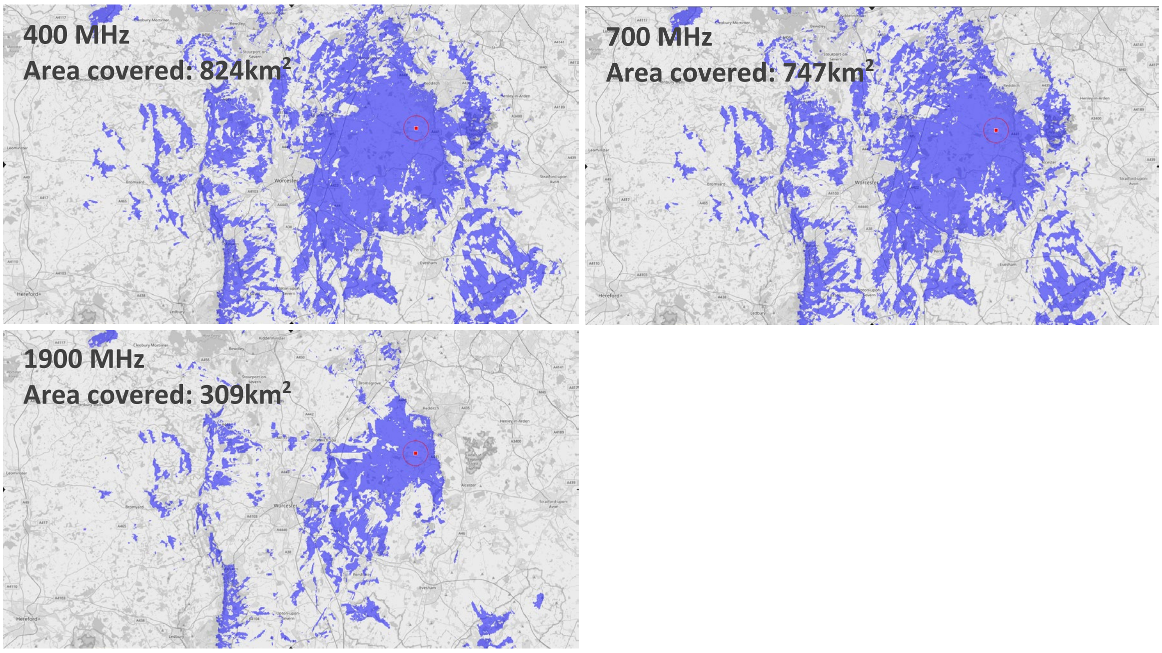


Figure A8.3: Comparison of coverage in flat terrain (base station location: south of Birmingham)



A8.5 Table A8.2 compares the coverage area and the number of substations served at 450 MHz, 700 MHz and 1900 MHz in different terrain types (urban, hilly and flat). This table also shows the percentage of coverage area at 700 MHz and 1900 MHz as compared to 450 MHz.

Table A8.2: Comparison of coverage area and number of substations served at each frequency, by terrain and showing % coverage area compared to 450 MHz

Frequency (MHz)	Urban terrain		Hilly terrain		Flat terrain	
	Coverage area (km^2)	No. of substations	Coverage area (km^2)	No. of substations	Coverage area (km^2)	No. of substations
	(showing % of coverage area compared to 450 MHz)					
450	531	2,014	221	421	824	3,326
700	490 (92%)	1,873 (93%)	193 (87%)	386 (92%)	747 (91%)	3,203 (96%)
1900	264 (50%)	1,109 (55%)	105 (48%)	207 (49%)	309 (38%)	1,235 (37%)

Sensitivity analysis – increased terminal height

A8.6 To understand the effect of terminal height on coverage of substations, we increased the height of terminals from 2m to 6m while keeping all other parameters unchanged. The comparison of coverage and improvement in percentage compared to a 2m height terminal are shown in table A8.3.

Table A8.3: Comparison of coverage area and number of substations served at each frequency and showing improvement from increased terminal height (2m to 6m)

Freq. (MHz)	Terminal height	Urban terrain		Hilly terrain		Flat terrain	
		Coverage area (km^2)	No. of substations	Coverage area (km^2)	No. of substations	Coverage area (km^2)	No. of substations
		(showing % improvement as compared to 2m terminal)					
450	**2m**	531	2,014	221	421	824	3,326
	6m	626 (18%)	2,324 (15%)	245 (11%)	458 (9%)	1,035 (26%)	4,252 (28%)
700	**2m**	490	1,873	193	386	747	3,203
	6m	576 (18%)	2,181 (16%)	213 (10%)	416 (8%)	946 (27%)	3,916 (22%)
1900	**2m**	264	1,109	105	207	309	1,235
	6m	330 (25%)	1,364 (23%)	122 (16%)	266 (29%)	408 (32%)	1,697 (37%)

Sensitivity analysis – higher base station EIRP at 700 MHz

A8.7 To understand the effect of base station power on coverage of substations, we increased the base station power from 50 dBm to 53 dBm EIRP at 700 MHz while keeping all other parameters unchanged. The comparison of the coverage and the improvement in percentage are shown in table A8.4.

Table A8.4: Comparison of coverage area and number of substations served at 700 MHz and showing the coverage improvement from higher base station power (50 dBm to 53 dBm EIRP)

EIRP (dBm)	Urban terrain		Hilly terrain		Flat terrain	
	Coverage area (km^2)	No. of substations	Coverage area (km^2)	No. of substations	Coverage area (km^2)	No. of substations
	(showing % improvement as compared to 50 dBm EIRP)					
50	490	1,873	193	386	747	3,203
53	616 (26%)	2,233 (19%)	240 (24%)	443 (15%)	999 (34%)	3,997 (25%)

A8.8 To see how much the coverage gap can be reduced between 450 MHz and 700 MHz, we increased the power at 700 MHz by 3 dB to compare the number of substations covered by a base station with EIRP of 50 dBm at 450 MHz and base station with EIRP of 53 dBm at 700 MHz. Our results in table A8.5, show that more substations were covered by a base station with an EIRP of 53 dBm at 700 MHz as compared to a base station with an EIRP of 50 dBm at 450 MHz.

Table A8.5: Comparison of number of substations served comparing a 50 dBm EIRP base station at 450 MHz with a 53 dBm EIRP base station at 700 MHz

Frequency (MHz)	EIRP (dBm)	Urban terrain	Hilly terrain	Flat terrain
		No. of substations (showing % improvement as compared to 450 MHz @ 50 dBm EIRP)		
450	50	2,014	421	3,326
700	53	2,233 (10.9%)	443 (5.2%)	3,997 (20.2%)

Study limitations

A8.9 The results we have illustrated here are based on the coverage of a single base station site and so it may not be possible to extrapolate them directly to the coverage of a private network over a wide area. A detailed cell planning and dimensioning exercise would be required to draw broader conclusions around how many base stations might be required for nationwide coverage considering each frequency band.

Interpreting our analysis

A8.10 As shown by our analysis as set out in this annex, the coverage area and the number of substations that a base station can serve varies a lot in different terrains and that terrain can have a greater impact on coverage than the frequency used to provide coverage (see table A8.2).

A8.11 By increasing the transmit power of a 700 MHz base station by 3 dB, we found that coverage at 700 MHz was greater than the lower power 450 MHz base station in all the types of terrain considered. We therefore infer that a 700 MHz base station transmitting with a power of 0 to 3 dB more than an equivalent 450 MHz base station could have broadly equivalent coverage to a 450 MHz base station. Higher base stations power at 700 MHz might only be possible if: terminal uplink coverage is not a constraining factor; and higher power base stations can coexist with other users.

A8.12 We found that the area that a base station using the 1900 MHz band was able to cover was around 40% of the area that the equivalent 450 MHz base station covers when in a flat area, but this increases to around 50% in a hilly area.[106] When compared with higher frequencies, lower frequencies improve coverage in hilly areas less than in flat areas because terrain blocks radio signals in hilly areas and the greater terrain diffraction that occurs at lower frequencies only partially mitigates this.

A8.13 We observed a significant improvement in the coverage area and the number of substations served when increasing the height of the terminal at each substation from 2m to 6m, especially in the 1900 MHz band (see table A8.3). This is because higher frequencies can be more attenuated by clutter than lower frequencies and the amount of clutter in the path of the wanted signal will tend to be reduced by installing terminals at a higher height. Installing terminals at a higher height might help to mitigate some of the reduction in coverage when comparing coverage at 1900 MHz with lower frequencies (i.e. 450 MHz or 700 MHz). It could therefore be beneficial to install terminals at a higher height at substations that are further away from a base station, however, we acknowledge that this may not be possible at all sites due to planning constraints.

[106] We have rounded the values in this interpretation from the more precise numbers given in the tables earlier in this annex to avoid giving a false sense of precision given that small changes in the base station parameters could change the calculated coverage by a few percentage points.

A9. Coexistence for adjacent spectrum users in the 450 MHz band

For incumbent narrowband users and a broadband private network

A9.1 In this annex we consider coexistence for introducing a new broadband private network in 450 MHz without the incumbent users vacating the band. It supports our view that additional base station filtering on the uplink and downlink of the broadband private network, in additional to frequency separation between the broadband private network and the narrowband incumbent users, may be necessary to mitigate the risk of interference.

A9.2 We consider that interference risks are likely to arise from:

- narrowband and broadband user equipment operating in adjacent blocks causing interference to one another; and
- narrowband and broadband base stations operating in adjacent blocks causing interference to one another.

A9.3 User equipment commonly operates at a lower power than base stations so the risk of interference will tend to be localised and might therefore be manageable, though this would need to be investigated further.

A9.4 Base station equipment for wide area coverage can transmit at high power and is commonly mounted on tall structures so there could be a significant risk of interference to other base stations receiving in adjacent spectrum across a wide area. The two interference cases that are likely to be relevant are:

- interference caused by **out-of-block emissions** from transmitters; and
- **receiver performance effects**, including blocking, overloading and receiver intermodulation, caused by high power transmissions in adjacent spectrum blocks.

A9.5 For both base station interference cases, we have considered the relevant standards to understand what additional technical conditions might be required to mitigate the risk of interference. We have not considered specific incumbent use cases, nor have we considered specific incumbent deployments. These may need to be considered in any future work because where and when equipment is used also impacts coexistence as well as the performance of the equipment itself.

A9.6 **Out-of-block emissions:** for narrowband services, these are typically low because out-of-block emissions tend to increase proportionally with in-block bandwidth.[107] The out-of-block emissions limits for broadband base stations are higher[108] and apply at a larger

[107] For example, in ECC Decision (19)02 the out-of-block emissions limits for narrowband systems (6.25 KHz to 200 kHz) is 60 dBc in the first and second adjacent channels (i.e. 12.5 to 400 kHz frequency separation) with spurious emissions limits applying at larger frequency separations.

[108] Considering the values in tables 8 and 9 in ECC Decision (19)02 and a transmitter bandwidth of 1.4 GHz, the out-of-block emissions limits in the first adjacent channel are between -45 and -55 dBc.

frequency separation[109] than those of narrowband base stations. We therefore consider that the dominant risk of interference by out-of-block emissions is likely to be from *broadband private network base stations to incumbent narrowband base stations* rather than the other way around.

A9.7 In order to mitigate such interference risks, maximum mean out-of-block EIRPs of -43 dBm/100 kHz may be needed to protect uplink frequencies.[110] This would mean that significant additional filtering of the out-of-block emissions from broadband base stations would be required over and above the limits set in the harmonised technical conditions.[111]

A9.8 **Receiver performance effects including blocking:** for adjacent channel selectivity and blocking, the limits are more stringent for incumbent narrowband users than for broadband systems.[112] ECC Report 240 also observed that extremely densely deployed narrowband networks may desensitise broadband base station receivers through receiver blocking and thereby reduce the uplink capacity of broadband networks if those base stations only implemented the minimum blocking requirements in the 3GPP standards.[113]

A9.9 We therefore consider that the dominant risk of interference by receiver performance effects including blocking is likely to be from *incumbent narrowband base stations to broadband private network base stations*. An important caveat is that this assessment assumes that narrowband incumbents all have as good selectivity as suggested by the harmonised technical conditions.

A9.10 In both of these base station interference cases, coexistence could be improved by:

- **additional filtering** on both the uplink and downlink of the broadband private network; and
- **frequency separation** between the narrowband incumbents and the new broadband private network.[114]

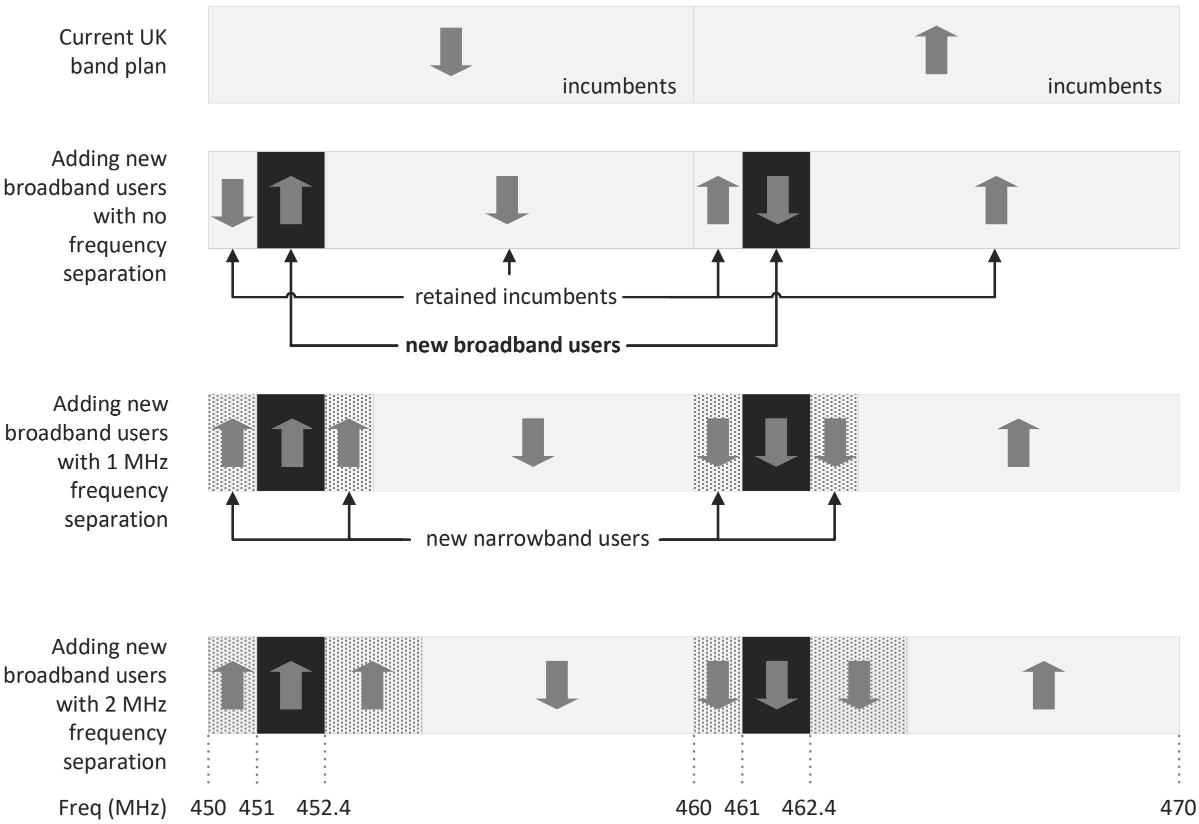
A9.11 We note that the density of base stations deployed for a new broadband private network may be relatively sparse[115] and this reduces the likelihood of deployment in the same area

[109] Out-of-block limits for the first adjacent channel for a 200 kHz carrier apply at a frequency separation of up to 200 kHz, however, the out-of-block emissions limits for the first adjacent channel for a 1.4 MHz carrier apply at a frequency separation of 1.4 MHz.
[110] See the notes to table 9 in ECC Decision (19)02. This is also the conclusion in paragraph 3 of ECC Report 240 which showed that the level of filtering necessary for the LTE downlink to coexist with narrowband incumbents is the same for the LTE uplink, i.e. the level of filtering provided by an LTE duplex filter. This report noted that this conclusion is valid when considering LTE400 user equipment transmitting up to 5 W (37 dBm).
[111] For example, for a 1.4 MHz carrier, the out-of-block emissions limit under the harmonised technical conditions are (-1 dBm / 100 kHz) at the block edge and (-11 dBm / 100 kHz) at 1.4 MHz frequency separation from the block edge. (table 9, ECC Decision (19)02). To reach out-of-block emissions levels of (-43 dBm / 100 kHz) to protect narrowband incumbent base stations in adjacent spectrum would therefore require 42 dB of additional filtering at the block edge or 32 dB of additional filtering at 1.4 MHz frequency separation from the block edge.
[112] For narrowband users, the limits from ECC Decision (19)02 are: **adjacent channel** = (-37 dBm) (see A1.6.1); and **blocking level** = (-27 dBm) (see A1.6.2). In addition, for broadband users, the limits from ETSI TS 136 104 V14.11.0 (2022-03) are: **adjacent channel selectivity** = (-52 dBm) (in table 7.5.1-3); and **narrowband blocking level** = (-49 dBm) (in table 7.5.1-1).
[113] Paragraph 3, ECC Report 240
[114] This is because practical filters require frequency separation to roll-off between the passband and the stopband.
[115] JRC's report assumes that base stations might have a coverage radius of 10 km (see page 11). This is larger than the cells typically used in public mobile networks, for example, 3GPP's low mobility, large cell scenario in 3GPP TS 37.910 (see section 5.4) assumes a 6 km inter-site distance.

as narrowband base stations which could improve coexistence. Furthermore, careful choice of base station sites could also help to improve coexistence (e.g. by ensuring that new broadband equipment is not co-located with incumbent narrowband equipment).[116]

A9.12 The amount of additional filtering and size of frequency separation would therefore require further study. To inform our initial view, we studied the roll-off characteristics of commercially available filters[117] and the magnitude of the additional filtering which might be required (see footnote 111). Taking this into account, we consider that a frequency separation of 0 to 2 MHz may be necessary in addition to the additional filtering requirement to enable coexistence. We illustrate the impact of a 0 to 2 MHz frequency separation for a 1.4 MHz private network in figure A9.1. Where a frequency separation is required, it may be possible use those frequencies for narrowband services using the harmonised band plan.[118]

Figure A9.1: Example options for configuring the 450 MHz band when introducing new 1.4 MHz broadband users using LTE band 72 (arrows indicate uplink ↑ and downlink ↓)



[116] JRC's report modelled coverage for utilities networks assuming that base stations could be deployed on existing WPD telecom sites rather than using commercial tower sites shared with other users (see page 7).
[117] Filters in 450 MHz can achieve 25-40 dB of isolation at a frequency offset of 1 MHz, and 45-70 dB of isolation at a frequency offset of 2 MHz (see duplexer bandpass 450-470 MHz; and integrated bandpass reject duplexer (370-512 MHz).
[118] ECC Decision 19(02) notes there was the potential for high power broadband signals to cause intermodulation distortion in narrowband receivers in adjacent spectrum. However, this decision does not conclude on the impact of this and notes that further study would be required to assess the impact on coexistence. In line with our spectrum strategy, we would expect narrowband receivers to be sufficiently resilient to broadband transmissions in adjacent spectrum.