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# Mobile phone repeaters

## A consultation on extending the range of mobile phone repeaters that can be used without a licence and on measures to improve information for consumers

Mobile Phone repeaters – Welsh overview

**CONSULTATION:**

Publication Date: 19 May 2021
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# 1. Overview

Mobile services have become an increasingly important part of our daily lives be it: keeping in contact with friends and family, using online services or conducting business. With this has come a growing expectation that mobile services will reliably work wherever we are.

Whilst mobile coverage continues to improve with investment in new mobile sites and better mobile technology, there are a particular set of challenges associated with achieving good indoor coverage. This is because mobile signal levels reduce as they enter buildings. There are also challenges associated with achieving good mobile coverage in sparsely populated rural areas where mobile base stations are generally more distant from the user and provide weaker and hence less reliable mobile signals.

One solution for those struggling to achieve good indoor coverage is the use of a mobile phone repeater. These typically amplify signals between a network operator's base station and a mobile phone and can therefore be used to enhance coverage in situations where the signal is otherwise weak.

In 2018, Ofcom made regulations to allow people and businesses to operate static mobile phone repeaters for indoor use on a licence-exempt basis, provided that they meet certain technical requirements. This included that the device only repeats the signal of one mobile network operator at any one time and, for this reason, we refer to these as 'single operator' repeaters. Our objective was to provide people with an option to improve mobile coverage in their own homes. We considered this would also help reduce the likelihood of people unwittingly purchasing unauthorised illegal repeaters which may cause undue interference to the mobile phone networks or other spectrum users.

In this document, we are considering whether there are any changes that Ofcom could make in order to provide people and businesses with greater options to improve mobile coverage in their homes and remove any unnecessary restrictions, as well as to provide more information to consumers regarding which devices are licence-exempt.

We do not address mobile phone repeaters for outdoor use in this consultation. The outdoor use of mobile phone repeaters remains unlawful unless supplied and operated under the control of a mobile network operator ("MNO") (under its Wireless Telegraphy Act licence).

We also do not consider mobile repeaters that are intended for use whilst in motion (such as, in a vehicle) in this consultation. Provided that they meet certain technical requirements, these are already licence-exempt.

## What we are proposing- in brief

We are proposing to extend the range of repeaters available for people to buy and install themselves without a licence. In particular, by allowing certain types of repeater ('provider-specific' and 'multi-operator' repeaters) that will operate on the frequencies of more than one mobile operator to be licence-exempt, provided that they meet our proposed technical requirements.

We are also seeking views regarding the value of Ofcom publishing a list of mobile phone repeaters that can be used without a licence on our website. We are proposing that a device only be listed on our website if it has been demonstrated (following testing by an accredited test house and in according with a voluntary testing standard produced by Ofcom) that it complies with the technical requirements of our licence exemption regime. This should help people identify static indoor mobile phone repeaters that can be legally used without the need for a licence.

**The overview section in this document is a simplified high-level summary only. The proposals we are consulting on and our reasoning are set out in the full document.**

We invite any comments on the proposals in this document by 5pm on **28 July 2021** and we expect to publish our conclusions in late 2021.

# 2. Background

2.1 Accessing the mobile network within their own home can be troublesome for some people, particularly if they live towards the edge of mobile network coverage. One potential solution to this problem is to use a device called a mobile phone repeater. These devices can help improve indoor coverage by boosting and retransmitting the available outdoor mobile signal indoors.

2.2 Typically, a repeater unit might be located in a window with a clear view to the base station. The unit will then either retransmit the outdoor mobile signal directly round the house/building or, in some cases, will relay the mobile signal to a separate unit deeper within the house/building from where it will be retransmitted (see Figure 1 below).

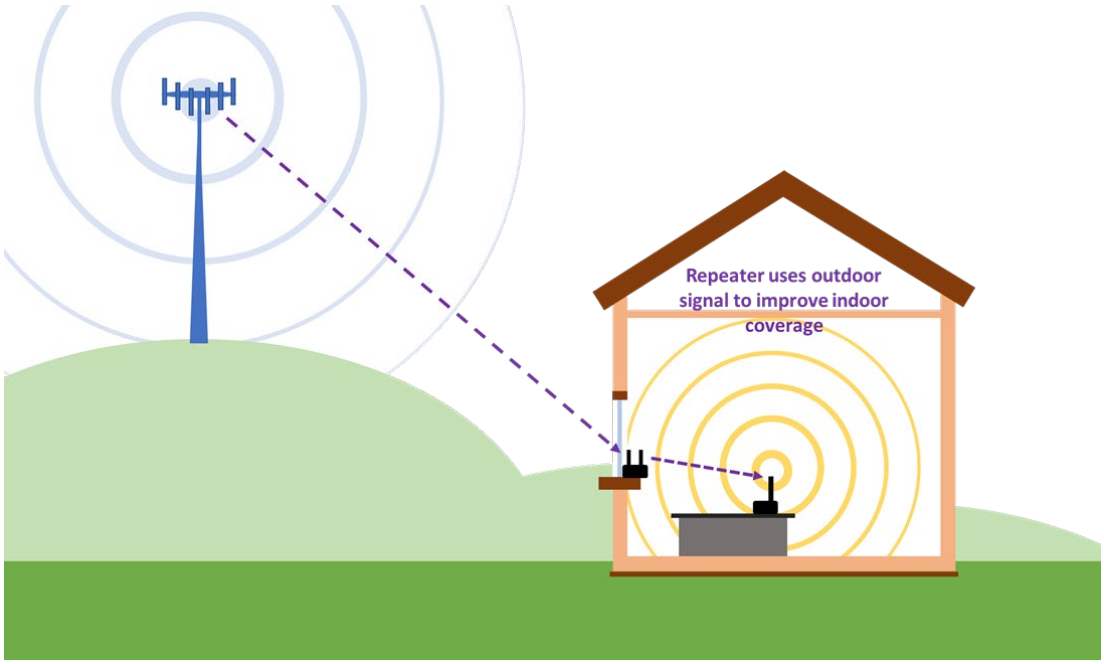


**Figure 1: Use of a mobile repeater to boots the mobile signal indoors**

2.3 Prior to 2018, the use of a mobile phone repeater was only authorised if supplied and operated under the control of a mobile network operator ("**MNO**") (under its Wireless Telegraphy Act licence). The use of consumer self-installed mobile phone repeaters was unlawful. In spite of this, such repeaters were sometimes used to address indoor mobile coverage needs of consumers and organisations (often without a real appreciation that the use of the device was unlawful).

2.4 In 2018, and as discussed in this section, we decided to authorise the use of certain mobile phone repeaters provided that they meet specific technical requirements. These requirements were intended to address the risk that mobile phone repeaters could otherwise cause harm to the MNO's networks or to other spectrum users in adjacent bands, and therefore to other consumers.

2.5 In this consultation, we are setting out our provisional thinking on whether there are any changes that Ofcom could make in order to provide people and businesses with greater options to improve mobile coverage in their homes[1] and remove any unnecessary restrictions, as well as to provide more information to consumers regarding which devices are licence-exempt.

2.6 Please note, we are not addressing mobile phone repeaters for outdoor use in this consultation. The outdoor use of mobile phone repeaters remains unlawful unless supplied and operated under the control of a MNO (under its Wireless Telegraphy Act licence).[2]

2.7 We are also not considering mobile repeaters that are intended for use whilst in motion (such as, in a vehicle) in this consultation. Provided that they meet certain technical requirements, these are already licence-exempt.[3]

2.8 In the remainder of this section, we explain: (a) the relevant legal framework; (b) the steps taken by Ofcom in 2018 in relation to static indoor mobile phone repeaters; and (c) why Ofcom is now revisiting this issue.

## Relevant legal framework

2.9 Ofcom's responsibilities for spectrum management are set out primarily in two Acts of Parliament which confer on us our specific functions, powers and duties: The Communications Act 2003 (the "**2003 Act"**) and the Wireless Telegraphy Act 2006 (the "**WT Act**"). Amongst our functions and powers are the making available of frequencies for use for particular purposes and the granting of rights of use of spectrum through wireless telegraphy licences and licence exemptions.

### The 2003 Act

2.10 Our principal duties under the 2003 Act, when carrying out our functions and exercising our powers, are to further the interests of citizens and consumers, where appropriate by promoting competition. In doing so, we are also required (among other things) to secure the optimal use of spectrum and the availability throughout the United Kingdom of a wide range of electronic communications services.

2.11 We must also have regard to: (i) the desirability of promoting competition in relevant markets; (ii) the desirability of encouraging investment and innovation in relevant markets; (iii) 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 (iv) the different interests of persons in the different parts of the United Kingdom, of the different

[1] Throughout the rest of this document, whenever we refer to 'repeaters' we mean 'static mobile phone repeaters for indoor use' unless explicitly stated otherwise.
[2] This is because we recognise that widespread use of downlink frequencies by mobile phone repeaters outdoors is likely to increase the risk of undue interference to the mobile networks.
[3] See, in particular, the Wireless Telegraphy (Mobile Repeater) (Exemption) Regulations 2018 (referred to in this document as the "**Exemption Regulations**") and the associated UK Interface Requirement 2102.2.

ethnic communities within the United Kingdom and of persons living in rural and in urban areas.

2.12 The 2003 Act also sets out certain regulatory principles which we must have regard to when performing our duties. Specifically, regulatory activities should be transparent, accountable, proportionate, consistent, and targeted only at cases in which action is needed.

## The WT Act

2.13 In carrying out our spectrum functions we have a duty under section 3 of the WT Act to have regard in particular to: (i) the extent to which the spectrum is available for use, or further use, for wireless telegraphy; (ii) the demand for use of that spectrum for wireless telegraphy; and (iii) the demand that is likely to arise in future for such use.

2.14 We also have a duty to have regard to the desirability of promoting: (i) the efficient management and use of the spectrum for wireless telegraphy; (ii) the economic and other benefits that may arise from the use of wireless telegraphy; (iii) the development of innovative services; and (iv) competition in the provision of electronic communications services.

2.15 Under section 8(1) of the WT Act, it is unlawful to establish or use a wireless telegraphy station or install or use wireless telegraphy apparatus except under and in accordance with a wireless telegraphy licence granted under the WT Act. However, under section 8(3), Ofcom has the power to make regulations exempting the establishment, installation or use of wireless telegraphy stations or wireless telegraphy apparatus from the licensing requirements either absolutely or subject to such terms, provisions and limitations as we may specify.

2.16 Ofcom may only approve regulations under section 8(3) within the limits set out in section 8(3B). In particular, the latter requires that section 8(3) exemptions must be:

- objectively justifiable in relation to the wireless telegraphy apparatus to which they relate;
- not such as to discriminate unduly against particular persons or against a particular description of persons;
- proportionate to what they are intended to achieve; and
- in relation to what they are intended to achieve, transparent.

2.17 Further to the above, under section 8(4), Ofcom has a duty to make regulations to exempt specific equipment from the requirement for a licence if its installation or use meets the requirements set out in section 8(5), namely that it is not likely to:

- involve undue interference with wireless telegraphy;
- have an adverse effect on technical quality of service;
- lead to inefficient use of the part of the electromagnetic spectrum available for wireless telegraphy;
- inhibit the development of effective arrangements for the sharing of frequencies;
- endanger safety of life;

- prejudice the promotion of social, regional or territorial cohesion; or
- prejudice the promotion of cultural and linguistic diversity and media pluralism.

## Radio Equipment Regulations

2.18 Radio equipment, including mobile phone repeaters, also has to comply with requirements derived from Directive 2014/53/EU on radio equipment (the "RED"), which came into force on 13 June 2016. The UK implemented the RED into UK law through the Radio Equipment Regulations 2017 (the "RER Regulations") and it now therefore constitutes retained EU law.[4]

2.19 One requirement of this regime is that radio equipment may only be placed on the market and put into service where it meets certain essential requirements. These include that it must be constructed such that it uses the relevant radio spectrum so as to avoid harmful interference.

2.20 One way in which these requirements may be satisfied is by meeting an applicable 'harmonised' or 'designated' standard (as applicable).[5] Meeting such a standard gives rise to a presumption of conformity with the requirements. Some of the standards contained in the RER Regulations apply to certain types of mobile phone repeater.

2.21 We note however that even mobile phone repeaters which meet one of the harmonised or designated standards (as applicable) may be liable to cause undue interference and/or adverse effects on technical quality of service if they are installed by consumers rather than by MNOs as part of their planned network installation. In order for consumers to use self-installed repeaters on a licence-exempt basis, it may therefore be necessary to identify a set of technical requirements which are additional to those in the relevant harmonised or designated standards.

# What we have done so far to help people improve their indoor mobile coverage using a static indoor repeater

2.22 On 24 October 2017, following consultation (including discussions with the MNOs and equipment manufacturers on what was necessary to ensure that undue interference or other adverse effects on technical quality of service was unlikely), Ofcom published a statement setting out its decision to make regulations that would allow people to operate

[4] The RER Regulations have been subsequently amended by the Product Safety and Metrology etc. (Amendment etc.) (EU Exit) Regulations 2019, with the effect that some of its provisions apply differently in Northern Ireland for as long as the Northern Ireland Protocol is in force. https://www.gov.uk/government/publications/radio-equipment-regulations-2017

[5] As noted above, the RER Regulations have been modified following the UK's departure from the European Union such that some of its provisions apply differently in Northern Ireland. One such example is provided in section 40 of the RER. This provides that, in respect of Northern Ireland, radio equipment which is in conformity with a 'harmonised standard' must be presumed to be in conformity with the essential requirements covered by that standard. However, it provides that, in respect of the rest of the UK, radio equipment which is in conformity with a 'designated standard' must be presumed to be in conformity with the essential requirements covered by that standard. Some harmonised standards may also be designated standards. For example, designated standards include technical specifications adopted by (amongst others) the European Telecommunications Standards Institute (ETSI).

static indoor mobile phone repeaters on a licence-exempt basis provided that these met certain technical requirements (the **"2017 Repeaters Statement"**)[6].

2.23 Our view was that such mobile phone repeaters could, provided that they meet certain technical requirements,[7] operate without causing harm to mobile networks and other spectrum users. On that basis, and consistent with the legal framework set out above, we decided that their use should be licence-exempt.

2.24 The technical requirements for licence exemption included that a static indoor repeater should: (a) only operate over the frequency bands of any single licensed network operator at a given time, (b) adjust their power to the minimum necessary to make a reliable connection, and (c) incorporate anti-oscillation measures. The requirement at (a) meant that we frequently refer to these licence-exempt mobile phone repeaters as 'single operator' repeaters. Whilst they may be re-configured to alternate frequencies, they must only operate (at any one time) on frequencies licensed to a single operator when configured.

2.25 In the 2017 Repeater Statement, we recognised that allowing the use of certain licence exempt mobile repeaters should promote a legitimate retail market for consumer-installed mobile phone repeaters. It was our view that this might, in turn, help reduce the likelihood that people unwittingly purchased unauthorised illegal repeaters which may cause undue interference to mobile networks or other spectrum users in adjacent bands.

2.26 On 12 April 2018, the Wireless Telegraphy (Mobile Repeater) (Exemption) Regulations 2018 (the "**Exemption Regulations**")[8] came into force. These implemented the policy decision set out in the 2017 Repeater Statement by exempting from the requirement to be licensed under section 8(1) of the Wireless Telegraphy Act the establishment, installation and use of static indoor mobile phone repeaters which comply with UK Interface Requirement 2102.1 ("**IR 2102.1**")[9].[10] IR 2102.1[11] sets out the detailed technical requirements applicable to licence-exempt static indoor mobile phone repeaters.

## Why we are reviewing our approach to static indoor mobile phone repeaters

2.27 Our decision in 2018 to make the Exemption Regulations represented the first time that Ofcom had considered whether mobile phone repeaters, or a subset of them, could be made licence-exempt. In reaching its decision, Ofcom was mindful of the need to avoid the risk of

[6] https://www.ofcom.org.uk/__data/assets/pdf_file/0019/107254/Repeaters-Statement-2017.pdf
[7] These technical requirements were in addition to those in the relevant harmonised standards (discussed above in relation to the RER Regulations). This reflected the fact that licence exempt repeaters may be installed anywhere, and would not form part of an MNOs planned network installation.
[8] https://www.legislation.gov.uk/uksi/2018/399/data.pdf
[9] UK Interface Requirement 2102 (ofcom.org.uk)
[10] A full list of technical requirements for licence exempt mobile repeaters is included in the UK Interface Requirements 2102.1, which can be found at https://www.ofcom.org.uk/__data/assets/pdf_file/0016/112291/IR_2102.pdf
[11] IR 2102.1 forms one section of "*UK Interface Requirement 2102*: *Licence exempt static indoor and low gain mobile phone repeaters*". As explained in paragraph 2.7 and footnote 3 above, we are not proposing any changes in this consultation to IR 2102.2 which sets out the technical requirements for in-vehicle mobile phone repeaters.

(amongst other things) enabling the use by consumers of mobile phone repeaters which could cause undue interference or have an adverse effect on technical quality of service.

2.28 Since then, and as discussed below, we have been able to see the impact that the Exemption Regulations (taken together with IR 2102.1) have had; both on the market for legitimate mobile phone repeaters and on the use by consumers of unlawful repeaters. We therefore now consider that it would be a good time to reconsider this issue and, in particular, consider whether there are any ways that we can improve our approach to static mobile phone repeaters for indoor use.

2.29 Our experience to date suggests that the unlawful use of indoor mobile phone repeaters (which have a propensity to cause harmful interference to the mobile phone networks) remains a concern. This is likely because:

- mobile repeaters complying with the Exemption Regulations (including the associated technical requirements in IR 2102.1) are significantly more expensive than their illegal counterparts. In part, this reflects the complexity of these existing technical requirements. It also reflects the fact that, as only single operator mobile phone repeaters are currently licence exempt, households which contain several members (each of which may have mobile phone contracts with different mobile network providers) may need to purchase multiple single-operator repeaters in order to address their network coverage issues. We also note that, to our knowledge, there is only one manufacturer of repeater equipment complying with the Exemption Regulations; and
- consumers may struggle to identify mobile repeaters that are licence exempt. Specifically, our enforcement work suggests that a range of off-shore companies place non-compliant mobile repeaters on the UK market. These products are frequently claimed to be endorsed by an MNO and/or approved by Ofcom. Once purchased, these illegal mobile repeaters are shipped to UK consumers, often bypassing border control through false custom declarations.

2.30 Since 2018, Ofcom's Spectrum Compliance Team has been investigating, on average, five cases per month where consumers have resorted to unwittingly installing non-compliant mobile wideband repeaters, thus risking harmful interferences to others. Ofcom's enforcement approach to date includes engaging with sellers who wish to cooperate and using our powers to disrupt the activities and take enforcement action against those who keep operating within our jurisdiction. We have recently suspended the internet domains used by some of the more prolific organisations. Whist significant, our efforts have only led to marginal gains, as new websites rapidly appeared to fill any gap left by our enforcement actions.

2.31 Further, we are also mindful of the informal submissions that we have received from a manufacturer of mobile phone repeaters, regarding the scope of the current licence exemption. It has noted, in particular, that the current Exemption Regulations (together with IR 2102.1) allow two (or more) 'single operator' repeaters to be placed next to each other in a building on a licence-exempt basis. However, a product that contains two (or more) 'single operator' repeaters in a single box would not be licence-exempt as it would be one product

amplifying two (or more) operators' licensed frequencies. It has asked Ofcom to reconsider this restriction on the basis that – in terms of technical impact – there should be no difference between these two situations.

2.32 In light of the above, and as part of our work supporting the strategic priority in Ofcom's annual plan 2021/22, 'Getting everyone connected'[12], we are revisiting our approach to mobile phone repeaters for indoor use to identify where improvements could be made to tackle these issues.

## Document Structure

2.33 The remainder of this document is structured as follows:

i) Section 3 sets out our proposals in relation to static mobile phone repeaters for indoor use;

ii) Annex A1 sets out the detailed technical analysis on transmit gain control for multi-operator repeaters; and

iii) Annexes A2 and A3 contain our proposed interface requirements for static indoor mobile phone repeaters. Specifically:

- draft example tables, setting out proposed changes to IR 2102.1, in order to allow for 'provider specific' mobile phone repeaters to be licence-exempt (rather than just 'single operator' repeaters); and
- a draft example table setting out proposals for a new licence exemption (and, in particular, a new UK Interface Requirement 2102.3)[13] in respect of 'multi-operator' static mobile phone repeaters for indoor use;

iv) Annexes A4 to A6 contain details of Ofcom's consultation processes.

v) Annex A7 contains the consultation questions on which we are particularly keen for stakeholder feedback.

## Impact Assessment

2.34 Section 7 of the 2003 Act requires that, where we are proposing to do anything for the purposes of, or in connection with, the carrying out of our functions, and it appears to us that the proposal is important, we are required to carry out and publish an assessment of the likely impact of implementing the proposal, or a statement setting out our reasons for thinking that it is unnecessary to carry out such an assessment.

2.35 The analysis presented in this document as a whole constitutes our impact assessment.

[12] https://www.ofcom.org.uk/__data/assets/pdf_file/0019/216640/statement-plan-of-work-202122.pdf
[13] To note, UK Interface Requirements 2102.2 sets out technical conditions for in-vehicle mobile phone repeaters, which is outside the scope of this consultation.

## Equality Impact Assessment

2.36 Ofcom is also required by statute to assess the potential impact of all its functions, policies, projects and practices on the following equality groups: age, disability, gender, gender reassignment, pregnancy and maternity, race, religion or belief and sexual orientation. Equality Impact Assessments (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 or identity.

2.37 The proposals set out in this document would apply equally to all users of mobile phone repeaters. We have not identified any differential impact of our proposals in relation to the identified equality groups and, in our assessment, they would not disproportionately affect any group of consumers

## Next Steps

2.38 Following publication of this consultation document, stakeholders are invited to provide their feedback on the proposals set out in this document.

2.39 Ofcom will carefully consider the responses and, should we decide to proceed with our proposals, we would then:

- publish a statement setting out our decision and describing the actions needed to implement it;
- consult on amendments to the Exemption Regulations under which a user of equipment complying with the Interface Requirements (in IR 2102.1 and/or 2102.3) would be exempt from the need to hold a WT Act licence; and
- notify to the European Commission the Interface Requirements (setting out the operational and spectrum management conditions under which such equipment could be authorised for use in Northern Ireland).

# 3. Our proposals

3.1 This sections sets out our proposals to (a) create measures to improve consumer awareness and information and (b) widen the scope of the exemption regime, which are intended to address the concerns highlighted in paragraphs 2.27 to 2.32.

## Measures to improve consumer awareness and information

3.2 One of the key challenges in reducing the sale and use of illegal repeaters is low consumer awareness around the status of such devices. A major problem we are trying to address is how to reduce the risk of consumers unwittingly purchasing non-compliant repeaters. Ofcom is regularly asked, particularly when illegal repeaters are seized during enforcement activity, which repeaters are licence-exempt.

3.3 There are a number of non-UK based websites selling static indoor repeaters into the UK that do not comply with the Exemption Regulations – many of these falsely advertise such devices as compliant with our regulations, and even fraudulently claim to be compatible with and/or endorsed by the MNOs. Ofcom publishes guidance for people and businesses to help them choose the most appropriate solutions to address inadequate mobile coverage, including a warning about non-compliant repeaters.[14] However, we are concerned that the available advice from Ofcom is not sufficient to really help people to understand the difference between a repeater that complies with the Exemption Regulations and can be used on a licence-exempt basis and a repeater that does not and is therefore illegal to use without a licence. We would like to improve this situation by providing clear, unambiguous information on those devices that comply with the Exemption Regulations (and, in particular, the technical requirements on static indoor repeaters), thus helping people to legitimately resolve and improve indoor coverage issues using mobile phone repeaters. This is in line with our proposal to understand, assist and inform our stakeholders, in our consultation on 'Supporting the UK's wireless future - Our spectrum management strategy for the 2020s'. [15]

3.4 We do not currently endorse specific repeater solutions by, for example, publishing a list of manufacturers/suppliers of compliant devices on our website. We are mindful, in particular, of the risk that we may be seen to endorse the use of equipment that is not compliant with the Radio Equipment Regulations 2017, which might cause harmful interference or is otherwise not fit for purpose. If we were to endorse a specific supplier, we could also not guarantee that every device sold by that supplier meets the criteria for licence exemption.

3.5 Notwithstanding the above, we have considered whether publishing further information on our website regarding repeater providers and/or individual equipment which we understand to be compliant with the Exemption Regulations could reduce the likelihood that people unwittingly purchase unauthorised illegal repeaters which may cause undue interference to mobile networks or other spectrum users in adjacent bands. We would need however to avoid the risks referred to above, and would need to find a way of being reasonably sure that

[14] https://www.ofcom.org.uk/phones-telecoms-and-internet/advice-for-consumers/advice/improving-indoor-coverage
[15] https://www.ofcom.org.uk/__data/assets/pdf_file/0027/208773/spectrum-strategy-consultation.pdf

devices which were claimed to be compliant with the Exemption Regulations, were in fact compliant.

3.6 Ofcom is not set up to operate as a commercial test house and conduct such compliance tests on behalf of manufacturers and it would conflict with our other responsibilities if we were to offer such a service – we need to remain independent to enable us to take enforcement action, as necessary, in relation to devices which may not meet the requirements of the various regulations and licence conditions for which we are responsible. We cannot be both a commercial test house offering compliance services to manufacturers and an enforcement body responsible for acting where we are concerned about a breach of the rules – that would be a conflict of interest.

3.7 We recognise however that there are likely to be independent commercial test houses (e.g. accredited by UKAS) that could conduct this type of testing. And that this could, if it were conducted in accordance with a voluntary testing standard set by Ofcom, give Ofcom sufficient reassurance regarding a specific mobile phone repeaters' compliance with the Exemption Regulations to enable us to list that device on our website.

3.8 The purpose of a voluntary testing standard would be to assist test houses when they are evaluating the compliance of a static indoor mobile phone repeater with the Exemption Regulations. It would not set additional technical requirements on mobile phone repeaters beyond those contained in the Exemption Regulations and associated interface requirements. Rather, it would set out the test methods and/or parameters which Ofcom considers should reasonably be applied by test houses when testing a device against the Exemption Regulations[16]. We would expect to develop any voluntary testing standard with the help of relevant industry partners (e.g. manufacturers, MNOs and test houses).

3.9 For the avoidance of doubt, we are not proposing that manufacturers would be required to have their devices tested by an independent test house against the Exemption Regulations (in accordance with the voluntary testing standard) and submit the results of their testing to Ofcom. We are however proposing that this would be necessary in order for a manufacturer to have its device listed on Ofcom's website as licence-exempt. Our provisional view is that the use of a voluntary testing standard would be a pragmatic way for Ofcom to gain reassurance that specific static indoor repeaters are compliant with the Exemption Regulations and therefore licence-exempt, such that they are suitable for inclusion on our website.

3.10 We are therefore seeking stakeholders' views on whether the creation of a voluntary testing standard, and the publication on Ofcom's website of a list of static indoor mobile phone repeaters that comply with the Exemption Regulations (following testing by an independent test house in accordance with that standard) would be useful.

[16] For example, we think it would be useful to specify in any voluntary testing standard that (i) a base station simulator and variable attenuation be used to confirm that a 'provider-specific' repeater's transmit gain does not exceed BSCL−30dB, where BSCL is the path loss between the base station and the repeater (part 8 of IR2102.1), (ii) representative base station signals be generated to test that a 'multi-operator' repeater's transmit gain does not exceed the limit that we are proposing in part 8 of IR2102.3 of 10 dB−RSSI (where RSSI is the downlink composite received signal power), and (iii) actual oscillation be induced in the repeater to verify that it correctly applies the anti-oscillation detection and mitigation requirements.

3.11 We recognise that providing a list of static indoor mobile phone repeaters on our website that are licence-exempt will not necessarily resolve the issue of the illegal use or non-compliant repeaters, particularly when one of the key factors affecting such use is the significantly higher cost of compliant devices. This approach has been used by some administrations in other countries with a limited impact on the numbers of illegal repeaters present on their markets. However, we consider that, taken together with the other technical changes proposed in this consultation (which should help improve the utility of compliant repeaters and potentially help to reduce their cost somewhat), providing a list of repeaters for which we have evidence that they meet our Exemption Regulations could be a worthwhile improvement and, in particular, reduce the risk that people unwittingly purchase unauthorised illegal repeaters. Providing people and businesses with a clear understanding of devices that meet our regulations can only be a good thing.

Question 1: Do you agree that Ofcom should consider working with relevant industry partners to develop a voluntary testing standard, and publishing a list on our website of static indoor mobile phone repeaters that comply with our licence exemption requirements?

## Widening the scope of the exemption regime

3.12 As explained in Section 2 above, Ofcom decided in 2017 to allow 'single operator' mobile phone repeaters to be licence exempt, provided that they meet the technical requirements set out in IR 2102.1.

3.13 We have considered four potential ways in which the scope of the current licence exemption could be amended. Specifically, we have considered whether it would be appropriate to:

a) modify the existing interface requirement for 'single operator' repeaters (IR 2102.1) so as to remove the requirement for a licence-exempt repeater to only amplify the signal of one MNO at any one time, and to allow for 'provider specific' (rather than 'single operator') repeaters. These 'provider specific' repeaters could repeat the signal of more than one MNO at any one time, individually setting the level of amplification for each MNO's signals. These would be distinct from the 'multi-operator' repeaters discussed at b) below;

b) allow certain 'multi-operator' mobile phone repeaters to be made licence-exempt (by the creation of a new UK Interface Requirement, specifically IR 2102.3). These would allow for the signals of more than one MNO to be amplified at the same time but, unlike the 'provider specific' repeaters discussed above, any such amplification would be by the same level and would not be calculated individually for each MNO. Because they would amplify each MNO's signal by the same amount, such repeaters would not need to decode the signal(s) they are repeating nor identify the type of signal (e.g. 2G, 3G or 4G) being amplified; they would likely therefore be simpler devices than 'provider specific' repeaters;

c) remove the requirement for licence-exempt repeaters that repeat 4G signals to also repeat a 2G and/or 3G signal at the same time. To date, this technical requirement has

been imposed (via IR 2102.1) to ensure that certain types of early 4G handsets (non-VoLTE handsets) would be able make emergency call when connected to the network via a repeater; and

d) allow licence-exempt mobile phone repeaters to repeat the 2.6 GHz band. This band was excluded from the existing Exemption Regulations to protect air traffic control radar operating in adjacent frequency bands from harmful interference.

3.14 Our provisional conclusions on each of these issues are set out below in turn.

3.15 In addition, now that the 700 MHz band has been awarded[17], we are also provisionally concluding that it would be appropriate to include the paired spectrum in this band (in particular, the 703-733 MHz uplink and 758-788 MHz downlink frequencies) within the interface requirements for static indoor mobile phone repeaters and therefore within IR 2102.1 and IR 2102.3.

## Modify the existing Interface Requirement for 'single operator' repeaters (IR 2102.1)

3.16 As explained at paragraph 2.24 above, the current interface requirement for static mobile phone repeaters for indoor use (IR 2102.1) provides, amongst other things, that the amplified frequencies shall be limited to those licensed to a "single MNO". And that, whilst the equipment may be re-configured to alternate frequencies, it may only operate using frequencies licensed to a single operator when configured. It is for this reason that we have tended to refer to these repeaters as 'single operator' repeaters.

3.17 However, one stakeholder has asked Ofcom to reconsider this restriction on the basis that, as drafted, it is unduly restrictive and that, instead, 'provider specific' mobile repeaters should be made licence exempt. See, in particular, paragraph 2.31 above. We have therefore reconsidered this particular point.

3.18 We are mindful that in the April 2017 Consultation[18] we proposed (in paragraph 3.18) that in order for a licence exempt repeater to work in a safe way, it would need to be able to determine the reduction in signal power on the path from the serving base station (the coupling loss) and automatically adjust its gain. This would allow the repeater to only amplify the signal sufficiently to provide an acceptable level of service, while not unduly raising the noise within the mobile network or blocking (overloading) the serving base station's receiver. As the coupling loss to the nearest serving base station of one network will be different to that of any of the other networks, we then proposed (in paragraph 3.19) that licence exempt repeaters should only be able to set their gain in relation to one network at a time and as such should only be allowed to communicate with one mobile network at a time. However, we now recognise that our view that the repeater could only set its gain in relation to one network at a time may have been overly simplistic.

3.19 The technical analysis in the April 2017 Consultation (in paragraph 3.22) showed that the proposed gain requirement, for the repeater to automatically adjust its gain in the channel of

[17] Award of 700 MHz and 3.6-3.8 GHz spectrum by auction - Ofcom
[18] https://www.ofcom.org.uk/__data/assets/pdf_file/0017/100277/Mobile-phone-repeaters.pdf

operation based on the coupling loss to the serving base station in that channel, would ensure that the repeater is unlikely to cause undue interference or adverse effects on the technical quality of service of the network. If a repeater can adjust the gain individually for each operator's channels based on the coupling loss to the serving base station of that operator, then the findings of this technical analysis remain true.

3.20 Our provisional view is therefore that modifying IR 2102.1 in order to allow for 'provider specific' repeaters would cause no greater risk of interference than is accepted today in respect of 'single operator' repeaters. It is currently legal to deploy multiple 'single-operator' repeaters next to each other, providing improved signal for each of the operators. If a 'provider-specific' repeater adjusts the gain applied to each operator individually, then it would be providing the exact same improvement in signal, simply within one unit. Therefore, the impact of deploying a 'provider-specific' repeater in any location would be the same as the impact of deploying multiple 'single-operator' repeaters in the same location, with the benefit of potentially reducing the cost of purchase and installation, due to only requiring one repeater instead of multiple.

3.21 In light of the above, our provisional view is that it would be appropriate to modify IR 2102.1 to allow for 'provider specific' (as well as 'single operator') repeaters. Specifically, to allow for repeaters to be licence exempt even if they repeat more than one mobile network at the same time, provided that the existing technical requirements applicable to single operator repeaters are complied with and, importantly, apply separately for the frequencies of each specific network.

3.22 Ofcom's proposed changes to IR 2102.1 are set out at **Annex A2** below.

Question 2: Do you agree that we should modify IR 2102.1 to allow for 'provider specific' mobile phone repeaters? If you do not agree, please explain your reasons.

## Create a new UK Radio interface requirement for 'multi-operator' mobile repeaters

3.23 Following the 2017 Repeater Statement, the use of 'multi-operator' mobile phone repeaters, which would amplify more than one MNOs' frequencies (and with the same gain across all channels in a frequency band), continued to be unlawful without a licence.

3.24 However, we recognise that allowing the licence exempt use of 'multi-operator' repeaters, which are likely to be simpler in design compared to 'provider specific' repeaters (as they do not have to decode the channels that are being repeated and apply the same gain across all channels in a frequency band), could provide a more cost effective option for people to improve mobile coverage within their homes.

3.25 Additionally, we recognise that 'multi-operator' repeaters are a technically viable alternative for improving mobile coverage within homes. Provided that appropriate technical conditions are in place to ensure that 'multi-operator' repeaters meet the requirements set out in section 8(5) of the WT Act, Ofcom has a duty to make regulations to exempt this equipment from the requirement for a licence.

3.26 As a result, Ofcom has undertaken further analysis to identify if the use of 'multi-operator' static indoor mobile phone repeaters could be made licence exempt (without being likely to cause undue interference or other adverse effects to mobile phone networks or other spectrum users) and, if so, what technical requirements would be appropriate. Detailed technical analysis on transmit gain control is set out in **Annex A1**.

3.27 We have provisionally concluded, taking account of this analysis and the relevant legal framework, that it is appropriate to exempt 'multi-operator' repeaters from the requirement for a licence, and that such an exemption would be in accordance with section 8(5) of the WT Act.

3.28 In order to ensure that this licence exemption would not be likely to cause undue interference to MNOs or other spectrum users, or to have an adverse effect on technical quality of service, our provisional view is that the following technical requirements (which would be specific to 'multi-operator' repeaters) would be appropriate and proportionate.

a) Transmit gain control: requirement that the uplink and downlink system gain in dB (referenced to its input and output ports), shall not exceed 10−RSSI, where RSSI is the downlink composite received signal power in dBm at the repeater donor port, for all base stations in the band of operation. In common with the 'single operator'/'provider specific' requirements, we propose that 'multi-operator' repeaters must provide equal uplink and downlink gain, and that the uplink and downlink gain shall not exceed 100 dB. This is discussed in more detail from paragraph 3.32 below, and in **Annex A1**;

b) Maximum downlink power: requirement that power spectral density be limited to 10 dBm/5 MHz. This is discussed in more detail from paragraph 3.37 below; and

c) Maximum uplink power: requirement that the maximum uplink power is 17 dBm / 5 MHz EIRP. This is discussed in more detail from paragraph 3.40 below.

3.29 We also propose that a number of the technical requirements which already apply to 'single operator' repeaters by virtue of IR 2102.1 (and which would by extension apply to 'provider-specific' repeaters, if we implemented our proposals on these) should apply to 'multi-operator' repeaters. We have set these out from paragraph 3.43 below.

3.30 The detailed technical requirements that we are proposing for 'multi-operator' repeaters are set out in a draft UK Interface Requirement at **Annex A3**. This would be included as a new section (specifically, IR 2102.3) in UK Interface Requirement 2102: Licence exempt static indoor and low gain mobile phone repeaters.

3.31 Our provisional view is that, with these technical requirements, mobile networks and other spectrum users would be protected to the same level as under the existing 'single operator' exemption regime, and that such an exemption would be in accordance with section 8(5) of the WT Act.

### Multi-operator repeater transmit gain control

3.32 The transmit gain control of the current 'single operator' and the proposed 'provider specific' repeaters is determined based on the base station coupling loss (the path loss between the serving base station and the repeater). However, as a 'multi-operator' repeater may be

improving the coverage of multiple MNOs, and therefore multiple base stations, applying the same gain for each MNO, it would no longer be appropriate to limit the gain based on a receive signal from a single base station. Therefore, we propose that the gain be controlled based on the total power received from all base stations in the band. This approach is similar to that developed by the FCC.[19]

3.33 The proposed uplink and downlink gain limit in dB is 10−RSSI. Here, RSSI is the downlink composite received signal power in dBm at the repeater donor port, for all base stations in the band of operation. In common with the current 'single operator' and the proposed 'provider specific' requirements, the repeater must provide equal uplink and downlink gain, and the uplink and downlink gain shall not exceed 100 dB.

3.34 Our analysis calculates the worst impact that could be caused by an individual 'multi-operator' repeater to be an I/N of −37 dB. This worst impact result was found for only one of the thousands of test deployment locations, amplifying the 1800 MHz band, and shows that in the most conservative case a total of 250 simultaneously active multi-operator repeaters per sector can be tolerated in any one frequency band. This is based on a maximum tolerable noise rise in the mobile network of 0.5 dB at any base station. In most cases, the impact of an individual 'multi-operator' repeater is less (a smaller I/N is produced), meaning a larger number of simultaneously active 'multi-operator' repeaters per sector could be tolerated in any one frequency band.

3.35 We consider it unlikely that this number of repeaters would be simultaneously active (there is a separate requirement for them to enter standby when not being used for five minutes), and therefore our provisional view is that the limits that we are proposing would provide sufficient protection to the mobile networks and to other spectrum users.

3.36 More details of this analysis are in **Annex A1** to this document.

### Multi-operator repeater maximum downlink power

3.37 The maximum downlink power for the current 'single operator' and the proposed 'provider specific' repeaters was chosen so that the repeater can provide good indoor coverage, while avoiding undue interference or adverse technical effects to mobile phone users outside the building where the repeater is located. We currently impose a maximum power spectral density of 10 dBm / 5 MHz, and an overall maximum power of 17 dBm per band.

3.38 Applying the same maximum downlink power to 'multi-operator' repeaters could result in a power reduction compared to the maximum downlink power of the current 'single operator' and the proposed 'provider specific' repeaters. This is because a 'multi-operator' repeater may have the ability to transmit across a wider bandwidth (of multiple operators), meaning a reduction in power per operator would be needed.

3.39 We therefore propose not to apply a requirement to limit the overall maximum power to 17 dBm per band but we instead propose to impose a limit on power spectral density of 10 dBm/5 MHz. This power spectral density requirement alone should ensure that 'multi-

[19] The FCC (Federal Communications Commission) is the spectrum regulator in the United States of America who have implemented their own regulations for mobile phone repeaters.

operator' repeaters pose no greater risk of undue interference to other mobile handset users outside the building where the repeater is located than the current 'single operator' and the proposed 'provider specific' repeaters.

### Multi-operator repeater maximum uplink power

3.40 Ofcom's current 'single operator' and proposed 'provider specific' technical requirements reflect the maximum uplink power requirements that apply to handsets, which are frequency band and technology dependent. This approach results in the current 'single operator' and the proposed 'provider specific' repeaters having the same impact on the network as consumer handsets.

3.41 The most restrictive maximum uplink power requirement in the 1800 MHz, 900 MHz and 800 MHz band is 23 dBm / carrier EIRP. In the 2100 MHz band the requirement is 24 dBm / carrier EIRP. For the technologies currently in use, the maximum carrier bandwidth in all bands is 20 MHz.

3.42 'Multi-operator' repeaters are not required to determine the technology they are repeating. Therefore, it is proposed that, in order to ensure that in all scenarios a 'multi-operator' repeater will have no greater impact than a current 'single operator' or a proposed 'provider specific' repeater (or mobile handset), the most restrictive uplink power requirement should be met (i.e. 23 dBm / 20 MHz EIRP). However, since the minimum licensed bandwidth in each of the mobile FDD bands is 5 MHz it is proposed that the maximum uplink power of 'multi-operator' repeaters is defined on a per 5 MHz basis, resulting in a maximum uplink power requirement of 17 dBm / 5 MHz EIRP.

### Further conditions that we propose to apply to 'multi-operator' repeaters

3.43 We also propose that the following technical conditions from the current 'single operator' requirements, which have been designed to protect the mobile frequency bands and any adjacent band users, should apply equally to the proposed 'provider specific' and 'multi-operator' repeaters:

a) static use indoors only.

b) authorised to amplify one or more of the 700 MHz, 800 MHz, 900 MHz, 1800 MHz and 2100 MHz FDD mobile frequencies only (however additional requirements may apply – see also the proposals in relation to 4G-only repeaters discussed in more detail from paragraph 3.44 below.

c) must amplify the signal equally in both directions (uplink and downlink), to and from the consumer's handset to the base station.

d) automatic standby when no longer serving an active device, ensuring that the repeater is unlikely to add noise to the network when not in active use.

e) anti-oscillation mechanism, preventing interference to the mobile network in the case where a repeater is poorly located.

f) noise figure requirement, ensuring that the mobile phone repeater has a similar noise figure to a mobile phone base station.

Question 3: Do you agree that we should make 'multi-operator' mobile phone repeaters complying with the technical requirements outlined above (and set out in the draft UK Radio Interface Requirement IR 2102.3 at Annex A3) licence exempt? If you do not agree, please explain your reasons.

## 4G-only repeaters

3.44 The deployment of 4G-only mobile phone repeaters is not currently permitted without a licence; all current 'single operator' repeaters must also transmit a 2G and/or a 3G signal. This is intended to avoid scenarios where non-VoLTE handsets (broadly those released between 2012 and 2014) are unable to make emergency calls in locations served by a 4G repeater where there is no 2G/3G coverage.[20]

3.45 We have considered if this technical requirement is still necessary or whether it should be retained, as its removal would likely simplify the design of mobile repeaters. In turn this could bring down costs for mobile repeater producers, thereby lowering prices for end consumers.

3.46 Discussions with the MNOs have revealed that their networks are designed to avoid this situation, through mechanisms such as avoiding areas of 4G-only coverage, or not allowing non-VoLTE handsets to connect in areas of 4G-only coverage. However, we remain concerned that the use of 4G-only static indoor mobile phone repeaters could create areas of 4G-only coverage without these mechanisms in place.

3.47 We have analysed the landmass coverage of each MNO to determine the locations that have outdoor 4G coverage but do not have indoor 2G/3G coverage. These locations would allow for a scenario in which a 4G-only repeater could extend the 4G service indoors, where there is no access to 2G/3G coverage. We found this scenario could occur at between around 10% and 40% of the UK landmass, depending on the particular MNO concerned, meaning that the introduction of 4G-only repeaters could potentially create considerable areas of 4G-only indoor coverage for some MNOs.

3.48 As a result of the above, our provisional view is that there is still a significant risk that 4G-only static indoor mobile phone repeaters could lead to situations where it would not be possible to call the emergency services in all cases (in particular, where there is only 4G coverage indoors) and that this risk could arise for a significant number of handsets (potentially in the range of 10% to 30%). We therefore propose that:

[20] Non-VoLTE handsets cannot make voice calls of any type on a 4G network; operators therefore force non-VoLTE handsets to switch to their 3G or 2G networks when they make or receive a voice call. Some mobile network operators may also force all emergency calls (even those made on VoLTE-capable handsets) on to their 2G or 3G networks. In either of these cases, if there is no 2G or 3G coverage from their network, the emergency call would fail. In addition, there is the fallback of national roaming for emergency calls, which allows a mobile handset to connect to a different network if there is no coverage from its own network. However, the roaming process would not be initiated by a mobile handset if it can receive 4G coverage from its own network, and the handset would not be able to make an emergency call.

a) for 'single-operator'/'provider-specific' repeaters, we will need to maintain the current technical requirement that 4G signals only be repeated when a 3G and/or 2G signal are being repeated; and

b) for 'multi-operator' repeaters, and in light of the fact that 'multi-operator' repeaters are not expected to be aware of the technology they are repeating (so they cannot determine whether they are meeting the requirement to repeat 2G/3G signals), we propose to impose a requirement that the repeater repeat the frequency bands used by each MNO's 2G and 3G networks (e.g. the 900 MHz, 1800 MHz and 2100 MHz frequency bands). This is reflected in the draft technical requirements for 'multi-operator' repeaters, at **Annex A3**

3.49 It is our intention however to keep this particular requirement under review as:

- when the MNOs switch off their 2G and/or 3G networks in the future, 'single-operator'/'provider-specific' repeaters may cease to operate (and/or would become unlawful) unless we make changes to these regulations; also
- over time the number of non-VoLTE handsets in active use will fall as people change their mobile phones to newer models, meaning that the risk of people being unable to call the emergency services in the circumstances described will fall.

Question 4: Do you agree with our provisional view as set out in paragraph 3.48 above? If you do not agree, please explain why you think the requirement is not necessary.

## Inclusion of the 2.6 GHz band

3.50 In response to Ofcom's 2017 consultation on mobile phone repeaters, a concern was raised about the possibility for repeaters in the 2.6 GHz band (2500-2690 MHz) to cause interference to air traffic control radar in the adjacent 2700-2900 MHz band. We therefore decided not to include the 2.6 GHz band in our Exemption Regulations and associated IR 2102.1.

3.51 As part of our further work on repeaters, and based on an informal submission that we received from a manufacturer of mobile phone repeaters on this topic, we have looked again at the question of whether we could allow the use of licence-exempt mobile phone repeaters in this band.

3.52 We have now carried out analysis which suggests that it would not be possible to allow repeaters to operate in the 2.6 GHz band on a licence-exempt basis, because we could not ensure that they would only ever be operated beyond the minimum separation distances necessary for protection of aeronautical radar.

3.53 Using the methodology outlined in Ofcom's "Notice of coordination procedure required under spectrum licences for the 2.6 GHz band"[21], which specifies the protection threshold and coordination procedures that are necessary to ensure the 2.6 GHz licensees' base station deployments protect the existing air traffic control radars operating in the 2.7 GHz bands

[21] https://www.ofcom.org.uk/__data/assets/pdf_file/0026/56951/final_radar_coordination.pdf

from potential harmful interference, we have assessed the minimum separation distance that would need to be guaranteed between the radar site and any repeater installations to ensure that the adjacent band emissions from repeaters are below the level that could cause interference to air traffic control radars. Based on the ETSI spurious emission requirements in the current harmonised standard for repeaters[22], separation distances of 24 km would be needed between the radar site and any repeater installations to ensure protection of the air traffic control radar. Additionally, we have reassessed the required separation distance based on measurements of spurious emissions from a sample repeater, and found that there is still a need for a separation distance of at least 1.5 km.

3.54 Considering that some airports have air traffic control radars that are closer than this to surrounding residential housing, our provisional view is that it would not be appropriate to allow the use of licence-exempt repeaters in the 2.6 GHz band.

Question 5: Do you agree that it would not be appropriate to allow the use of licence-exempt repeaters in the 2.6 GHz band? If you do not agree, please explain your reasons.

## Addition of the 700 MHz band

3.55 The award of the 700 MHz frequency band concluded in May 2021, and this band will be used for mobile network services. Since this frequency band is now available, we consider it appropriate to consider it for use by repeaters.

3.56 The 700 MHz band consists of paired spectrum (703-733 MHz uplink and 758-788 MHz downlink) and an unpaired portion (738-758 MHz). In common with unpaired spectrum in other mobile bands, we do not propose to include the 738-758 MHz frequencies in the interface requirement. We do however consider that the use of static indoor mobile phone repeaters which amplify the paired 700 MHz frequencies should be permitted on a licence-exempt basis.

3.57 We therefore propose to add the 703-733 MHz uplink and 758-788 MHz downlink frequencies to the interface requirement with the same limits on maximum uplink and downlink power as those that will apply in the 800 MHz band. Our provisional view is that, with the technical requirements set out in the draft Interface Requirements at **Annexes A2 and A3,** the amplification of frequencies in the 700 MHz band would not be likely to cause undue interference or to have an adverse effect on technical quality of the mobile networks, mobile users or other users of the radio spectrum.

Question 6: Do you agree that we should allow the use of static indoor mobile phone repeaters (on a licence-exempt basis) in the paired 700 MHz mobile band?

[22] ETSI HS 301 908-15 (IMT cellular networks; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU; Part 15: Evolved Universal Terrestrial Radio Access (E-UTRA FDD) Repeaters) defines the spurious emission limit for a repeater in the 2.6 GHz band as -30 dBm/MHz.

## Our provisional assessment

3.58 Our provisional view is that those static indoor mobile phone repeaters which meet the technical requirements set out in (i) the revised version of IR 2102.1 at **Annex A2** or (ii) the new interface requirement at **Annex A3,** would meet the requirements set out in section 8(5) of the WT Act. This includes that they would not be likely to involve undue interference with wireless telegraphy or have an adverse effect on technical quality of service. On that basis, their use should be authorised via licence-exemption, so that they could be used without the need for a licence, like other low power devices use of which is normally authorised that way.

3.59 In making these proposals, Ofcom is mindful of the fact that the changes it is proposing to the scope of the licence exemption regime should promote a legitimate retail market for consumer-installed mobile phone repeaters (and that this may, in turn, reduce the number of illegal repeaters on the market)..

3.60 However, there is a risk non-compliant potentially harmful repeaters will remain on the market, which will continue to cause harmful interference to networks. As such, our continued enforcement action and consumer advocacy and information campaigns will be required to combat their sale and use. We also propose to take measures to improved consumer information on mobile phone repeaters by considering the publication of a list of licence exempt static indoor mobile phone repeaters on our website (where those repeaters have been independently tested in accordance with a voluntary testing standard developed by Ofcom).

3.61 We have formulated our proposals above by reference to our statutory duties. For the reasons set out in this document, our provisional assessment is that they are consistent with those duties and the terms, provisions and limitations would meet the requirements of sections 8(4) and 8(5) of the WT Act.

3.62 In our view, the proposals set out in this document are:

a) objectively justified in that they address the risks of undue interference that might otherwise arise from the use of in-door mobile repeaters, and should reduce the risk that consumers purchase devices which are unlawful;

b) not unduly discriminatory against particular persons or against a particular description of persons in that they would apply to all users of relevant repeaters (and, indirectly, to all manufacturers and sellers);

c) proportionate to what they are intended to achieve, in that we have undertaken necessary technical analysis to minimise the risk that use of the relevant equipment would not be likely to cause undue interference or to have an adverse effect on technical quality of the mobile networks, mobile users or other users of the radio spectrum; and

d) transparent in relation to what they are intended to achieve, in that they are described and explained in this document.

3.63 More generally, we note that our proposals should encourage the further development of a retail market for lawful consumer-installed static mobile phone repeaters for indoor use. This

would help provide coverage solutions for consumers who need them, without being likely to harm MNOs and other spectrum users. It should also help increase competition in the market for mobile repeaters and reduce the likelihood that consumers purchase unauthorised (and unlawful) repeaters which do cause such harm.

# A1. Multi-operator repeater transmit gain control analysis

## Background

A1.1 The transmit gain control requirement for the licensing (via licence-exemption) and use of 'single operator'/'provider specific' repeaters is defined in IR 2102.1 as follows:

a) The uplink and downlink system gain in dB of a provider-specific repeater, reference to its input and output ports, shall not exceed BSCL−30. Here, BSCL (base station coupling loss) is the path loss between the base station and the repeater. Where BSCL cannot be determined, the repeater must not transmit.

b) The uplink and downlink system gain of a repeater shall not exceed 100 dB.

c) The apparatus shall determine the value of BSCL by calculating the difference between the carrier power received at the repeater and the carrier power transmitted from the base station. The carrier power transmitted by the base station may be determined from the system information messages sent by the base station on its control channels.

d) This definition ensures that the noise rise at the serving BS is limited to a less than 0.5 dB under an extreme, but plausible, scenario of 50 users simultaneously communicating with a the base station at any instant in time via the use of a repeater.

A1.2 Applying a gain control based on the BSCL is valid for current 'single operator' and proposed 'provider specific' repeaters, as avoiding interference to the MNO network is achieved by applying lower gain if the base station is nearby (i.e. if there is less path loss), while higher gain can be used if the base station is more distant. However, as 'multi-operator' repeaters will be amplifying the signals of multiple base stations located at different distances, and they need to apply the same gain across the frequency band, we do not consider that defining a gain control requirement based on the BSCL from a single MNO, or requiring them to derive the BSCL values for every MNO, would be appropriate for these types of repeaters.

A1.3 The FCC have resolved this issue by defining 'multi-operator' repeater gain control based on the downlink composite received signal power, i.e. the total power received from all base stations in the band. We are proposing that the gain control requirement for the licensing (via licence-exemption) and use of 'multi-operator' repeaters be defined in a similar way to the FCC.

A1.4 We propose that the transmit gain control of 'multi-operator' repeaters is defined as follows:

a) The uplink and downlink gain in dB shall not exceed 10−RSSI. Here, RSSI is the downlink composite received signal power in dBm at the repeater donor port, for all base stations in the band of operation.

b) The uplink and downlink gain, referenced to the input and output ports, shall not exceed 100 dB. This ensures that any unintended consequences from extremely high gain repeaters is avoided.

c) The repeater must provide equal uplink and downlink power.

# Analysis

A1.5 The analysis in this section of the Annex shows how the proposed gain control ensures undue interference or adverse effects on the technical quality of service of MNO networks is unlikely to occur by assessing the potential impact of 'multi-operator' repeaters on real networks.

## Analysis Methodology

A1.6 As explained in Section 4, this analysis focuses on the potential impact that 'multi-operator' repeaters could cause to MNO networks. We have analysed the impact on two network deployments, one based on the Beacon grid (i.e. either Vodafone or Telefonica/O2) and one based on the MBNL grid (i.e. either Three or BT/EE).

A1.7 The analysis initially calculates the potential impact (I/N) caused by an individual 'multi-operator' repeater on the two MNO networks from various test deployment locations. The worst I/N result is then used to analyse the potential aggregate impact from a high take-up of 'multi-operator' repeater use within premises. The analysis is similar to the analysis detailed in the 2017 Repeaters Statement (Annex 2)[23].

A1.8 The following processing steps summarise the methodology for this analysis, with more details given in the subsequent sections:

a) Part 1: Ofcom's 4G coverage model[24] is used to simulate the signal strength received by a repeater in a sample of test deployment locations, based on the relative location of the surrounding 4G base stations (BS).

i) The test deployment locations are a sample of potential repeater deployment locations spanning the whole of the UK, capturing both extremely rural and extremely urban locations.

ii) Ofcom's 4G coverage model provides the coupling loss[25] from the 20 closest 4G BS (for each MNO network) to the test repeater deployment location. This model allows the locations and parameters of real BS to be modelled, as well as effectively accounting for the impact of the surrounding terrain and clutter on the propagation path.

[23] Ofcom's Statement: Mobile phone repeaters – https://www.ofcom.org.uk/consultations-and-statements/category-2/mobile-phone-repeaters

[24] Ofcom's 4G coverage model is described in the Consultation: Coverage obligations in the 700 MHz and 3.6-3.8 GHz spectrum award - Ofcom's approach to verifying compliance - https://www.ofcom.org.uk/consultations-and-statements/category-2/coverage-obligations-in-the-700-mhz-and-3.6-3.8-ghz-spectrum-award

[25] The coupling loss calculated by Ofcom's 4G coverage model excludes any building entry loss caused by the static repeater being deployed indoors

b) Part 2: The receive signal strength calculated by Ofcom's coverage model, plus an additional factor for building entry loss, is used to determine how the proposed gain control will be applied at the 'multi-operator' repeater for each test deployment location.

c) Part 3: The coupling loss calculated by Ofcom's coverage model, plus the additional factor of building entry loss, gives the loss from each BS to the repeater location. As the loss in the opposite direction, from the repeater to the BS, is equal, this loss is used to determine the impact caused by the 'multi-operator' repeater at each test deployment location to the surrounding BSs. The impact (I/N) caused by the 'multi-operator' repeater is due to the amplification of in-band noise. This amplified noise is received as interference at the surrounding BSs.

   i) I/N = Repeater Gain (from Part 2) – Coupling Loss to the BS (including Building Entry Loss).

   ii) This conservative analysis only models the impact of the proposed gain control limit, and does not model the potential for reduction in impact caused by the proposed maximum uplink and downlink power limits. To meet these power limits, the repeater may need to further reduce the gain. The additional benefit of this gain reduction has not been assessed in this analysis.

d) Part 4: The worst I/N result is used in an aggregate analysis, to give a conservative estimate for the number of 'multi-operator' repeaters which can be tolerated within a BS sector.

   i) The number of 'multi-operator' repeaters that can be tolerated within a BS sector corresponds to an aggregate noise rise in the mobile network limited to 0.5 dB.

   ii) Additionally, this aggregate analysis looks at the number of premises within a sector for both typical and very extreme scenarios, to understand the maximum percentage of premises at which a 'multi-operator' repeater can be deployed.

A1.9 By modelling a sample of test points from both rural and urban scenarios, the proposed gain control and its impact on the surrounding BS in different 'multi-operator' repeater use cases is captured and analysed – for example, a scenario where the 'multi-operator' repeater is a long way from all BSs, which is expected to result in a high gain being applied, or a scenario where the 'multi-operator' repeater is a long way from one MNO's BSs but close to another MNO's BSs (commonly known as the near-far problem), which is expected to result in the gain being controlled to protect the close BSs.

### Methodology Part 1: Ofcom's 4G coverage model set-up

A1.10 For each MNO network and frequency band under test, Ofcom's 4G coverage model is used to determine the coupling loss from the 20 closest 4G BS locations (or all 4G BS within 50 km, whichever is smaller) to the test repeater deployment location, for a sample of deployment locations across the UK. The coupling loss calculated by Ofcom's 4G coverage model includes the effects of terrain and clutter on the propagation path, but excludes the building entry loss caused by the static 'multi-operator' repeater being deployed indoors.

A1.11 The coupling loss and detailed 4G BS parameters are then used to calculate the signal strength received by the 'multi-operator' repeater in each of the test deployment locations. An adjustment to the receive signal strength is made in Methodology Part 2 to account for the effects of building entry loss on the propagation path.

A1.12 For each test deployment location, three deployment heights are tested:

a) 1.5 m, representing the repeater being deployed on the ground floor of the premises;

b) 4.5 m, representing the repeater being deployed on the first floor for the premises; and,

c) 10.5 m, representing the repeating being deployed on the third floor of the premises – this case is only assessed for urban/dense urban deployment scenarios.

A1.13 Ofcom's 4G coverage model is set-up as follows:

**Table 1: Ofcom's 4G coverage model input parameters**

| Parameters | Value |
|---|---|
| BS Technical Parameters (e.g. Location, Power, Height, Downtilt, Antenna Pattern, etc.) | Provided by the MNOs – assessing 800 MHz and 1800 MHz bands.<br>The 900 MHz and 2100 MHz bands are not assessed. It is expected that the results will be similar to those of the 800 MHz and 1800 MHz bands respectively. |
| Propagation Model | P.1812-4, with 50% time percentage |
| Repeater Test Deployment Location Height 1 – representing ground floor deployment | 1.5 m |
| Repeater Test Deployment Location Height 2 – representing first floor deployment | 4.5 m |
| Repeater Test Deployment Location Height 3 – representing third floor deployment –assessed only for urban/dense urban scenarios | 10.5 m |
| Repeater Test Deployment Location Step Size – to provide a repetitive sample of test deployment locations across the UK, capturing both rural and urban scenarios | 10 km steps, resulting in 2438 test points across the UK |

### Methodology Part 2: Gain Control Calculation

A1.14 The application of the proposed 'multi-operator' repeater gain control requirement is calculated based on the receive signal strength from Methodology Part 1. However, an adjustment is made to the receive signal strength, to account for the effects of building entry loss on the propagation path caused by the static repeater being deployed indoors.

A1.15 Additionally, the gain control calculated in this analysis is adjusted to account for only modelling the 4G BS deployments of two MNOs. This adjustment is made by assuming that

the two MNOs occupy adjacent spectrum, and the bandwidth of the repeater matches the bandwidth of the two MNO's spectrum holdings, rather than the bandwidth of the whole frequency band. This bandwidth adjustment impacts the RSRP calculation, and results in a gain representative of the scenario where the 'multi-operator' repeater is amplifying the full bandwidth of the band, containing up to 4 MNOs and multiple technologies.

A1.16 The calculation of how the gain control is applied at each test deployment location and height requires the following parameters:

**Table 2: Gain control calculation input parameters**

| Parameters | Value |
|---|---|
| Building Entry (Exit) Loss | P.2109 – This model provides a distribution of building entry loss values for buildings with traditional construction, and buildings with thermally efficient construction. The distribution represents the potential distribution of construction materials used, and the potential distribution of the receiver (repeater) locations within the building (close to the exterior wall, or deep within the building).<br><br>For this analysis, the coupling loss used to calculate the receive signal strength each test deployment location and each surrounding BS calculated in Methodology Part 1 is adjusted using a random value from the traditional construction distribution. This adjustment to the coupling loss, and subsequently the receive signal strength, represents the additional propagation loss caused by the static repeater being deployed within a property, rather than outdoors. The traditional construction is assumed as this is representative of typical residential property construction. The full distribution is used in the randomisation, to account for the fact that the repeater may be deployed in a window close to one BS, but this window may be on the opposite side of the building from another BS. |
| Frequency Allocation | It is assumed that the two MNOs are adjacent in frequency, and the repeater is designed to amplify only the two MNO's spectrum holdings.<br><br>800 MHz bandwidths assumed for this analysis:<br><br>Beacon = 10 MHz, |

| | |
|---|---|
| | MBNL = 5 MHz.<br>1800 MHz bandwidths assumed for this analysis:<br>Beacon = 5 MHz,<br>MBNL = 20 MHz. |
| 'Multi-operator' Repeater Maximum Gain | min ( 10 dB – RSSI , 100 dB ),<br>where,<br>RSSI = composite received downlink signal power, in dB, for all BS in the band of operation |

### Methodology Part 3: I/N Calculation

A1.17 The impact (I/N) of a 'multi-operator' repeater at the surrounding BSs is calculated for each repeater test deployment location and height, based on the repeater gain and coupling loss to the BS (including Building Entry Loss) output from Methodology Part 2, as follows:

**Table 3: I/N calculation**

| Parameter | Value |
|---|---|
| I/N received at each surrounding BS, due to the 'multi-operator' repeater amplifying any in-band noise | I/N = Repeater Gain – Coupling Loss to the BS (including Building Entry Loss) |

### Methodology Part 4: Aggregate Noise Analysis Set-up

A1.18 An aggregate analysis is carried out, based on the worst I/N result created from a single 'multi-operator' repeater in any test deployment location and height.

A1.19 This analysis is similar to the analysis detailed in the 2017 Repeaters Statement (Annex 2), and calculates the total number of repeaters that can be tolerated per sector, based on a limited noise rise in the mobile network of 0.5 dB (aggregate I/N = –10 dB).

a) This aggregate analysis results in a conservative number of 'multi-operator' repeaters, because many 'multi-operator' repeater deployments will cause less interference individually to the MNO network (see Figure 6 and Figure 7). However, this analysis assumes that all 'multi-operator' repeaters cause the same impact (I/N), based on the worst result from Methodology Part 2.

b) The analysis initially calculates the maximum number of simultaneously active 'multi-operator' repeaters which can be tolerated in any one frequency band per sector.

c) The analysis then calculates the total number of 'multi-operator' repeaters which can be tolerated per sector, based on some assumptions that Ofcom consider to be conservative.

    i) A very conservative test case also analysed, in order to fully assess this scenario.

A1.20 The aggregate impact processing requires the following parameters:

**Table 4: Aggregate analysis input parameters**

| Parameters | Value |
|---|---|
| Acceptable aggregate I/N, corresponding to a noise rise in the mobile network limited to 0.5 dB | –10 dB |
| *Factors included in the aggregate I/N calculation, to determine the maximum number of simultaneously active 'multi-operator' repeaters in any one frequency band:* I/N caused by a single BS. | Worst I/N result determined in the Methodology Part 2. |
| *Factors included in the aggregate I/N calculation, to determine the maximum number of simultaneously active 'multi-operator' repeaters in any one frequency band:* Headroom for other effects. | 3 dB. This allows for effects which might include amplifier overdriving[26] for example. |
| *Factors to determine the maximum number of 'multi-operator' repeaters per sector:* Number of frequency bands | 4 (800 MHz, 900 MHz, 1800 MHz and 2100 MHz).<br>Assume equal likelihood of channel attachment.<br>Exclude the 2100 MHz frequency band from the very conservative case. |
| *Factors to determine the maximum number of 'multi-operator' repeaters per sector:* Number of active repeaters during the busy hour. | 70% active, 30% in standby mode.<br>As detailed in 2017 Repeaters Statement (Annex 2). |
| *Factors to determine the maximum number of 'multi-operator' repeaters per sector:* Number of frequency bands active per repeater. | 1 for the conservative case.<br>2 for the very conservative case (e.g. could represent a handset utilising carrier aggregation, or simultaneous use of two carriers by two independent handsets). |

## Analysis Results

### Worst-case I/N

A1.21 Histograms of the I/N results from Methodology Part 3 of the analysis are given below. These show the distribution of I/N caused by a single 'multi-operator' repeater on the surrounding BSs, from all of the repeater test locations and heights[27].

[26] Amplifier overdriving may occur when a handset is briefly held too close to the repeater.
[27] Note: Less results are given for the test deployment location height of 10.5 m, as this was only assessed for urban/dense urban test deployment locations.

A1.22 The worst I/N result from modelling the 800 MHz band, out of a total of 197,992[28] I/N results, is −40.52 dB.

A1.23 The worst I/N result from modelling the 1800 MHz band, out of a total of 183,298[29] I/N results, is −37.08 dB.

[28] Total number of results is based on the following: 2 MNOs, 2438 repeater test location, 3 repeater test heights, 20 surrounding BS per repeater test location = 281,760 test results. However, due to the 3rd test height (10.5 m) only being tested for urban/dense urban scenarios, the number of total test results produced is slightly less. Additionally, due to the coverage model only assessing the BSs within 50 km of the repeater test location, and some locations having less than twenty 800 MHz BS within 50 km, the number is further reduced.

[29] Total number of results is based on the following: 2 MNOs, 2438 repeater test location, 3 repeater test heights, 20 surrounding BS per repeater test location = 281,760 test results. However, due to the 3rd test height (10.5 m) only being tested for urban/dense urban scenarios, the number of total test results produced is slightly less. Additionally, due to the coverage model only assessing the BSs within 50 km of the repeater test location, and some locations having less than twenty 1800 MHz BS within 50 km, the number is further reduced. Note: The repeater test locations that have less than twenty 1800 MHz BS within 50 km can differ from those repeater test locations that have less than twenty 800 MHz BS within 50 km, resulting in a different number of total test results per band.

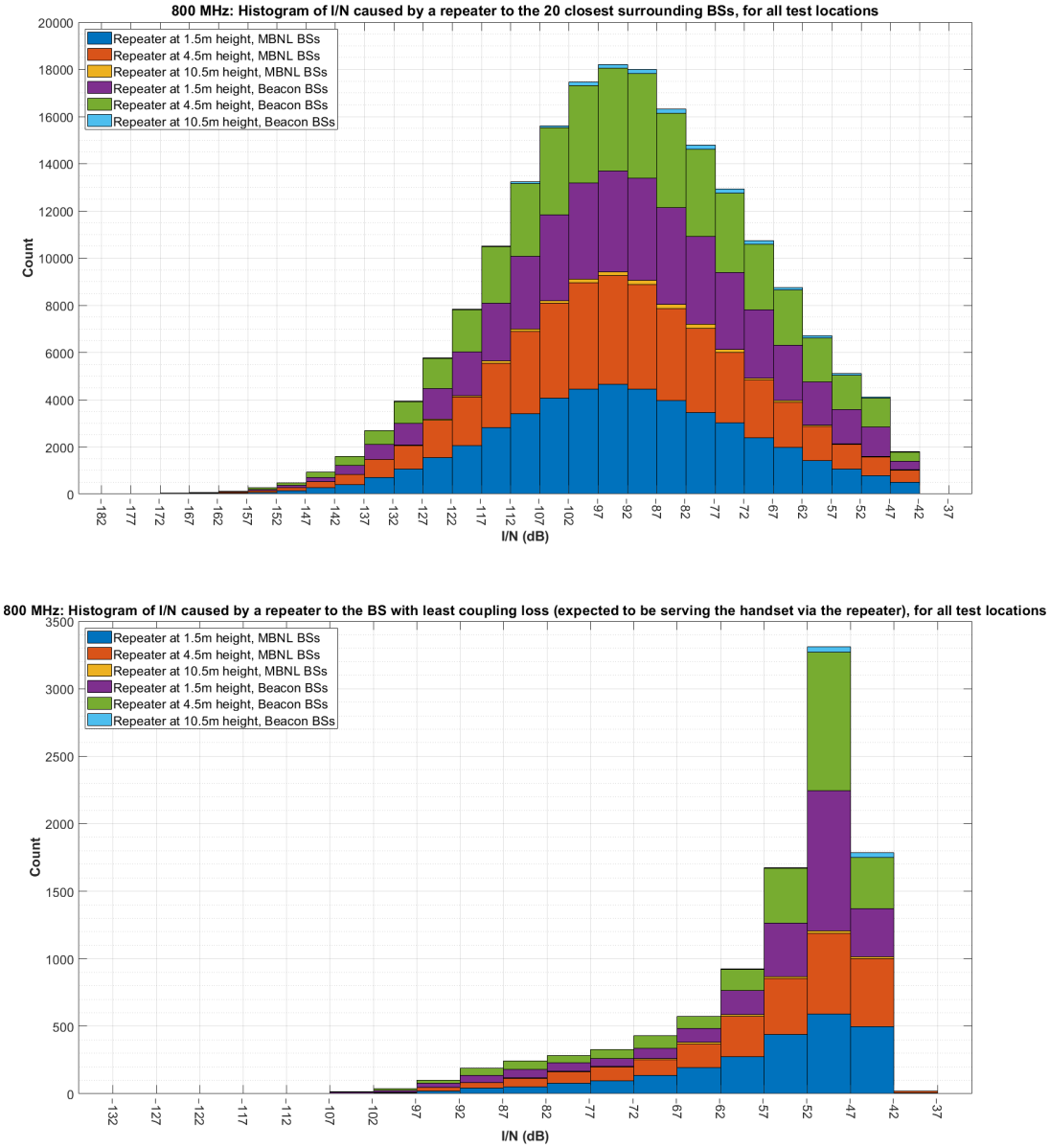


**Figure 2: 800 MHz I/N results histograms**

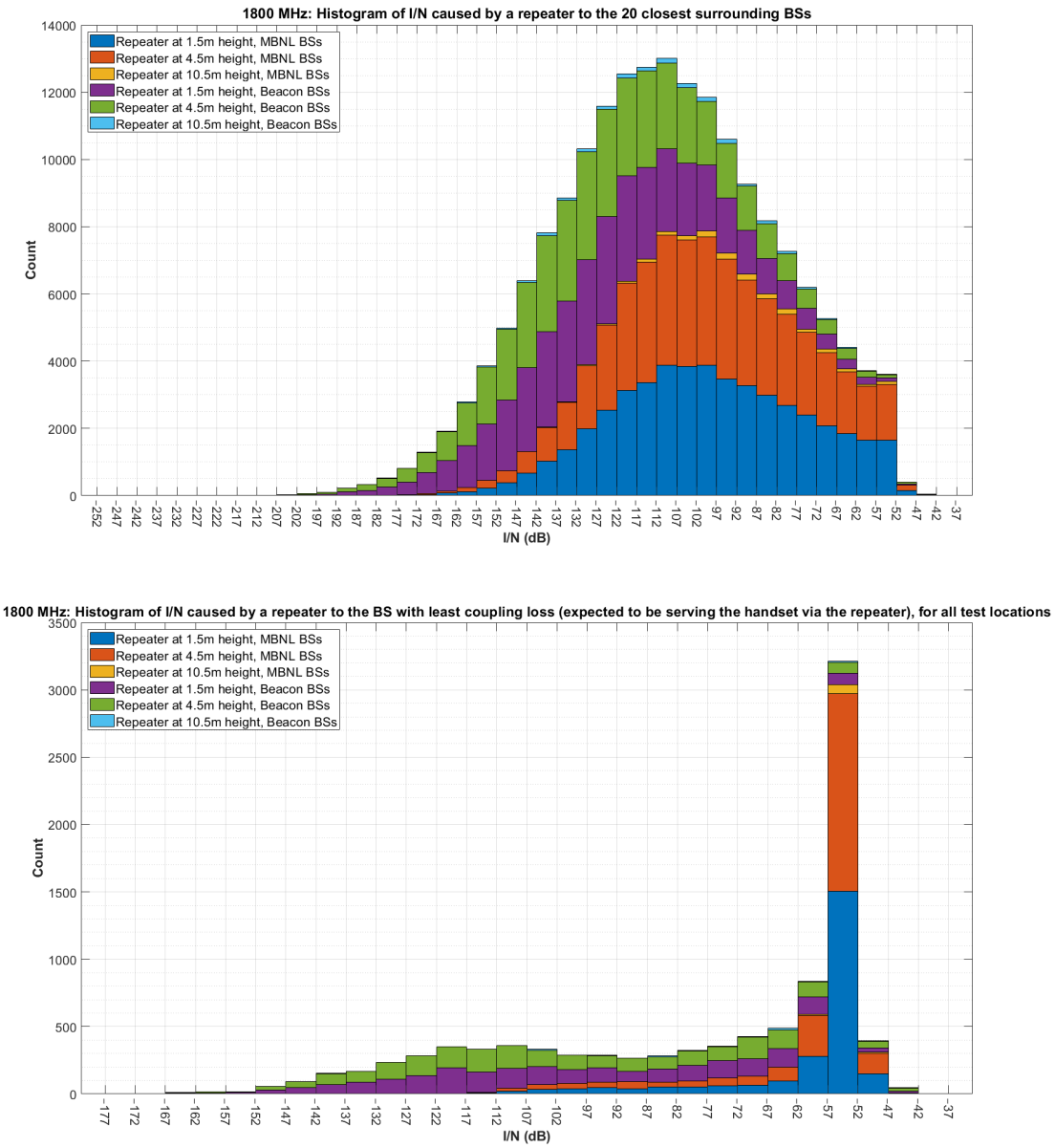


**Figure 3: 1800 MHz I/N results histogram**

## Maximum Number of Simultaneously Active 'Multi-operator' Repeaters in any Frequency Band

A1.24 Based on the worst I/N result of −37 dB, caused by a 'multi-operator' repeater in one of the test deployment locations amplifying the 1800 MHz band, a total of 250 simultaneously active 'multi-operator' repeaters can be tolerated in any one frequency band. This is based on a maximum tolerable noise rise in the mobile network of 0.5 dB at any BS, and is summarised as follows:

**Table 5: Calculation of number of active 'multi-operator' repeaters that can be tolerated per frequency band**

| | | |
|---|---|---|
| ***WORST I/N per repeater*** | −37 dB | This I/N per 'multi-operator' repeater is based on the worst impact result. Therefore, the resultant number of simultaneously active 'multi-operator' repeaters that can be |

| | | |
|---|---|---|
| | | tolerated is conservative. In many cases, a smaller I/N is produced, meaning a larger number of 'multi-operator' repeaters could be tolerated per band in a sector. |
| *Headroom for effects not considered in this analysis* | 3 dB | Other effects that have not been considered in this analysis might include amplifier overdriving, when a handset is briefly held too close to a repeater, for example. |
| *Margin for aggregate noise from multiple multi-operator repeaters per band* | 24 dB | This additional 24 dB of margin allows for up to 250 'multi-operator' repeaters to simultaneously amplify each frequency band in a sector without exceeding the target I/N threshold. We discuss what we consider to be a reasonable assumption for number of mobile probe repeaters attached to a single frequency band within a sector later in this Annex. |
| ***TARGET I/N per band*** | −10 dB | The target I/N at the mobile phone base station receiver is −10 dB which means that the noise rise in the mobile network base station will not exceed 0.5 dB. |

### Maximum Number of 'Multi-operator' Repeaters per Sector

A1.25 The technical requirement which ensures that the repeater enters standby mode after not being used for 5 minutes, ensuring that the repeater is not active when it is not needed, reduces the number of 'multi-operator' repeaters that are simultaneously amplifying any band at any time, further reducing the in-band noise generated by repeaters.

A1.26 Based on this requirement, and the number of frequency bands available for use, we estimate that the total number of 'multi-operator' repeaters that could be tolerated in a sector is approximately 1400, as shown in Table 6 below. We consider that we have made some conservative assumptions in this estimate. However, to fully test our assumptions, we have additionally considered a very conservative case which still estimates 525 repeaters could be tolerated in a sector.

**Table 6: Calculation of total number of 'multi-operator' repeaters that can be tolerated per sector**

| Mitigation Factor | Conservative | | Very Conservative | |
|---|---|---|---|---|
| | Multiplier | Total | Multiplier | Total |
| Maximum of 250 simultaneously active 'multi-operator' repeaters per in any frequency band | - | 250 | | 250 |
| 5 bands available. Exclude the 2100 MHz frequency band for very conservative case. | ×4 | 1000 | ×3 | 750 |

| | | | | |
|---|---|---|---|---|
| Assume equal likelihood of channel attachment. | | | | |
| Assume 70% of repeaters active during the busy hour, and the remaining 30% are in standby mode | ×1.4 | 1400 | ×1.4 | 1050 |
| Assume one band active per repeater; two for the very conservative case (e.g. could represent carrier aggregation or simultaneous use of two carriers independently) | ×1 | 1400 | ×0.5 | 525 |
| **Total tolerable 'multi-operator' repeaters per sector** | | **1400** | | **525** |

### Examining the percentage of premises at which a 'multi-operator' repeater can be deployed

A1.27 We examined the number of premises in sectors to understand the penetration rates that would be necessary for over 1400 'multi-operator' repeaters to be used in a sector.

A1.28 Across the UK, there might typically be 500 premises in a sector because there are around 30 million premises in the UK and each MNO has around 20 thousand macro sites, typically split into three sectors. However, we recognise that this can vary significantly from sector to sector, so we also investigated a rural scenario and a tower block scenario.

A1.29 We set out our results in Table 9 below, showing that for a typical UK sector there would have to be an extraordinarily high penetration of 'multi-operator' repeaters, more than two in every premise, for the number of 'multi-operator' repeaters in a sector to exceed 1400. Even for the very conservative case, more than one 'multi-operator' repeater in every premises is needed to exceed the total tolerable number, and we do not consider this to be realistic.

A1.30 Indoor mobile phone repeaters "get the outside signal indoors" and so will be of greatest use to those users in premises who have outdoor coverage, but no indoor coverage. Our most recent Connected Nations report[30] showed that around 4 to 8% of premises are in that position. We consider that these premises are those most likely to benefit from a mobile phone repeater and users in these premises may decide to install one. However, users in these premises may also use alternative indoor solutions, such as femtocells and Wi-Fi, and so not all of these users in such premises will install indoor mobile phone repeaters.

A1.31 In Table 9 we can see that the 'multi-operator' repeater penetration rate would be very high per premises even in very extreme scenarios including very large rural sectors (e.g. Inverurie, Scotland) and ultra-dense urban sectors containing many tower blocks (e.g. New Cross, London). We therefore do not consider it realistic that the aggregate noise radiated by 'multi-operator' repeaters will cause a noise rise of greater than 0.5 dB in mobile networks.

[30] Connected Nations 2020 - https://www.ofcom.org.uk/research-and-data/multi-sector-research/infrastructure-research/connected-nations-2020

**Table 7: Repeater deployment scenarios and the maximum 'multi-operator' repeater penetration rates necessary to exceed a noise rise in the mobile network of more than 0.5 dB**

| Location | Scenario | Cell Radius | Premises in the cell | Premises per sector[a] | Max pene-tration rate (cons.)[b] | Max pene-tration rate (v. cons.)[c] |
|---|---|---|---|---|---|---|
| Typical, *UK* | UK-wide average | - | 1500 | 500 | 280% | 105% |
| Waunfawr, *Wales* | Cons. Rural, *Few villages* | 7.2 km | 941 | 314 | 446% | 167% |
| Inverurie, *Scotland* | V. Cons. Rural, *Larger town* | 4.7 km | 6508 | 2169 | 65% | 24% |
| St. Luke's, *London* | Cons. Urban, *Tower Blocks* | 0.4 km | 3310 | 1103 | 127% | 48% |
| New Cross, *London* | V. Cons. Urban, *Tower Blocks* | 0.9 km | 7229 | 2410 | 58% | 22% |

[a] Assuming three sectors per cell.

[b] The percentage of premises in each sector which would have to install a 'multi-operator' repeater for the total number of 'multi-operator' repeaters in the sector to exceed 1400, as calculated using our conservative assumptions in Table 8.

[c] The same as for [b], but using the very conservative values from Table 8 to calculate the percentage of premises in each sector which would have to install a 'multi-operator' repeater for the total number of 'multi-operator' repeaters in the sector to exceed 525.

### Examining the impact of more than 250 'multi-operator' repeaters per frequency band on BS noise rise

A1.32 In the very unlikely event where more than 250 'multi-operator' repeaters simultaneously amplify an individual frequency band within any sector, the noise rise in the mobile network will remain low.

A1.33 Our analysis shows that the noise rise is relatively insensitive to the number of simultaneously active 'multi-operator' repeaters. For example, over 630 simultaneous active users would need to attach to a single band for the noise rise in the mobile phone base station received to exceed 1 dB, even when considering that the additional 3 dB protection margin has been fully used. The impact of this would be to slightly desensitise the mobile phone base station on that band, consequently slightly reducing the sector size and slightly reducing uplink throughput on that carrier. However, as we say above, we think that more than 250 'multi-operator' repeaters attaching simultaneously to a given frequency band is very unlikely to occur in practice.

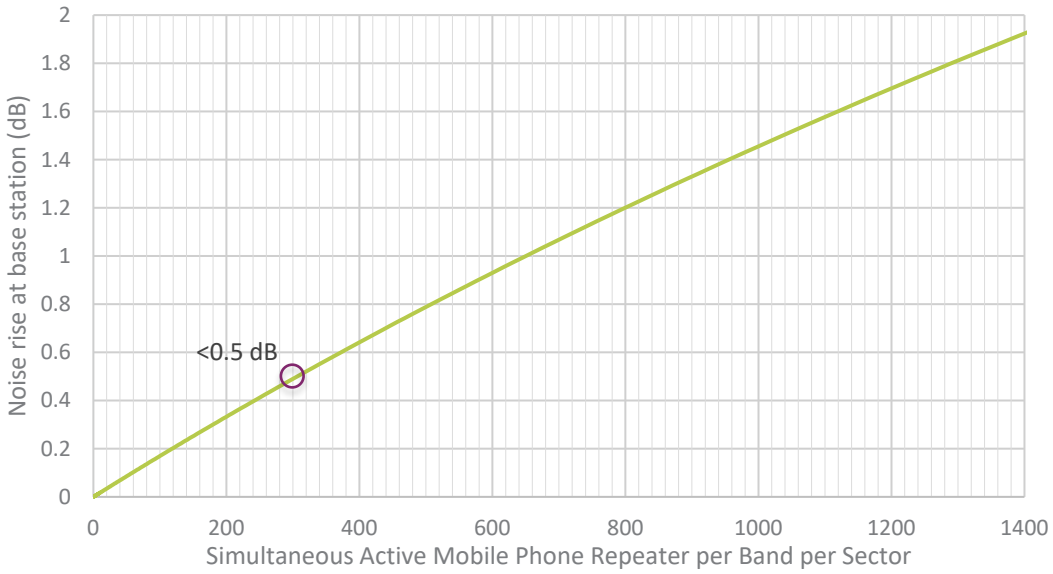


**Figure 4: Sensitivity analysis of the aggregate noise rise at any mobile network base station plotted against the number of simultaneous active 'multi-operator' repeaters in the sector**

## Analysis Provisional Conclusion

A1.34 Our provisional view is that a technical requirement which limits the transmit gain control for 'multi-operator' repeaters to 10 dB−RSSI, along with the maximum power limits and further technical conditions proposed in paragraphs 3.23 to 3.43, would be sufficient to ensure undue interference or other adverse effects on the technical quality of service of MNO networks in unlikely to occur.

A1.35 Our proposed technical requirements for 'multi-operator' mobile phone repeaters limit the noise rise in mobile networks by setting a gain control equation which limits the noise received at the surrounding BS, as well as reducing the number of 'multi-operator' repeaters which will simultaneously amplify any individual band at any one time by enforcing an automatic standby requirement.

a) We examined the I/N caused by a single 'multi-operator' repeater in a range of scenarios, including large rural macrocells and ultra-dense urban sectors. The proposed gain control ensures that the I/N caused by any individual 'multi-operator' repeater is limited to −37 dB, based on the worst result from the modelling.

b) We then assessed the number of 'multi-operator' repeaters that could be deployed within the same frequency band and sector before the aggregate I/N exceeded the protection limit of I/N = −10 dB. The aggregate analysis assumes that all 'multi-operator' repeater deployments result in the worst I/N result from all of the deployment scenarios modelled. In practice, many deployment scenarios would result in the 'multi-operator' repeater causing less impact (a lower I/N). Therefore, the results of this analysis are conservative, and it is expected that more 'multi-operator' repeaters could be deployed per band and sector before the I/N requirement is exceeded in reality.

c) Finally, we examined the typical number of premises within any BS sector, as well as the number of premises within a BS sector for more extreme scenarios including large rural macro-cells and ultra-dense urban sectors containing tower blocks, to understand the penetration of 'multi-operator' repeaters that is required to exceed the I/N protection limit. Our analysis found that, even in the most extreme scenarios, the number of 'multi-operator' repeaters that might be deployed would be unlikely to cause a noise rise of more than 0.5 dB in the surrounding mobile phone base station receivers.

A1.36 Putting the point another way, the technical requirements we propose, assuming the use of 250 'multi-operator' repeaters to simultaneously amplifying an individual frequency band, would allow, in effect, for 1400 'multi-operator' repeaters being used within a sector without being likely to cause the negative effects proscribed by section 8(4) of the WT Act. For the reasons explained, that level of use, and those effects, are not likely to occur.

# A2. Proposed changes to the UK Radio Interface Requirement for License Exempt Provider-Specific Static Mobile Phone Repeaters for Indoor Use

A2.1 This annex shows the changes that we are proposing to make to **IR 2102.1** using tracked changes. We have taken the following approach to show the changes that we are proposing to make:

a) the words in yellow highlight (and in bold font) are those that we are proposing to insert (e.g. "**example**");

b) the words struck through are those that we are proposing to delete (e.g. "~~example~~").

| IR2102.1: Minimum requirements for the use of: **provider-specific** static mobile phone repeaters for indoor use | | | |
|---|---|---|---|
| Mandatory (1-11) | | | |
| 1 | Radiocommunication Service | Mobile | |
| 2 | Application | **Provider-specific** static mobile phone repeaters for indoor use | |
| 3 | Frequency band | **700** | **703-733 MHz (Uplink)**<br>**758-788 MHz (Downlink)** |
| | | 800 | 791-821 MHz (Downlink)<br>832-862 MHz (Uplink) |
| | | 900 | 880-915 MHz (Uplink)<br>925-960 MHz (Downlink) |
| | | 1800 | 1710-1785 MHz (Uplink)<br>1805-1880 MHz (Downlink) |
| | | 2100 | 1920-1980 MHz (Uplink)<br>2110-2170 MHz (Downlink) |
| 4 | Channelling | Not specified | |
| 5 | Modulation / Occupied bandwidth | Not specified | |
| 6 | Direction / Separation | Repeater transmit/receive | |
| 7 | Transmit power/Power density | See Table A1 | |
| 8 | | **Transmit Gain Control** | |

| | | |
|---|---|---|
| | Channel access and occupation rules | The uplink and downlink system gain in dB of a repeater, referenced to its input and output ports, shall not exceed BSCL−30, where BSCL (base station coupling loss) is the path loss between the base station and the repeater. Where BSCL cannot be determined, the repeater must not transmit<br><br>The uplink and downlink system gain of a repeater shall not exceed 100 dB.<br><br>The apparatus shall determine the value of BSCL by calculating the difference between the carrier power received at the repeater and the carrier power transmitted from the base station. The carrier power transmitted by the base station may be determined from the system information messages sent by the base station on its control channels. |
| | | **Automatic Standby**<br><br>When the repeater is no longer serving an active device connection it must, after no more than 5 minutes, reduce any uplink noise power to no more than −70 dBm/MHz EIRP. |
| | | **Anti-Oscillation**<br><br>Repeaters must detect and mitigate (i.e. by automatic gain reduction or shut down) any oscillations in uplink and downlink bands. Oscillation detection must occur automatically within:<br><br>0.3 seconds in the uplink band; and<br><br>1 second in the downlink band.<br><br>In cases where oscillation is detected, the repeater must continue this mitigation for at least one minute before restarting. After five such restarts, the repeater must not resume operation until manually reset. |
| | | **Provider Specific ~~Signal Operator~~ configuration**<br><br>**In respect of each frequency band,** the **Transmit Power/Power Density and Transmit Gain Control requirements** ~~amplified frequencies~~ shall be **calculated and applied individually for** ~~limited to~~ those **frequencies** licensed to a single mobile network operator.<br><br>**Where a repeater is capable of amplifying frequencies in respect of more than one mobile network at a time, the Transmit Power/Power Density and Transmit Gain** |

| | | |
|---|---|---|
| | | **Control requirements shall be calculated and apply individually for the frequencies of each specific network.**<br><br>~~The equipment may be re-configured to alternate frequencies but may only operate using frequencies licensed to a single operator when configured..~~ |
| | | **Noise Figure**<br><br>The repeater system noise figure shall not exceed 7 dB. |
| 9 | Authorisation regime | License Exempt[31] |
| 10 | Additional essential requirements | Nil |
| 11 | Frequency planning assumptions | Not specified |
| **Informative (12-15)** | | |
| 12 | Planned changes | Nil |
| 13 | Reference | EN 303 609<br><br>EN 301 908-11<br><br>EN 301 908-15 |
| 14 | Remarks | The deployment of a 4G only **provider-specific static mobile phone repeater** ~~transmitters~~ is not permitted. **When transmitting a 4G signal for a mobile network operator,** all **provider-specific static mobile phone** repeaters must also transmit a 2G and/or a 3G signal **for that mobile network operator**. |
| 15 | Notification Number | ~~2017/509/UK~~ |

## Table A1

| **Band** | **Technology** | **Maximum Uplink Power** | **Maximum Downlink Power (indoor use only)** |
|---|---|---|---|
| **700 &** 800 | Technology Neutral | 23 dBm EIRP | PSD 10 dBm / 5 MHz EIRP; and Total 17 dBm EIRP |
| 900 | GSM | 33 dBm EIRP | 10 dBm EIRP |
| 1800 | GSM | 30 dBm EIRP | 10 dBm EIRP |
| 900, 1800 & 2100 | 3G | 24 dBm EIRP | PSD 10 dBm / 5 MHz EIRP; and Total 17 dBm EIRP |

[31] See remarks

| | | | |
|---|---|---|---|
| 900 & 1800 | LTE & WiMAX | 23 dBm EIRP | PSD 10 dBm / 5 MHz EIRP; and<br>Total 17 dBm EIRP |
| 2100 | Technology Neutral | 24 dBm EIRP | PSD 10 dBm / 5 MHz EIRP; and<br>Total 17 dBm EIRP |
| Where PSD is power spectral density | | | |

# A3. Proposed UK Radio Interface Requirement for License Exempt Multi-Operator Static Mobile Phone Repeaters for Indoor Use

| IR2102.3: Minimum requirements for the use of multi-operator static mobile phone repeaters for indoor use | | | |
|---|---|---|---|
| **Mandatory (1-11)** | | | |
| 1 | Radiocommunication Service | Mobile | |
| 2 | Application | Multi-operator static mobile phone repeaters for indoor use | |
| 3 | Frequency band | **700** | 703-733 MHz (Uplink)<br>758-788 MHz (Downlink) |
| | | **800** | 832-862 MHz (Uplink)<br>791-821 MHz (Downlink) |
| | | **900** | 880-915 MHz (Uplink)<br>925-960 MHz (Downlink) |
| | | **1800** | 1710-1785 MHz (Uplink)<br>1805-1880 MHz (Downlink) |
| | | **2100** | 1920-1980 MHz (Uplink)<br>2110-2170 MHz (Downlink) |
| 4 | Channelling | Not specified | |
| 5 | Modulation / Occupied bandwidth | Not specified | |
| 6 | Direction / Separation | Repeater transmit/receive | |
| 7 | Transmit power/Power density | **Maximum Uplink Power per Band** | 17 dBm / 5 MHz EIRP |
| | | **Maximum Downlink Power per Band** | 10 dBm / 5 MHz EIRP (indoor use only) |
| 8 | Channel access and occupation rules | **Transmit Gain Control**<br>The uplink and downlink system gain in dB of a repeater, reference to its input and output ports, shall not exceed 10−RSSI, where RSSI is the downlink composite received signal power in dBm at the | |

| | | |
|---|---|---|
| | | repeater donor port, for all base stations in the band of operation.<br><br>The uplink and downlink system gain of a repeater shall not exceed 100 dB. |
| | | **Automatic Standby**<br><br>When the repeater is no longer serving an active device connection it must, after no more than 5 minutes, reduce any uplink noise power to no more than −70 dBm/MHz EIRP. |
| | | **Anti-Oscillation**<br><br>Repeaters must detect and mitigate (i.e. by automatic gain reduction or shut down) any oscillations in uplink and downlink bands. Oscillation detection must occur automatically within:<br><br>0.3 seconds in the uplink band; and<br><br>1 second in the downlink band.<br><br>In cases where oscillation is detected, the repeater must continue this mitigation for at least one minute before restarting. After five such restarts, the repeater must not resume operation until manually reset. |
| | | **Noise Figure**<br><br>The repeater system noise figure shall not exceed 7 dB. |
| 9 | Authorisation regime | License Exempt[32] |
| 10 | Additional essential requirements | Nil |
| 11 | Frequency planning assumptions | Not specified |
| **Informative (12-15)** | | |
| 12 | Planned changes | Nil |
| 13 | Reference | EN 303 609<br><br>EN 301 908-11<br><br>EN 301 908-15 |
| 14 | Remarks | All multi-operator static mobile phone repeaters must transmit the entirety of the 900, 1800 and 2100 frequency bands as defined in **Mandatory 3**. |

[32] See remarks

| | | |
|---|---|---|
| | | This requirement ensures that the 2G/3G layers of all MNOs are repeated by the multi-operator repeater, ensuring that 4G-only hotspots are not created in premises using a licence exempt repeater. |
| 15 | Notification Number | TBD |

# A4. Responding to this consultation

## How to respond

A4.1 Ofcom would like to receive views and comments on the issues raised in this document, by 5pm on **28 July 2021**.

A4.2 You can download a response form https://www.ofcom.org.uk/consultations-and-statements/category-1/mobile-phone-repeaters-extended-range. You can return this by email or post to the address provided in the response form.

A4.3 If your response is a large file, or has supporting charts, tables or other data, please email it to mobilephonerepeaters@ofcom.org.uk, as an attachment in Microsoft Word format, together with the cover sheet. This email address is for this consultation only, and will not be valid after 28 July 2021.

A4.4 Responses may alternatively be posted to the address below, marked with the title of the consultation:

Eniola Awoyale
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A4.5 We welcome responses in formats other than print, for example an audio recording or a British Sign Language video. 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.

A4.6 We will publish a transcript of any audio or video responses we receive (unless your response is confidential)

A4.7 We do not need a paper copy of your response as well as an electronic version. We will acknowledge receipt if your response is submitted via the online web form, but not otherwise.

A4.8 You do not have to answer all the questions in the consultation if you do not have a view; a short response on just one point is fine. We also welcome joint responses.

A4.9 It would be helpful if your response could include direct answers to the questions asked in the consultation document. The questions are listed at Annex A7. 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.

A4.10 If you want to discuss the issues and questions raised in this consultation, please contact Eniola Awoyale on 020 7783 4680, or by email to mobilephonerepeaters@ofcom.org.uk.

## Confidentiality

A4.11 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 all responses on the Ofcom website as soon as we receive them.

A4.12 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 don't have to edit your response.

A4.13 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.

A4.14 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

A4.15 Following this consultation period, Ofcom plans to publish a policy statement in late 2021.

A4.16 If you wish, you can register to receive mail updates alerting you to new Ofcom publications.

## Ofcom's consultation processes

A4.17 Ofcom aims to make responding to a consultation as easy as possible. For more information, please see our consultation principles in Annex A5.

A4.18 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.

A4.19 If you would like to discuss these issues, or Ofcom's consultation processes more generally, please contact the corporation secretary:

Corporation Secretary
Ofcom
Riverside House
2a Southwark Bridge Road
London SE1 9HA
Email: corporationsecretary@ofcom.org.uk

# A5. Ofcom's consultation principles

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

### Before the consultation

A5.1 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

A5.2 We will be clear about whom we are consulting, why, on what questions and for how long.

A5.3 We will make the consultation document as short and simple as possible, with a summary of no more than two pages. We will try to make it as easy as possible for people to give us a written response. If the consultation is complicated, we may provide a short Plain English / Cymraeg Clir guide, to help smaller organisations or individuals who would not otherwise be able to spare the time to share their views.

A5.4 We will consult for up to ten weeks, depending on the potential impact of our proposals.

A5.5 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.

A5.6 If we are not able to follow any of these seven principles, we will explain why.

### After the consultation

A5.7 We think it is important that everyone who is interested in an issue can see other people's views, so we usually publish all the responses on our website as soon as we receive them. 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.

# A6. 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 | o |
| Name/contact details/job title | o |
| Whole response | o |
| Organisation | o |
| Part of the response | o |

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 seeks to publish responses on receipt. 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)

# A7. Consultation questions

A7.1 This annex lists the questions we are consulting on.

Questions:

Question 1: Do you agree that Ofcom should consider working with relevant industry partners to develop a voluntary testing standard, and publishing a list on our website of static indoor mobile phone repeaters that comply with our licence exemption requirements?

Question 2: Do you agree that we should modify IR 2102.1 to allow for 'provider specific' mobile phone repeaters? If you do not agree, please explain your reasons.

Question 3: Do you agree that we should make 'multi-operator' mobile phone repeaters complying with the technical requirements outlined above (and set out in the draft UK Radio Interface Requirement IR 2102.3 at Annex A3) licence exempt? If you do not agree, please explain your reasons.

Question 4: Do you agree with our provisional view as set out in paragraph 3.48 above? If you do not agree, please explain why you think the requirement is not necessary.

Question 5: Do you agree that it would not be appropriate to allow the use of licence-exempt repeaters in the 2.6 GHz band? If you do not agree, please explain your reasons.

Question 6: Do you agree that we should allow the use of static indoor mobile phone repeaters (on a licence-exempt basis) in the paired 700 MHz mobile band?