Ofcom
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Mobile Phone Repeaters

Extending the range of repeaters that can be used by people to improve their indoor mobile coverage

STATEMENT

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Annex

1. Overview

Mobile services are seen as a vital part of daily life and people expect their mobile devices to work reliably wherever they are.

Although mobile coverage is constantly improving, some people still find it difficult to get a consistently good signal, particularly indoors. In some circumstances, the use of a mobile repeater device can boost a good outdoor signal so it can penetrate more effectively indoors.

Until recently, the use of such devices was unlawful without a licence from Ofcom because of concerns about interference to networks and other users. But in 2018 Ofcom decided to allow consumers to install and use a limited range of repeaters ('single operator repeaters') to boost the signals of one mobile operator at a time.

Since then, further technical analysis has satisfied us that we can safely extend the range of self-installed repeater devices that can operate without a licence.

This document sets out our final decisions on proposals set out in a consultation published in May 2021.

What we have decided – in brief

We have decided to extend the range of static indoor repeaters available for people to buy and install themselves without a licence. In particular, we will allow the use of two additional types of repeater:

- provider specific repeaters; and
- multi-operator repeaters.

Both these types of repeater may amplify the frequencies of more than one mobile operator at a time, provided they meet appropriate technical requirements specified by Ofcom.

In order to help the public identify repeaters that can be 'legally' used without a licence – rather than 'illegal' devices that risk causing interference – we have also decided to publish on our website a list of mobile phone repeaters that we understand comply with the technical requirements of our licence exemption regime.

To be clear, Ofcom will not endorse or approve particular products. Instead, the list will simply identify devices that have been subjected to testing by an accredited test house to show they meet our technical requirements, using a voluntary testing standard produced by Ofcom.

Our decisions will be implemented in early 2022 after licence Exemption Regulations come into force. Until then, the use of mobile phone repeaters, apart from those single operator repeaters covered by our existing licence exemption and those supplied and operated under the control of a mobile network operator, will remain unlawful.

N.B This overview section in this document is a simplified high-level summary only. The decisions we have taken, and our reasoning, are set out in the full document.

2. Introduction and background

2.1 Mobile services are seen as an essential part of everyday life, and there is an ever-growing expectation that those services should work reliably wherever we are. People want the services they buy to work effectively to provide easy communication with friends and family; access to the internet; the smooth conduct of business; the delivery of entertainment; the operation of 'smart' devices; and much more.

2.2 Mobile coverage is always improving, with investment in better infrastructure and technology. But some people still struggle with poor quality signals and inadequate coverage – especially indoors, where consumers also expect to receive a good service.

2.3 In this section, we explain briefly the options currently available to consumers looking to improve their coverage, and the proposals on which Ofcom consulted in May 2021, as well as the key statutory provisions.

Options for consumers looking to improve their coverage

2.4 There is a range of options open for improving indoor mobile coverage, and consumers may wish to seek advice from their network operator. In some circumstances, network operators may be prepared to supply additional technology, such as femto cells or operator-provided mobile repeaters to boost the signal.

2.5 Alternatively, some customers may turn to solutions installed by specialist companies – although these solutions can be expensive for individual consumers, and may be more suitable for customers such as small businesses needing to serve multiple devices throughout an office or factory.

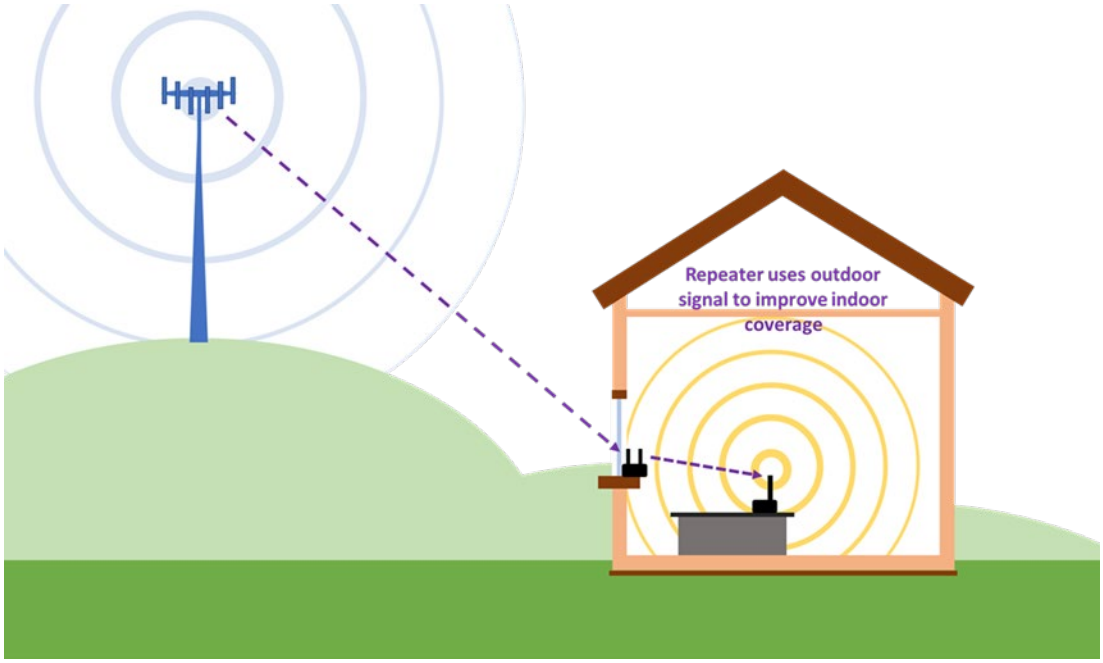
2.6 In recent years, indoor coverage has been boosted by the increasing support, by network operators, for domestic Wi-Fi to handle calls and send SMS messages (e.g. using Wi-Fi calling). Wi-Fi calling depends on the compatibility of particular mobile phones, however virtually all modern devices support this feature (though it may need to be enabled in 'settings' before it can be used).

2.7 This solution is not always available to everyone however, and some people opt to use self-installed mobile phone repeaters as a means of improving indoor coverage. These devices can boost the signals between a network operator's base station and a mobile phone, and so improve access to mobile services. They are often placed in a window of a home or office where the outdoor mobile signal can more easily be accessed.

2.8 Self-installed repeaters can provide a good solution for some consumers. For example, they may work well for domestic consumers where there is a reasonable outside signal but poor coverage indoors. However, they may not work in all circumstances (for example if the outdoor mobile signal is poor or non-existent) and in many other circumstances alternative solutions may work better depending on the users' needs.

2.9 Until 2018, the use of self-installed mobile repeaters was illegal[1] in the UK. Mobile repeaters were only allowed if installed and operated by a mobile operator within the terms of their licence. The requirement for a licence was applied because of the potential for poorly designed repeaters to cause harmful interference to the mobile phone networks and other services.

Figure 2.1: Use of a mobile repeater to boost the indoor mobile signal



2.10 However, the situation led to a thriving market in illegal poor-quality devices as businesses and consumers nevertheless sought to find ways of improving their mobile reception. In many cases, the sellers of these devices claimed falsely that their products complied with UK regulations.

2.11 Although Ofcom acted against such suppliers, and confiscated installed equipment where it was discovered, we also began to consider whether alternative approaches might be appropriate. We wanted to help consumers achieve the reliable coverage they sought without any resulting problems for mobile operators.

2.12 This led us to consider whether it would be appropriate to allow people to install and use some types of repeaters - provided they complied with important technical requirements and could operate without causing interference.

[1] Where we refer to 'illegal' repeaters in this statement, we mean repeaters which do not meet our licence exemption criteria and for which the owner does not hold a Wireless Telegraphy Act licence.

2.13 As a result of our analysis, and a public consultation, we made regulations in 2018 allowing people and businesses to install and use certain static mobile phone repeaters for indoor use on a licence exempt basis. The conditions included a requirement that devices only boosted the signal of one mobile network operator at any one time (we refer to these devices as 'single operator' repeaters).

Our 2021 consultation

2.14 Having reviewed the operation of the 2018 regulations following their introduction, we considered whether there were any further changes we could make to remove unnecessary restrictions and provide people with a wider choice of repeaters to improve their indoor mobile coverage

2.15 In May 2021 we published a new public consultation ('the 2021 Repeaters Consultation') outlining proposals to further extend the range of static repeaters available for people to buy and install themselves without a licence. In particular, we proposed to allow repeaters that operate on the frequencies of more than one mobile operator - 'provider specific' and 'multi-operator' repeaters - provided they met our proposed technical requirements.

2.16 One factor behind our new proposals was the recognition that the 2018 regulations had represented a cautious approach to the introduction of legal self-installed repeaters. Further technical analysis satisfied us that it would be appropriate to consult on extending the range of repeaters that could be installed and used on a licence exempt basis, because the conditions we were proposing to apply meant they were not likely to have an adverse impact on mobile networks or other services.

2.17 We also noted some restrictions that did not need to be maintained. For example, the 2018 requirements allowed installers to place two or more 'single operator' repeaters next to each other to boost the signals of more than one operator. The same improvement could be achieved more simply and cheaply in one device with no greater impact on other services – but that is, at present, illegal.

2.18 A further factor behind the proposals set out in the 2021 Repeaters Consultation was that the use of illegal repeaters remains a concern. This is because legal repeaters that comply with our current regulations tend to be significantly more expensive than their illegal counterparts - in part, reflecting the complexity of the technical requirements we put in place, chiefly to prevent undue interference.

2.19 The result is that the market for lawful licence exempt repeaters has not expanded in the way we had hoped, whilst the market for illegal repeaters has been maintained.

2.20 Many illegal repeaters boost the signals of multiple networks simultaneously, making them particularly attractive for households which may contain people using handsets provided by different mobile operators (noting that illegal repeaters rarely, if ever, incorporate the features necessary to prevent undue interference).

2.21 This apparent advantage would be mitigated if repeaters that *do* incorporate the technical features necessary to prevent undue interference, could also boost the signals of multiple networks simultaneously and could be installed and used on a licence exempt basis.

2.22 Separately, we believe consumers may be struggling currently to identify which mobile repeaters are compliant with the regulations and which are not. Our enforcement work suggests that a range of off-shore companies continue to place non-compliant repeaters on the UK market – often claiming they are endorsed by Ofcom and/or the mobile operators. They are then shipped to the UK with false customs declarations.

2.23 In spite of significant efforts by Ofcom's Spectrum Compliance Team, including action to suspend the internet domains used by some suppliers, the market for illegal devices remains extensive. In many cases, businesses and consumers have installed illegal equipment and systems entirely unwittingly, believing them to be legal.

2.24 For this reason, the 2021 Repeaters Consultation also explained that we were considering publication on our website of a list of devices that can be used without a licence. We proposed that a device could only be listed on our website if it had been demonstrated (following testing by an accredited test house and in according with a voluntary testing standard produced by Ofcom) that it complied 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.

Consultation responses

2.25 We received responses to the 2021 Repeaters Consultation from 28 organisations and individuals. Of those, 24 respondents submitted non-confidential responses, although three requested that their identity be withheld. All of the non-confidential responses are published on our website here.

2.26 We have considered all the responses in reaching our decisions. Details of the responses - and our assessment of the points raised by respondents - are included in the following sections of this statement, where relevant.

Statutory context

2.27 Section 8(3) of the Wireless Telegraphy Act 2006 ('WTA') provides that Ofcom has the power to make regulations exempting the establishment, installation or use of wireless telegraphy stations or wireless telegraphy apparatus from the requirement for a wireless telegraphy licence either absolutely or subject to such terms, provisions and limitations as we may specify.

2.28 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.

2.29 Further to the above, under section 8(4), Ofcom has an obligation to make licence exemption regulations in respect of apparatus of particular descriptions where the use of the apparatus is not likely to (amongst other things):

- 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; or
- endanger safety of life.

2.30 The legal framework is set out in more detail at Annex 1.

2.31 We have taken the decisions set out in this document by reference to our statutory duties. For the reasons set out in this document, our assessment is that they are consistent with those duties.

2.32 We also consider that the draft technical requirements set out at Annexes 2 and 3 are also consistent with section 8(3B) of the WTA. They will comprise terms, provisions and limitations of a licence exemption that, for the reasons set out in detail in sections 3 and 4 below, are:

a) **objectively justified** in that they enable Ofcom to expand the range of legal repeaters, for the benefit of citizens and consumers, whilst seeking to ensure that those repeaters are not likely to involve undue interference, endanger safety of life, or have adverse effects on technical quality of service;

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 technical analysis to satisfy ourselves that use of the relevant equipment would not be likely to cause undue interference to the mobile networks, mobile users or other users of the radio spectrum, endanger safety of life, or have adverse effects on technical quality of service, and any restrictions are no more than is necessary to achieve this; and

d) **transparent** in relation to what they are intended to achieve, in that they are described and explained in this document (and in the 2021 Repeaters Consultation) and would be specified in the accompanying relevant Interface Requirements and Exemption Regulations.

Structure of this statement

2.33 The remaining sections of this document are set out as follows:

- **Section 3** considers responses on our proposals to widen the scope of our exemption regime to allow provider specific and multi-operator repeaters, and sets out our decisions on each.
- **Section 4** looks at responses to our proposals on specific spectrum bands (the 2.3 GHz and 700 MHz bands) and our approach to the introduction of 4G-only repeaters. It then goes on to set out our decisions on these issues.
- **Section 5** concentrates on our approach to publishing information about licence exempt repeater devices (including the use of a voluntary testing standard), taking account of consultation responses.
- **Section 6** describes the next steps**.**

3. Widening the scope of the exemption regime

3.1 In the 2021 Repeaters Consultation we proposed to allow people to buy and install for themselves two additional types of static indoor repeater: **provider specific repeaters** and **multi-operator repeaters**. Both of these types of repeater would be allowed to operate licence exempt on the frequencies of more than one mobile operator, provided they met our proposed technical requirements.

3.2 We proposed technical requirements designed to ensure consumers could boost existing mobile signals without this being likely to cause undue interference to mobile networks or other users, cause adverse effects on technical quality of service, or endanger safety of life.

3.3 In this section of the statement we consider the consultation responses to the core part of our proposals – the principle of allowing provider specific and multi-operator repeaters. We then set out our decisions on the proposals, in light of consultation responses.

3.4 In the following section of the statement (section 4), we go on to consider responses on the use of repeaters in particular spectrum bands and for specific mobile technologies.

3.5 We have considered all responses in reaching our decisions. In the sub-sections below, we first consider responses on the overall proposed policy of widening the scope of the exemption regime for mobile repeaters, including alternative approaches suggested by some respondents. We then assess comments focused directly on provider specific repeaters, and then on multi-operator repeaters.

Responses on our overall approach

3.6 Responses to the 2021 Repeaters Consultation revealed a general recognition that consumers and businesses would want to ensure they had access to reliable mobile connections - and a general understanding that some did not currently have the indoor services they expected.

3.7 However, there were differences expressed among respondents on the best way to deliver better connectivity. Some respondents expressed broad support for our range of proposals to allow people to install and use both provider specific and multi-operator repeaters. But some were more cautious, and said we should allow only provider specific repeaters, and not multi-operator equipment.

3.8 Other respondents – notably most of the Mobile Network Operators (MNOs)[2] and some businesses which install and operate alternative connectivity solutions – were opposed to any further extension of the mobile phone repeater exemption regime. They cited the risk of negative impacts on networks and other services. Some respondents said recent

[2] BT, Telefónica and Vodafone

improvements in mobile coverage meant there was, in any case, less need for repeaters than previously.

3.9 Most respondents opposed to aspects of our proposals were less concerned about small-scale installations of repeaters in domestic settings than about large scale deployments in commercial settings. Some said large scale deployments risked serious degradation of services, and may not actually solve connectivity problems.

3.10 Nearly all respondents agreed with our identification of the potential problems caused by illegal repeaters.

Use of repeaters as a solution for poor connectivity

3.11 BT, Telefónica and Vodafone suggested the need for repeaters was declining because investment in mobile infrastructure and developments in new technology were already addressing connectivity issues.

3.12 They pointed to the rapid expansion of Wi-Fi calling capabilities; the development of a Shared Rural Network; and other initiatives such as the Joint Operator Technical Specifications (JOTS) and the Neutral Host In-Building (NHIB) specification. They said these developments meant there was less need for people to look to repeaters as a solution and so a further liberalisation was not justified.

3.13 BT said extending the scope of the Exemption Regulations may give rise to unintended consequences that would be harmful to consumers and would undermine the plans of operators to improve coverage in a more managed way.

3.14 Telefónica agreed, saying its own experiences showed repeaters could have a direct impact on customers by causing service disruption and degradation to its network. It said existing regulations were designed to protect networks from undue interference, but Ofcom was proposing to erode this protection.

3.15 Vodafone said Ofcom's earlier relaxation of regulations to allow single operator repeaters had simply opened the door to a much wider range of illegal repeaters. It said the result had been interference to the operation of blue-light services caused by repeaters that are *"incredibly difficult to track down".*

3.16 The Small Cell Forum and Freshwave said they instead supported alternative connectivity solutions provided by neutral hosts and system integration. They said it was important to work with MNOs to provide the best solutions. Freshwave said it was aware of the issue of illegal repeaters causing significant impact on the quality of mobile services, but said it was not convinced our proposals would significantly reduce their deployment.

3.17 The Small Cell Forum noted that small cells densify networks by adding capacity, whilst repeaters dilute the network by spreading the same capacity more thinly, and described repeaters as "parasitic" on macro networks. However, it recognised that residential consumers may not be willing or able to pay for managed network services, and that repeater solutions may be appropriate in some circumstances. Similarly, repeaters may make sense for small offices or in rural situations where macro capacity is plentiful.

3.18 Nevertheless, it said the provision of Wi-Fi calling by all UK MNOs and on many handsets, coupled with extensive rollout of fixed broadband, meant that most residential requirements were already well met. If more repeaters were allowed, they should be limited to one repeater in each premises per operator (or one provider specific repeater in each premises, or one multi-operator repeater in each premises).

3.19 There was overall support for our proposals from a range of individuals and businesses. Manufacturers, suppliers and installers of repeater equipment backed our proposals to extend the scope of the Exemption Regulations and said properly regulated equipment did not cause interference issues – although one (Nextivity) was supportive only of proposals for provider specific repeaters.

3.20 In a joint response, the Ofcom Communications Consumer Panel and the Advisory Committee for Older and Disabled People welcomed our proposals to provide consumers, citizens and micro-businesses with additional connectivity solutions to improve indoor mobile coverage. They noted that repeaters that complied with the current regulations were significantly more expensive than non-compliant versions, and that driving down costs represented an *"important benefit and protective measure"*. They said the Covid-19 pandemic had made many financially vulnerable but increasingly dependent on reliable digital connectivity.

3.21 In their response the panel and committee said they remained concerned that people with no indoor mobile coverage and no broadband connection could find themselves unable to participate digitally. This was particularly acute in rural areas. They therefore supported our proposals.

3.22 A number of individuals who responded to the consultation also expressed strong support for our proposals. One said that options presently available legally were too expensive and only served the wealthy.

Ofcom assessment

3.23 We acknowledge the improvements in coverage and reliability for mobile users that have been achieved through investment and ongoing initiatives such as the Shared Rural Network and the roll-out of Wi-Fi calling. Nevertheless, for some consumers, their experience of mobile coverage (particularly indoors) remains stubbornly poor – even in some densely populated areas. In some circumstances, mobile operators are reluctant to provide their own solutions for customers, such as femto cells or network-provided repeaters.

3.24 The demand for self-installed solutions to poor coverage is evident from the number of internet sites offering cheap, illegal repeaters as an option and from the experience of our enforcement teams. We remain of the view that a better solution for some consumers is for them to install properly regulated legal repeaters that are not likely to cause interference problems. We also note that, where we consider that those repeaters would satisfy the criteria in section 8(5) of the WTA 2006, we are under a statutory obligation to make them licence exempt. However, we recognise that repeaters are not the only

possible solution and, as set out in paragraphs 2.4 to 2.6, alternative solutions may work better, depending on the circumstances.

3.25 We have not been presented with any evidence that single operator repeaters installed since they were permitted in 2018 have caused undue interference to networks and other users. Nor has any convincing evidence been presented to show that extending the range of repeaters we would allow – and which would operate under the technical requirements we proposed – would be likely to cause any undue interference. Rather, it is the continuing deployment of illegal repeaters that remain problematic.

3.26 In any case, even if there were a rare occasion where a repeater that otherwise meets our technical requirements caused interference issues, we retain the power to intervene in order to protect incumbents from undue interference.

3.27 We also do not consider it likely that the quality of service provided by mobile operators will be adversely affected. We consider however that it would still be appropriate to exercise our general discretion to make licence exemption regulations under section 8(3) of the WTA 2006, taking account of our statutory duties and powers (including to secure the optimal use of spectrum and encourage innovation and investment), even if there were some instances where technical quality of service might be adversely impacted.

3.28 Any additional demand on networks – even if it causes congestion in some limited circumstances – should not impact quality of service in a way that operators do not already have to address in the normal course of their business. We note there are many reasons why networks can become congested[3] and which networks manage successfully. The extended licence exemption regime should help consumers to get a better service and encourage investment by MNOs to address any issues of congestion.

3.29 We do not accept the suggestion that further liberalisation of repeaters could undermine the plans of operators to improve coverage in a more managed way, and have seen no evidence to show why this should be the case.

3.30 We note the views of those suppliers of coverage solutions who suggested that alternative approaches to poor connectivity – such as those provided by neutral hosts and through system integration - represent better options. In many circumstances that is likely to be the case.

3.31 However, we consider the use of self-installed static repeaters to be a viable (and cheaper) option for consumers in some circumstances e.g. where there is a good signal outdoors but poor penetration inside (and where alternatives such as Wi-Fi calling are not available, e.g. due to the absence of a broadband connection).

3.32 We agree with the comments of the Ofcom Communications Consumer Panel and the Advisory Committee for Older and Disabled People about the high cost of legal repeaters,

[3] Congestion is caused by excessive demand on network provision e.g. by large numbers of people wanting access at the same time (such as in crowds or if there is a major news event or disruption to travel); or by consumers wanting to use greater bandwidth (for example, if a popular new app is released); or the opening of a big new office; or by changes in consumer contracts (such as a major employer switching networks for its company-issued mobile phones); or many more.

and the potential impact on digital participation. A key motivation behind the proposals set out in the 2021 Repeaters Consultation was to encourage the development of a wider market in legal repeaters and at a lower cost to consumers.

Large scale installations

3.33 Although BT, Telefónica and Vodafone expressed a general opposition to extending the scope of Exemption Regulations for repeaters, they were specifically concerned about large scale installations in such places as commercial premises, hospitals, office blocks, entertainment venues, stadiums and residential blocks.

3.34 BT said it recognised our earlier relaxation of the regulations represented a desire to allow coverage options for homes and small offices, but said it had also allowed solutions with multiple coverage units able to target much larger premises. These represented a risk to other customers on the mobile network. BT said it would be "greatly concerned" by further unmanaged deployments exacerbated by a further relaxation of licence Exemption Regulations.

3.35 Vodafone said the focus of Ofcom's technical analysis in the 2021 Repeaters Consultation had been on avoiding the potential for harm to mobile networks via interference to wireless signals. The "bigger picture" was the harm to mobile networks via unexpected traffic demand caused by mobile repeaters, particularly in the context of commercial deployments.

3.36 The Wireless Infrastructure Group said large scale deployments of licence exempt equipment ran the risk of significantly degrading MNO or neutral host outdoor and indoor service quality. It recommended that such systems should only be allowed to support a maximum of 10 users. Larger scale systems should be subject to coordination with MNOs or neutral hosts and be compliant with the latest revision of JOTS (DAS) or JOTS NHIB (small cells)[4].

3.37 The Small Cell Forum said it should generally be left to MNOs to determine whether or not repeaters can be installed. It said repeaters should certainly not be operated via large indoor and multi-operator deployments in urban and suburban areas where macros are already congested (except on a temporary basis – limited to six months – ahead of a broader structural solution).

3.38 Further, it said there should be a requirement that large scale deployments are installed only by professional and industrial installers (i.e. system integrators or neutral hosts). Larger in-building systems should be deployed in coordination with mobile operators' networks to ensure network quality.

3.39 Freshwave said a small number of compliant repeaters used by a small number of users in a single cell might not impact quality of service significantly, but one or more repeaters used by potentially hundreds of users would have a substantial impact – especially in urban

[4] Joint Operators Technical Specification for Distributed Antenna Systems (DAS) and Neutral Host In-Buildings (NHIB)

areas where existing mobile capacity is more likely to be under strain. It said it supported the idea of limiting the number of repeaters allowed in a single building.

3.40 Colt Technology Services noted that the deployment of isolated repeaters for small indoor coverage areas, which have a limited impact on donor cell capacity, might be useful in rural areas where demand is low and alternatives may not be practical. But urban and built up areas required a properly engineered solution, which added new capacity to the network instead of diluting existing capacity. It proposed a limit of one repeater per operator per premises.

Ofcom assessment

3.41 We have considered carefully the points made by BT, Telefónica and Vodafone about large cale installations and by those whose businesses are based on small cell and neutral host solutions.

3.42 When we first allowed single operator repeaters in 2018, our focus had been mainly on the domestic market and on improving coverage for those with unreliable or weak connections. However, poor services are not confined to domestic situations. For that reason, we would only consider limiting the number of repeaters permitted in one place if there was clear evidence that, for example, undue interference to wireless telegraphy or adverse effects on technical quality of service was likely.

3.43 Our own analysis suggests the chief issue for networks is not undue interference, but the additional pressure that repeaters can place on network capacity in congested areas in certain circumstances. As noted above (paragraphs 3.27 and 3.28), we do not consider this to represent a quality of service issue markedly different from other congestion issues faced by networks.

3.44 We are mindful of the fact that this pressure ultimately comes from the networks' own customers who already exist in these locations and, with the use of a repeater, become able to receive the services they expect where previously they could not. To that extent, we see this as an issue for the MNOs to resolve themselves through increased investment in infrastructure, such as in densifying their networks.

3.45 Nor do we consider that this would justify not making this licence exemption; we have decided that it would still be appropriate to exercise our general discretion to make licence exemption regulations even if there are some instances where technical quality of service might be adversely impacted.

Registration or licensing

3.46 Telefónica and Vodafone – expressed concern about the lack of visibility they had over the deployment of repeaters. Telefónica said any repeaters authorised for use by Ofcom should be subject to registration, so that MNOs are more easily able to identify where a repeater is located.

3.47 Vodafone said the repeater industry was a *"sector with a history of misrepresenting the legality of using its equipment"*. It therefore proposed that Ofcom adopts a light-licensing approach, so that mobile repeaters are used only where they represent an appropriate

solution. This would mean that MNOs then had the necessary knowledge, and could adapt macro networks accordingly.

3.48 It said it did not consider such a licensing approach onerous, either from the perspective of operational burden to Ofcom, or cost burden to potential users. Under such an approach, anyone wishing to make use of a mobile repeater would need to apply to Ofcom, setting out the nature of the proposed deployment (i.e. single repeater/multiple repeaters being used in the deployment; domestic or commercial premises; location; device type; etc.).

3.49 Ofcom could then:

- inform them whether the device has been tested to be compliant with Ofcom's specification;
- warn of the ramifications if it is not compliant;
- for domestic installations, use coverage mapping data as provided by the mobile operators to assess whether a repeater is likely to improve coverage;
- in the case of commercial installations, carry out simple checks to assess whether a repeater solution is likely to be suitable (e.g. how many are already in the area, and is the applicant deploying multiple repeaters that could overload the macro-network to the detriment of other users) and if there is any doubt liaise with the mobile network operators; and
- keep a log of repeater deployments approved, so that if there is undue interference, or congestion to macro networks, the mobile operators can be notified.

Ofcom assessment

3.50 We have considered the options of either a registration or light licensing approach to extending the range of repeaters allowed under licence exemption. We do not consider either of these options to be straightforward. Any such scheme would require a significant administration regime with consequent costs, that would need to be passed on.

3.51 In such circumstances, the imposition of a registration or light licensing regime would only be justified if the expense and administrative burden were proportionate and necessary. We do not believe this is the case.

3.52 As noted elsewhere, we believe issues experienced by networks and other users by repeaters are overwhelmingly caused by illegal devices, which would continue to be unregistered and unlicensed. Indeed, the initiation of a registration/licence regime – with its associated costs – is likely to make the installation of illegal equipment appear even more attractive by comparison to legal alternatives.

Electromagnetic fields

3.53 Electrosensitivity UK said Ofcom should adopt a testing standard which authorised only mobile phone repeaters that did not transmit out of the particular home or building in which they are located. It said it was unacceptable for the health of people in adjoining

homes and buildings to be harmed by high levels of radiofrequency radiation from someone else's mobile phone repeater.

3.54 A respondent who wished its name to remain confidential [✂REDACTED] said the high proposed power limits for multi-operator repeaters (both in the uplink and downlink directions) arising from a spectral density limitation of 10dBm/5MHz could lead to concerns over consumers/installers exceeding emissions guidelines. In the case of a fully populated multi-band, multi-operator repeater, consumers could reasonably deploy systems that exceeded ICNIRP guidelines without knowledge of radio-frequency exposure safety guidelines.

Ofcom assessment

3.55 All uses of radio spectrum generate electromagnetic fields (EMF) and there are internationally recognised guidelines to help ensure services operate in a way that will not adversely affect health.

3.56 The guidelines are published by the International Commission for Non-Ionising Radiation Protection (ICNIRP) and include limits on EMF exposure for the protection of the general public. We refer to these limits as the 'general public EMF limits'.

3.57 The UK Health Security Agency (UKHSA) takes the lead on public health matters associated with EMF and health, and has a statutory duty to provide advice to Government on any health effects that may be caused by exposure to EMF. UKHSA's main advice is that EMF exposure should comply with the ICNIRP general public EMF limits.

3.58 Ofcom authorises and manages the use of the radio spectrum in the UK through the issue of licences and/or by setting conditions for spectrum use on a licence exempt basis. In performing that role, we take into account UKHSA's advice on EMF exposure.

3.59 Further, all radio equipment placed on the market in the UK (including mobile phone repeaters) must comply with the Radio Equipment Regulations 2017. These regulations include requirements on safety that ensure ICNIRP guidelines are not exceeded. We do not, therefore, believe that consumers could reasonably deploy systems that exceed the ICNIRP guidelines.

Enforcement

3.60 The Wireless Infrastructure Group said that in the event that network degradation occurs as a result of the deployment of repeaters, protection must be provided to MNOs and neutral hosts. It said there should be a "ratified process" provided, enabling a mechanism for the repeater system to be decommissioned or re-engineered.

Ofcom assessment

3.61 The WTA 2006 empowers Ofcom to make regulations exempting certain equipment from the requirement for a licence provided that terms, provisions and limitations specified in that regulation are met. A particular requirement in the exemption regulations (which we would expect to retain when the licence exemption regime is widened) is that the use of

the equipment must not cause or contribute to any undue interference to any wireless telegraphy.

3.62 Where Ofcom determines there are reasonable grounds for believing that a person is contravening, or has contravened, a requirement included in an exemption regulation it may use powers included in the Act to take measures proportionate to the risk of harm. Details of the methods and principals of enforcement are published on our website.

3.63 However, as noted elsewhere in this document (see especially paragraphs 3.27 and 3.28), we do not consider impacts to service caused by network congestion – even if they occurred in rare circumstances – would represent an issue that operators do not already have to address in the normal course of their business.

Provider specific repeaters

3.64 In the 2021 Repeaters Consultation we proposed to modify the existing Interface Requirement for single operator repeaters. IR 2102.1 specifies, amongst other things, that amplified frequencies shall be limited to those licensed to a "single MNO". Although such equipment may be re-configured to alternative frequencies, it may only operate using frequencies licensed to a single operator once configured.

3.65 We proposed to modify IR 2102.1 to remove this requirement and allow for provider specific, rather than single operator, repeaters. Provider specific repeaters can repeat the signal of more than one MNO at any one time, individually setting the level of amplification for each MNO's signals.

3.66 Our proposal was based on an acceptance that the assessment we made when we allowed single operator repeaters in 2018 may have been overly simplistic, and that there was no greater risk of interference if a repeater can adjust the gain individually for each operator's channels.

3.67 The proposal was also a recognition that it is already 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.

3.68 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 – but with the benefit of potentially reducing the cost of purchase and installation (due to only requiring one repeater instead of multiple repeaters).

3.69 We asked stakeholders the following question:

> 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.

Consultation responses

3.70 A significant majority of respondents who addressed this question supported our proposal to allow provider specific repeaters. For example, Frequency 3G Telecom said provider specific repeaters which complied with the Exemption Regulations did not cause harmful interference to mobile networks and would support Ofcom's aim to "get everyone connected".

3.71 Almost all the manufacturers, suppliers and installers of equipment who responded – both UK and overseas based - were in support of our proposal (including Antenna Pro, CellPhone-Mate/SureCall, Herbert In Building Wireless, Nextivity, Stella Doradus, Signal Solutions, Smartcell Networks, Trellis Works and Zonewave). The proposal was also supported by two confidential business respondents and four individuals.

3.72 The Small Cell Forum and Wireless Infrastructure Group also offered a degree of support for our proposal, but expressed some caution too. The Small Cell Forum said installations should not be installed in an uncontrolled way. The Wireless Infrastructure Group said protection must be provided to MNOs and neutral hosts, and a process established to decommission or re-engineer installations if necessary.

3.73 Respondents who opposed the proposals were BT, Telefónica and Vodafone and some businesses involved with providing alternative connectivity solutions (Colt Technology and Freshwave).

3.74 BT said it noted the logic that if separate single operator repeaters can already be deployed together in the same location, then allowing these to be in the same box did not enable any new risk of interference. However, it said it was concerned that this would further encourage a proliferation of such devices.

3.75 It also warned that provider specific repeaters were not optimised for any particular operator and may typically be omnidirectional in design, and so can result in the amplification of multiple different potential donor cells. Particularly in dense urban areas, with many nearby cells optimised for ground level not rooftop coverage, this can result in significant interference levels.

3.76 Telefónica said it understood the basis of Ofcom's technical reasoning on provider specific equipment, but did not support the use of licence exempt repeaters on an unregistered basis in any case.

3.77 Vodafone also acknowledged a "superficial technical attraction" to our proposal, but said the problem was not just a technical one. It said potential purchasers of repeaters could not be expected to understand the distinction between legal and illegal repeaters or between a provider specific repeater and a multi-operator repeater – especially when some vendors deliberately mislead consumers.

3.78 Freshwave said any loosening of the regulations might increase the number of repeaters in use. It was concerned about the impact on network quality of service of repeaters that were not approved by the MNOs.

Ofcom assessment

3.79 The chief concern of the MNOs appears to be that any further liberalisation of licence exemption for repeaters could stimulate an unwelcome growth in the market.

3.80 On its own, we do not believe a potential increase in demand or use can justify continued restrictions on provider specific repeaters in the absence of evidence of undue interference. Our own evidence, summarised in Annex 1 of the 2021 Repeaters Consultation, shows that repeaters complying with our technical requirements are not likely to cause undue interference.

3.81 Additionally, our assessment of the aggregate noise radiated by repeaters in the 2018 Repeaters Statement found that repeater penetration rates would have to be very high to cause even a limited noise rise in the mobile networks. Therefore, based on this assessment, even a significant growth in the market of legal repeaters should not cause an interference risk.

3.82 We acknowledge BT's view that some provider specific repeaters may use a single donor antenna for all operators, which will not be optimised for any particular operator. This minor inefficiency in the design of some repeaters is outweighed by the benefits of a device which can improve access to multiple operators' networks. This in turn gives the networks' own customers access to the services they expect, where previously they could not, and a potential reduction in cost as a result of this design.

3.83 The technical requirements set out in IR 2102.1 limit the amplification of the repeater based on the dominant serving cell. Our technical assessment of these conditions shows that this gain limit is sufficient to ensure it is not likely to cause undue interference to mobile networks.

3.84 For those users within the repeater coverage area, the potential amplification of multiple different donor cells is not likely to cause interference or a negative impact on performance. These users will now be able to connect to the network where they previously could not, and will be receiving a signal which is equivalent to the signal received at the repeater antenna (e.g. at the window).

3.85 As such, these users will be provided with a similar signal, and therefore similar level of performance, as if they were located in the same place as the repeater antenna.

3.86 As mobile handset antennas are generally omnidirectional, the use of an omnidirectional antenna on the repeater will not negatively impact the performance for the user compared to using a mobile handset alone. The downlink power limit ensures that the repeated indoor signal does not pose a significant risk of undue interference to mobile networks or to other mobile handset users outside the repeater coverage area (i.e. outside the building where the repeater is located).

3.87 The uplink power limits, which are the same as those imposed on mobile user equipment, ensure that the repeater looks similar to the mobile phone user equipment from the perspective of the mobile phone network. Therefore, the use of rooftop antennas for the

uplink transmissions causes no greater risk of interference than the user standing outside to access sufficient coverage.

3.88 Additionally, the transmit power control mechanisms that the mobile phone network uses to manage the received power from the mobile handsets within the cell, ensuring good performance of the network, will continue to work through the use of a repeater.

3.89 We acknowledge Vodafone's point that potential purchasers of equipment may not understand the difference between legal and illegal repeaters. Our proposals are aimed at drawing a clearer distinction. For example, we believe the provision of clear information on our website about devices compliant with the new Interface Requirements will make this easier (see section 5 of this statement).

3.90 We note the caution expressed by some respondents about allowing the further installation of repeaters in an unmanaged way, and the potential impact on networks. We continue to believe that evidence suggests the issues raised by respondents are not to do with potential interference but with pressure on the capacity of networks, which can be addressed through normal network management.

3.91 All mobile customers are entitled to expect a decent service. It is a matter for the MNOs to manage their services in a particular area in the light of demand from their customers.

Multi-operator repeaters

3.92 Our 2021 Repeaters Consultation proposed to allow certain 'multi-operator' mobile phone repeaters to be made licence exempt through the creation of a new UK Interface Requirement (IR 2102.3).

3.93 The new regulations would allow the signals of more than one MNO to be amplified at the same time but, unlike 'provider specific' repeaters, amplification would be by the same level and not calculated individually for each MNO. As a result, the repeaters would not need to decode the signals nor identify the type of signal (e.g. 2G, 3G or 4G). It was therefore likely that the devices would be simpler than 'provider specific' repeaters, and be more cost effective for consumers.

3.94 We carried out technical analysis to ensure 'multi-operator' static indoor mobile phone repeaters were not likely to cause undue interference - or other adverse effects to mobile phone networks or other spectrum users - and what technical requirements would be appropriate. We set out the details of our analysis and our provisional conclusions on technical conditions in the body and annexes to the 2021 Repeaters Consultation.

3.95 We asked stakeholders the following question:

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.

Consultation responses

3.96 There was a more even split between respondents supporting our proposal on multi-operator repeaters and those opposing the proposal, although the majority who submitted responses were opposed.

3.97 Respondents who supported our proposal included CellPhone-Mate/SureCall and Stella Doradus, plus five individual respondents and a confidential respondent. CellPhone-Mate/SureCall said competitive market forces would drive down retail prices for approved and network friendly repeaters to a nominal premium over illegal versions. Consumers would most likely choose the minimally higher priced legal repeater over the illegal versions, thus limiting the further spread of illegal versions.

3.98 The Wireless Infrastructure Group said it understood that Ofcom sought to help people and businesses improve coverage in their home and that multi-operator repeaters may simplify this process. However, it expressed the same caution, as it had for provider specific repeaters, about the need to work with MNOs.

3.99 Eight companies who supported our proposal to allow provider specific repeaters were opposed to the idea of extending this to multi-operator repeaters (Antenna Pro, Frequency 3G, Herbert In-Building Wireless, Nextivity, Smart Cell Networks, Trellis Works, UC Tel and Zonewave). Likewise, the Small Cell Forum and one confidential respondent.

3.100 As with the proposal to allow provider specific repeaters, BT, Telefónica, Vodafone plus Freshwave and Colt Technologies also opposed extending the scope of the exemption regime to multi-operator devices. These respondents made some general points about the use of multi-operator repeaters and some specific, more technical issues. These more technical issues are addressed in sub-sections below.

3.101 BT said its general concerns about the adverse and unpredictable impact of all repeaters on its network were further amplified in the case of multi-operator repeaters. It said this kind of licence exempt system would detract from its own efforts to extend and improve coverage. It said it was particularly concerned about large scale deployments, saying our proposal went far beyond the original intention of fixing isolated coverage issues for domestic consumers.

3.102 It said that MNOs already had a strong incentive to improve indoor mobile coverage in order to compete effectively. Allowing multi-operator mobile repeaters removes some of the incentive for operators to improve their network coverage. As such, facilitation of licence exempt repeaters could actually have a negative impact for consumers.

3.103 Telefónica also objected to our proposal, saying Ofcom needed to be clearer in stating that static indoor repeaters are intended for residential use only. The current description of

'indoor' had seen the continued misuse of devices being deployed into commercial environments such as offices, industrial units, hotels, universities etc. causing harmful interference.

3.104 Rather than allowing multi-operator repeaters, Telefónica said Ofcom should take a more active role in providing information to all mobile users on how to improve coverage, for example through greater and more prominent consumer information about using Wi-Fi calling - as well as in-building solutions, which are suited to commercial premises.

3.105 Vodafone said legalising multi-operator repeaters would make it extremely difficult to determine which equipment is lawful and which is not. At present, it was easy to identify the bulk of non-compliant repeaters by the mere fact that they purport to repeat multiple operators' signals.

3.106 Vodafone said there was scope for consumer harm from multi-operator repeaters because they may not improve weak network signals in the way that might be expected (see 'near-far issue' below). It noted that the use case for repeaters was becoming "increasingly redundant", with wider rollout of mobile networks (e.g. via the Shared Rural Network) and support of Wi-Fi calling capability being "the norm". It also said that repeaters compliant with the proposed technical specifications are unlikely to be price-attractive for domestic use.

Ofcom assessment

3.107 The general points raised by MNOs and others about multi-operator repeaters reflect points made elsewhere in their responses, about repeaters in general.

3.108 We acknowledge that repeaters may not provide the best answers in all circumstances, but we believe it is a matter for customers to determine themselves whether to invest in such devices. We note that MNOs themselves have a role in informing customers of ways to improve coverage, not just Ofcom.

3.109 The proposals we set out in the 2021 Repeaters Consultation to improve information were aimed at helping them take decisions to install repeaters or rely on alternatives, such as Wi-Fi calling. Better information will also help customers to identify and distinguish between legal and illegal repeaters.

3.110 We believe it is a positive development if the need for repeaters is reduced through investment and new initiatives by MNOs. However, we do not believe the welcome improvements to services for many justify us denying options for those customers who continue to experience poor connectivity.

3.111 We also do not accept that the installation of repeaters by some customers removes an incentive for MNOs to continue improving their network coverage. Repeaters are only likely to be installed where service is sub-optimal – most consumers and businesses would prefer instead to have reliable services without the need for additional devices.

Impact on network capacity

3.112 A chief concern for BT was the unpredictability of demand on its capacity. In deploying its own solutions BT said it took account of a wide range of factors to which a third party does not have access, due to commercial sensitivity. It said it was concerned that licence exempt multi-operator repeaters could amplify degradation of an MNOs' macro network, and that users elsewhere in a cell will see less available capacity.

3.113 BT said Ofcom's technical analysis was helpful to examine interference considerations, but there were additional technical aspects that needed to be considered, including the impact of unplanned deployments of repeaters on other users of the network. The introduction of large numbers of additional users has the potential to require significant amounts of optimisation work and capacity upgrades (which will be delayed by lack of forewarning).

3.114 Vodafone said its greatest concern was the potential use of multi-operator repeaters in commercial settings such as shopping centres and offices. Were Ofcom to liberalise multi-operator mobile repeaters, the owners of such buildings would inevitably go with the superficially attractive option of using repeaters rather than more expensive managed solutions. This can lead to an unexpected surge in demand and a high risk of network congestion. Remedying the situation would involve further investment by the mobile operators.

3.115 In contrast, it added, a properly engineered coverage solution would resolve the issue more holistically for the long term and would not impair service for other users in the short term. Vodafone said that making multi-operator repeaters licence exempt was the wrong solution, even if all repeaters on the market complied with Ofcom's technical specification.

Ofcom assessment

3.116 As noted elsewhere, we would be concerned if our analysis suggested an extension to the range of legal licence exempt repeaters may result in undue interference to networks. However, the evidence we have suggests this is not the case.

3.117 Instead, we note the chief issue raised by MNOs is the potential pressure on capacity from previously unexpected sources. We continue to believe issues of capacity – if they do indeed arise - are matters for MNOs to resolve themselves in order for them to deliver the services their customers expect. We also consider, taking account of our statutory duties, that it would be appropriate to exercise our general underlying discretion to make licence exemption regulations in that case. We consider below the specific arguments made about interference.

Interference and degradation of services

3.118 BT said an uncontrolled repeater handling multiple technologies/bands/operators with a wide range of donor levels will likely degrade user experience and the macro network performance.

3.119 When repeaters are used to support all MNOs, there is increased likelihood of active and passive intermodulation interference that will result in performance distortion[5]. In this scenario, the repeater may become degraded or useless for some frequency combinations (e.g. two MNOs' carriers in 1800 MHz) and not work for all MNOs equally.

3.120 BT said the way to resolve this was to limit the supported frequency range, which is then unlikely to achieve repeaters that support all MNOs.

Ofcom assessment

3.121 We have considered the point raised about the risk of intermodulation. Although the ETSI mobile phone repeater standards include requirements on intermodulation due to signals outside the repeater pass band, they do not include any test on transmitted intermodulation products arising from input signals inside the repeater's operating band.

3.122 We have therefore decided to introduce a requirement in IR.2102.3 (see the yellow highlighted text in Annex A3), which will also be reflected in the voluntary testing standard (see Section 5), on the maximum transmitted intermodulation produced due to input signals within each band of operation of a multi-operator repeater. This should ensure that the problem of intermodulation interference is avoided.

Near-far issue

3.123 A number of respondents said that multi-operator repeaters did not deliver good solutions for consumers because of what we identified in the 2021 Repeaters Consultation as the "near-far issue". This arises when a repeater boosts all signals by an equal amount. The result is that a strong nearby signal will be amplified just enough to provide good reception from that operator – but an equal level of amplification will be insufficient for weaker signals from further away.

3.124 Vodafone said it was likely that the purchaser of a repeater will be a customer of a network with the weaker signal and they would, therefore, be less likely to get the benefits expected. It said Ofcom has a duty to protect consumers and so should not encourage the purchase of devices if they don't deliver the purported benefits.

3.125 This view was also supported by Frequency 3G Telecom, Freshwave, Nextivity, Small Cell Forum and a confidential respondent. Zonewave suggested multi-operator repeaters might be more acceptable if there was an option to have all network channels pre-programmed, so a nearby channel (which may not need boosting) could be turned off, and so allow a good user experience.

3.126 Signal Solutions said it could understand the introduction of multi-operator repeaters as long as they have the in-built technology to manage each band on each network in a controlled manner.

[5] Intermodulation is where a combination of two or more signals creates another signal which may fall into another frequency band of the system and cause interference.

Ofcom assessment

3.127 The purpose of the proposals set out in the 2021 Repeaters Consultation was to provide for both types of repeater: provider specific (including an option to boost the signals of more than one provider) and multi-operator. In some use cases one type will be better than the other type - but it is our intention to give consumers both options.

3.128 We acknowledge that where a consumer needs to improve the signal from one wanted network which is significantly lower in strength than other networks, a provider specific repeater may be the optimum solution. However, we also recognise that some households have subscriptions to different networks. For these consumers, the multi-operator repeater may be the better choice.

Ofcom's technical analysis

3.129 Vodafone questioned much of the technical analysis behind our proposals. It said in any case there was insufficient detail to conclude whether the "narrow conclusions" regarding radio interference with the mobile network were reasonable.

3.130 In particular, it questioned the separate study of the Beacon grid (i.e. Vodafone and Telefónica's networks) and the MBNL grid (i.e. either Three or BT). It said it was not clear why the analysis failed to consider both grids together.

3.131 Vodafone also questioned the assumptions we used on repeater placements within a building for our analysis (i.e. random). It said consumers would probably locate a repeater close to a window and experiment with different window locations to maximise the signal strength shown on the handset. It said Ofcom needed to better explain our noise rise calculations, and then repeat our analysis showing the results for zero building entry losses.

3.132 It said that since third parties are unlikely to be able to correctly plan donor antenna alignment - lacking detailed knowledge of the network and in some cases necessary radio frequency planning knowledge - this creates further potential for poor performance for both new users covered by the repeater and existing macro users.

Ofcom assessment

3.133 We acknowledge that the summary of our technical analysis, as set out in the 2021 Repeaters Consultation, may have been unclear on how it accounted for the two grids. To clarify, and alleviate the concerns expressed by Vodafone, we can confirm that both grids were considered together in the technical analysis.

3.134 A limitation of Ofcom's 4G coverage model[6] means that it can only model one MNO network deployment at a time, and hence the simulation of the signal strength received by a repeater in a test deployment location from each of the 20 closest base stations (Part 1) is modelled separately for each grid. However, the calculation of the gain control (Part 2)

[6] 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-andstatements/category-2/coverage-obligations-in-the-700-mhz-and-3.6-3.8-ghz-spectrum-award

then combines the two sets of results from Part 1, meaning the gain control is based on the signal strength received from 40 base stations (20 from each grid).

3.135 Additionally, an adjustment is made to account for only modelling two MNO's spectrum holdings (rather than four), by assuming that the repeater is only operating over the bandwidth of the two MNOs. This adjustment impacts the RSRP[7] calculation, and results in a gain that is 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, ensuring the full functionality of the repeater is exercised in this analysis.

3.136 The impact caused by the multi-operator repeater on the 40 surrounding base stations (20 from each grid) is then calculated (Part 3). When displaying the I/N (interference to noise ratio) in histograms, we separated the results based on repeater height and the grid being impacted, showing that both grids are impacted in a similar way.

3.137 We agree with Vodafone that consumers would usually locate a repeater close to a window. They may very well experiment with different window locations when they initially install their repeater – although, ultimately, a fixed location would be found. However, this does not change our view on the selection of a random value from the distribution of building entry loss values for buildings with traditional construction given in Recommendation ITU-R P.2109 on *Prediction of building entry loss*.

3.138 As highlighted in the 2021 Repeaters Consultation, the distribution represents not only the potentiation distribution of the receiver (repeater) location within the building, but also represents the potential distribution of construction materials used – not all buildings have the same impact on radio frequency propagation.

3.139 Additionally, use of a different random value from the full distribution for each of the surrounding base stations[8] accounts for the fact that locating the repeater close to a window may reduce the propagation loss to some of the surrounding locations (i.e. those on the same side of the buildings as the repeater) while increasing the propagation loss to others (i.e. those on the other side of the building).

3.140 With this in mind, and given that the technical analysis of aggregate interference given in the 2021 Repeaters Consultation is based on the worst-case I/N results from approximately 200,000 tests (meaning that it is already a conservative assessment[9]) we do not believe that is appropriate to repeat the analysis for zero building entry losses.

3.141 As a better explanation for noise rise, the I/N ratio indicates the relative level of interference compared to the existing noise floor. It can be used to calculate the system noise level including this interference, and therefore the increase in system noise caused by this interference. This noise rise is defined by the following equation:

[7] Reference Signal Received Power
[8] 40 base stations (the 20 nearest base stations of each grid) were simulated in our technical analysis
[9] As shown in Figure 3 of the 2021 Repeaters Consultation, the majority of results give an I/N which is at least 10 dB lower than the worst-case.

$$\begin{aligned}\text{Noise Rise} &= \text{System Noise (Noise Floor plus Interference)} - \text{Noise Floor} \\ &= 10 * \log_{10}\left(10^{\text{Noise Floor}+\frac{\text{I}}{\text{N}}} + 10^{\text{Noise Floor}}\right) - \text{Noise Floor} \\ &= 10 * \log_{10}\left(10^{\frac{\text{I}}{\text{N}}} + 1\right)\end{aligned}$$

3.142 If the interference is 10 dB below the noise floor of the base station (i.e. I/N = −10 dB), then the new total noise is 0.41 dB higher than the noise floor, which we simplified to 0.5 dB in our analysis. The value of I/N = −10 dB relates to the impact of 250 simultaneously active multi-operator repeaters in any frequency band, and Figure 4 of the 2021 Repeaters Consultation is a sensitivity analysis around this value.

3.143 Our assessment in the 2021 Repeaters Consultation shows that the technical conditions on gain control, and uplink and downlink power limits, should protect the mobile networks and their existing macro users, regardless of the repeater's deployment location indoors.

Other technical issues

3.144 Nextivity, a manufacturer of some repeater devices which comply with current regulations, said it was opposed to the deployment of multi-operator repeaters. It said European specifications (ETSI EN 301 908-11 and EN 301 908-15) set an absolute limit on harmful emissions in the pass band and are not applicable to wideband 'multi-operator' repeaters (EN 301 908-11 §4.2.2.2.3 and EN 301 908-15 -15 §4.2.2.2.2).

3.145 If Ofcom were minded to allow multi-operator repeaters in any event, we should consider gain limitations in line with regulations in the USA.

3.146 Stella Doradus made a number of points about oscillation, gain control formulation and uplink and downlink gains. In summary:

- Oscillation: It is best not to allow restarts, but instead widen the time for oscillation control to maybe 10 seconds. The repeater should be able to detect oscillations, automatically reduce its gain in 1dB steps and, finally, do an extra gain reduction to smooth the uplink noise pedestal.
- Gain control formula 10-RSSI: Unless the designer of the repeater keeps in mind the 7 dB noise figure requirement, the gain formula conditions can be met without reducing the noise power. If the attenuator that causes gain reduction is placed at the start of the amplifier chain, then no noise power reduction will occur as the gain is reduced. The gain reduction formula is better stated around uplink noise power requirements specifically.
- Uplink and downlink gains must be less than 100dB: This is a very large gain. The ETSI RED standards 301 908-11 and 301 908-15 state that the uplink noise power must be less than -53dBm/100kHz. If the 7 dB noise figure requirement is just met, the gain limitation would be 64dB. Maybe it is unnecessary to mention a gain limit of 100dB.

Ofcom assessment

3.147 Regarding the comment that European specifications (ETSI EN 301 908-11 and EN 301 908-15) set an absolute limit on harmful emissions in the pass band and are not applicable to wideband 'multi-operator' repeaters, we do not see any indication in the ETSI standards that they are not applicable to certain types of repeaters. Their requirements do not place a limit on the number of contiguous channels covered by the repeater pass band.

3.148 In response to the points made by Stella Doradus about oscillation, our concern has to be to avoid interference to other wireless telegraphy users from oscillating repeaters. Oscillation is not just a local issue, it can affect other users in the cell. In this regard, the shortest possible period of continual oscillation should be the aim. So, rather than allowing oscillation to continue for up to 10 seconds, we have decided to apply a near-instant shutdown and allow the repeater to attempt a restart with lower gain.

3.149 Regarding the concern that the gain formula conditions could be met without reducing the noise power (i.e. in certain conceivable designs there would be no reduction in noise power as the gain is reduced) we can clarify that we need the repeater to apply the noise figure requirement for all values of gain control. Our voluntary testing standard (which is discussed in Section 5) will include tests to verify that the noise figure requirement is met at a range of gain settings.

3.150 Regarding the comment that specifying a maximum gain may be unnecessary because equipment with a noise figure of 7 dB would not be able to exceed a gain of 64dB due to the need to meet the ETSI standard noise power limit of −53dBm/100kHz, we do not dispute the calculation. However, we consider it to be useful to provide a clear statement of the absolute maximum gain that can be permitted, rather than relying on manufacturers to derive it from other parameters. We expect the gain control formula will normally be the limiting factor, and the maximum limit is there to provide certainty that there is a gain value that cannot be exceeded.

Our decisions

3.151 Having considered all consultation responses to our proposals on widening the scope of the exemption regime we have decided to proceed with our proposals to allow people to install and use static indoor provider specific repeaters and static indoor multi-operator repeaters.

3.152 Repeaters will be required to meet the technical requirements set out in (i) the revised version of IR 2102.1 at Annex 2 or (ii) the new Interface Requirement Annex 3.[10] We consider these IRs meet the requirements set out in section 8(5) of the WTA 2006, and so are not likely to (amongst other things) involve undue interference with wireless telegraphy, have an adverse effect on technical quality of service or endanger safety of life.

[10] As explained in Annex 1, all radio equipment placed on the market in the UK (including mobile phone repeaters) must also comply with the Radio Equipment Regulations 2017

We therefore consider that we have a duty to exempt repeaters compliant with these IRs from the requirement for a licence.

3.153 We also consider that – even if there are some instances where the wider exemption regime may place additional pressure on network capacity in congested areas in certain circumstances – it nevertheless remains appropriate for us to exercise our general underlying discretion to make licence exemption regulations taking account of our wider statutory duties.

3.154 Making a licence exemption subject to the technical requirements set out in Annexes 2 and 3 should, in our judgment, extend the coverage solutions for consumers who need them, without being likely to cause harmful effects on other spectrum users. It should also help reduce the likelihood that consumers purchase unauthorised (and unlawful) repeaters which do cause such harm, and so reduce the market for such devices.

3.155 In those ways, the exemption will help secure optimal use of the spectrum. It will also help encourage investment and innovation, and promote competition, in relevant markets, as well as furthering the different needs and interests, so far as the use of the electromagnetic spectrum for wireless telegraphy is concerned, of all persons who may wish to make use of it in the United Kingdom, including those in rural areas (where mobile coverage is often less).

3.156 As explained at paragraph 2.29 above, we also consider that the terms, conditions and limitations that we are imposing are objectively justified; are not unduly discriminatory; are proportionate to what we intend to achieve; and are transparent.

3.157 Accordingly, we will notify the European Commission of the Interface Requirements included in the Exemption Regulations. The EC has three months to comment (see section 6 of this document for a fuller explanation of the next steps).

3.158 The use of static indoor provider specific repeaters and static indoor multi-operator repeaters will therefore be authorised via licence exemption, so that they can be used without the need for a licence, like other low power devices normally authorised in that way.

3.159 As noted above, these changes should encourage and promote a legitimate retail market for consumer-installed mobile phone repeaters. This may, in turn, reduce the number of illegal repeaters on the market. However, we recognise the risk that non-compliant and potentially harmful repeaters will continue to be marketed and sold.

3.160 For this reason, enforcement action will continue, alongside consumer advocacy and information campaigns to combat their sale and use. As set out in section 5 of this document, we will also take measures to improve consumer information on mobile phone repeaters by publishing on our website a list of licence exempt static indoor mobile phone repeaters that can be demonstrated to have met our exemption standards.

4. Limits and requirements for mobile repeaters

4.1 In the 2021 Repeaters Consultation we set out our proposals on a range of technical conditions to be applied to the installation and use of provider specific and multi-operator repeaters. These matched the requirements already applied to current single operator repeaters, and included that provider specific and multi-operator should:

a) be for static use indoors only;[11]

b) be authorised to amplify one or more of the 700 MHz, 800 MHz, 900 MHz, 1800 MHz and 2100 MHz FDD mobile frequencies only;

c) amplify the signal equally in both directions (uplink and downlink), to and from the consumer's handset to the base station;[12]

d) be on 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) have an anti-oscillation mechanism, preventing interference to other wireless telegraphy users in the case where a repeater is poorly located;

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

4.2 In addition to these proposals, we invited stakeholders to respond to questions on three specific issues to do with the future operation of repeaters. We sought views on whether we should:

- 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[13]) would be able to make an emergency call when connected to the network via a repeater;
- 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;
- include paired spectrum in the 700 MHz 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.

[11] Static mobile phone repeaters are intended to be placed indoors and to remain in-situ when operating. They are not intended to be used whilst in motion (e.g. in a vehicle).
[12] For multi-operator repeaters only.
[13] Voice over Long-Term Evolution (i.e. 4G): mobile devices able to make calls over a 4G network

4.3 In this section of the statement we assess consultation responses on each of these issues in turn, before setting out our decisions.

4G-only repeaters

4.4 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 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 but where there is no 2G/3G coverage.[14]

4.5 We considered whether this technical requirement was still necessary, 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 consumers.

4.6 Our provisional conclusion was that there remained 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. We therefore proposed to retain the requirement for repeaters to support 2G/3G signals.

4.7 However, we said we would keep the requirement under review as the MNOs developed their plans to switch off 2G/3G signals in future; and as the number of non-VoLTE handsets in active use fell due to users replacing their handsets with more modern models.

4.8 We asked stakeholders the following question:

> Do you agree with our provisional view as set out in paragraph 3.48 above* [*in the 2021 Repeaters Consultation]? If you do not agree, please explain why you think the requirement is not necessary.

Consultation responses

4.9 A majority of respondents opposed our provisional view, and said 4G-only repeaters should be permitted. However, BT, Telefónica and Vodafone said they supported our view that 2G/3G support should continue, along with an individual respondent and two equipment suppliers.

4.10 Those who wanted to see 4G-only repeaters allowed included Antenna Pro, Frequency 3G Telecom, Herbert In-Building Wireless, Nextivity, Smart Cell Networks, Trellis Works, UCTel, and Zonewave. All made the point that the switch-off of older generation networks was

[14] 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.

imminent, and so the requirement to repeat 2G/3G signals would soon be obsolete or irrelevant. They also stressed the low number of non-VoLTE devices still in circulation.

4.11 Herbert In-Building Wireless said with VoLTE being in place in all new handsets for at least two years – and the average replacement rate of handsets being three years – it was safe to assume 3G calling will not be necessary.

4.12 Antenna Pro said if customers were still using older phones, then *"this will force a timely update to benefit from the new technologies".* Frequency 3G Telecom said with the switch-off of the 3G mobile phone networks and the discontinuation of the Circuit Switch Fall Back (CSFB) feature, it strongly believed it was the right time to allow 4G-only mobile phone repeaters.

4.13 Smartcell Networks said that anyone using a repeater with a phone that did not work on 4G would find out that they cannot make phone calls as soon as they switched the device on. They would either know not to use the repeater or change their phone.

4.14 Trellis Works said it was arguable that the risk of being unable to make an emergency call where 4G only is available was offset by the ability for VoLTE handsets to make emergency calls where otherwise no other coverage would be available.

4.15 Counter arguments were expressed by the MNOs. BT said, if allowed, multi-operator repeaters would need to repeat the frequency bands used by MNOs for 2G/3G. It said consumers with older 4G handsets that are not VoLTE capable were still a significant market share.

4.16 Telefónica said it did not support the use of 4G only repeaters on a licence exempt and unregistered basis anyway, as there would be no ability to detect their location. This was of key importance in relation to changes and re-configurations across the mobile networks.

4.17 Vodafone said neither the equipment manufacturers/vendors, nor the users of mobile repeaters, have any knowledge of the closure plans for 2G/3G networks and, unlike the mobile networks, do not have visibility of the terminals. If technology-specific repeaters are deployed on a licence exempt basis, there would be no information as to their location, with a consequent impact as the macro network evolves.

4.18 CellPhone-Mate/SureCall said it agreed that broadband repeaters should support the 2G and 3G frequencies used by each MNO to give the user the best chance of making an emergency call. An individual respondent said the more vulnerable are less likely to be `early-adopters` of newer technology.

Ofcom assessment

4.19 We note the strong feelings of manufacturers and vendors that 4G-only repeaters should be permitted. We accept the points made by many that a declining number of mobile phones are unable to make VoLTE calls.

4.20 However, as set out in the 2021 Repeaters Consultation, it is not only an issue about mobile devices, but also about coverage area. Our analysis suggests that between 10% and

40% of the UK landmass, depending on the particular MNO concerned, may have outdoor 4G coverage but does not have indoor 2G/3G coverage, meaning the introduction of 4G-only repeaters could create considerable areas of 4G-only indoor coverage for some MNOs.

4.21 In those areas, we believe there remains a significant risk that 4G-only 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 have seen no evidence to suggest our analysis is incorrect.

4.22 We therefore conclude that:

- for 'single operator'/'provider specific' repeaters: we will retain the current requirement that 4G signals can only be repeated when a 2G and/or 3G signal is being repeated; and
- for 'multi-operator' repeaters: we will introduce a requirement that the repeater must also 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).

4.23 As stated in the 2021 Repeaters Consultation we intend to keep these requirements under review. We note that when the MNOs finally switch off their 2G and/or 3G networks in the future, repeaters will no longer be lawful unless we make changes to our regulations (and, in any case, repeaters may cease to operate).

4.24 Importantly, as the volume of non-VoLTE handsets in active use continues to fall, the risk of people being unable to call the emergency services in the circumstances described will also fall, reducing the importance of these requirements.

Inclusion of the 2.6 GHz band

4.25 In the 2021 Repeaters Consultation we noted we had carried out analysis which suggested it would not be possible to allow repeaters to operate in the 2.6 GHz band on a licence exempt basis. We said we could not ensure that repeaters would only ever be operated beyond the minimum separation distances necessary for the protection of aeronautical radar.

4.26 We noted that some airports have air traffic control radars that are closer to surrounding residential housing than the minimum separation distance needed, and so our provisional view was that it would not be appropriate to allow the use of licence exempt repeaters in the 2.6 GHz band.

4.27 We asked stakeholders the following question:

> 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.

Consultation responses

4.28 There was a clear split in responses to the question of allowing support for the 2.6 GHz band by repeaters.

4.29 Almost all manufacturers and installers of equipment disagreed with our proposal that use of the 2.6 GHz band should not be allowed. On the other hand, BT, Telefónica and Vodafone, supported our proposal. It was also supported by a minority of equipment manufacturers and installers, including Colt Technology, Freshwave, Stella Doradus and the Small Cell Forum.

4.30 Antenna Pro and Frequency 3G both said they were often asked by customers when the 2.6 GHz band might become included in the Ofcom licence exemption. They said in overloaded urban areas it would be a valuable addition as an alternative to using the 800 MHz band – and identified the EE and Vodafone networks in particular.

4.31 Frequency 3G said mobile networks often prioritised use of higher frequencies, like the 2.6 GHz band, over lower frequencies that offered better in-building coverage. The result was week signals and poor quality of service for customers situated close to the central or core areas of a building. This could be addressed by allowing repeaters to access the 2.6 GHz band. At the same time it would relieve pressure on the 800 MHz band in congested urban areas.

4.32 Others agreed with this analysis. Nextivity said the omission of the 2.6 GHz band denied a valuable option for repeater deployment in urban areas. It said there was often spare capacity in the 2.6 GHz band, but this was often only available outdoors, as most buildings strongly attenuate the signal. By bringing the 2.6 GHz band into the licence exemption, repeaters can bring the spare capacity that exists outdoors into buildings.

4.33 It added that provider specific repeaters only operated in the presence of an actual mobile network base station. It could not interfere with air traffic control (ATC) as 2.6 GHz base stations are unlikely to be deployed near airports or other ATC radar installations. If there were lingering doubts, perhaps Ofcom could consider a notification obligation for devices that include the relay of band 7 frequencies. This is something Nextivity supports in other jurisdictions via, for instance a mobile app, before a device will operate.

4.34 Zonewave said the question of using the 2.6 GHz band was the most important part of the 2021 Repeaters Consultation. Since mobile phones choose higher frequencies over low ones, and hold on to them even though they can be poor quality, customers who spend a lot of money on licence exempt devices still get a poor user experience, making it pointless deploying such equipment in some situations.

4.35 Stella Doradus said there seemed to be no extra noise power in the radar bands. The filters and the final stage duplexer should be able to filter out any noise power in the radar bands.

4.36 Support for Ofcom's proposal to exclude use of the 2.6 GHz band was led by the BT, Telefónica and Vodafone. Of these, Telefónica urged Ofcom to go further on restricting use

of high frequency bands and also disallow use of repeaters in the 2.3 GHz band. Vodafone said it would also support – by extension – restrictions in the 3.4 GHz band.

4.37 Vodafone said that if Ofcom allowed 2.6 GHz operation on a licence exempt basis, there would be nothing in principle to prevent deployment of a multi-operator multi-repeater solution within *"for example, the terminal buildings at Gatwick airport, with subsequent risk to aircraft operations"*. In contrast, Vodafone itself was required to comply with *"onerous coordination requirements".*

Ofcom assessment

4.38 The summary of our technical analysis on potential interference from 2.6 GHz repeaters into aeronautical radionavigation (radars) in the adjacent 2700-2900 MHz spectrum was set out in paragraphs 3.50 to 3.54 of the 2021 Repeaters Consultation.

4.39 To reiterate the findings: based on the ETSI spurious emission requirements in the current harmonised standard for repeaters, 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.

4.40 We stated in paragraph 3.53 that we had reassessed the required separation distance based on measurements of spurious emissions from a sample repeater, and found that there was still a need for a separation distance of at least 1.5 km. We then indicated in paragraph 3.54 that some airports have air traffic control radars that are closer than this to surrounding residential housing. Our provisional view therefore was that it would not be appropriate to allow the use of licence exempt repeaters in the 2.6 GHz band.

4.41 We have not seen any suggestion that our analysis produced incorrect separation distances, and we have also not seen evidence that other repeaters have lower emissions in the radar band than the sample repeater that we tested.

4.42 As a result, we consider that our provisional view remains valid and we have concluded that the 2.6 GHz band should be excluded from the licence exemption for consumer repeaters.

Addition of the 700 MHz band

4.43 The 700 MHz band consists of paired spectrum (703-733 MHz uplink and 758-788 MHz downlink) and an unpaired portion (738-758 MHz). Ofcom's award of the 700 MHz frequency band concluded in May 2021, and this band will now be used for mobile network services.

4.44 In the 2021 Repeaters Consultation we said, since this frequency band is now available, we considered it appropriate to consider it for use by repeaters. In common with unpaired spectrum in other mobile bands, we did not propose to include the 738-758 MHz frequencies in the Interface Requirement. We did 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.

4.45 We therefore proposed 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.

4.46 We said that, with the technical requirements we set out in our draft Interface Requirements (Annexes A2 and A3 of the 2021 Repeaters Consultation), 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.

4.47 We asked stakeholders the following question:

> 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?

Consultation responses

4.48 Only BT and Telefónica expressed any opposition to our proposal to allow repeaters to use the paired 700 MHz band. Vodafone noted that it was not a licensee in the band, but said it could see no reason why the 700 MHz band should be treated any differently to any other band.

4.49 BT's arguments against use of the 700 MHz band noted that it was only very recently awarded and was in the process of being deployed, including to improve indoor coverage. It said use of the band by repeaters would conflict with this and would raise other technical concerns.

4.50 BT said the 700 MHz band will penetrate well into buildings, likely making the need for mobile repeaters obsolete in time, or ineffective where 700 MHz is not yet deployed. It was also concerned about increased interference to digital terrestrial television (DTT). If this occurred, it said there could be increased costs to MNOs who must, according to licence conditions, fund mitigation measures.

4.51 Finally, it noted that, with current non-standalone mode 5G services, a 700 MHz repeater would not provide a service without also providing coverage on a suitable 4G control layer. Appropriate layers would be operator dependant, with no common frequency band supporting all. It therefore urged Ofcom to remove the 700 MHz band– and also the 800 MHz band - from the draft Interface Requirements.

4.52 Telefónica said one reason for its own objection was the likelihood of a generation of intermodulation distortion when a repeater is designed to operate across, for example, 700 MHz, 800 MHz and 900 MHz concurrently. It said this can cause excessive uplink interference.

4.53 All other respondents who answered this question expressed support for our proposal. However, the Small Cell Forum said certain conditions should be applied, including a registration process to avoid MNOs not being aware of uncontrolled installations; and a

limit in each premises of only one repeater per operator (or one provider specific or one multi-operator repeater).

Ofcom assessment

4.54 On the comment that the 700 MHz frequency band should not be included because it is being rolled out and will penetrate well into buildings, we do not see any material difference between the propagation characteristics or building entry loss of the 700 MHz band compared to the existing 800 MHz band, which is already permitted for licence exempt consumer mobile phone repeaters.

4.55 In addition, consumers can benefit from repeaters that cover a frequency band that is in the process of being deployed, since by definition the coverage will not yet be universal and some of them will be located at or near the edge of present coverage. As further deployments are made, the requirements on repeaters' automatic gain control will ensure that they reduce their amplification as the local signal strength improves.

4.56 Although we note the concerns expressed about whether the inclusion of the 700 MHz frequency band could lead to increased interference effects to DTT, it was not explained whether a specific risk scenario had been identified and no technical evidence was provided. We would expect that a repeater would present no more problem to DTT than a mobile phone being used in the same location.

4.57 With reference to the comment about repeaters needing coverage from a suitable 4G control layer in order to provide 700 MHz 5G coverage for current non-standalone mode 5G services, we consider it likely that 700 MHz-capable repeaters would also be repeating 4G frequency bands but, if they did not, this omission would not lead to any increase in interference to other spectrum users.

4.58 We have addressed comments about intermodulation earlier in this document (paragraphs 3.120 to 3.121). It refers to a potential for uplink interference when a repeater is designed to operate across, for example, 700 MHz, 800 MHz and 900 MHz concurrently.

4.59 We observe that although a single amplification stage could in theory cover the 700 MHz and 800 MHz downlink frequencies because they are immediately adjacent, the same would not be true of the uplink frequencies, nor of the 900 MHz uplink frequencies which are separated from the 800 MHz band by 18 MHz of other spectrum which the repeater is not permitted to amplify. Therefore, we consider that the approach we outlined earlier on intermodulation due to signals within the repeater's pass band will address this concern.

4.60 As already set out in section 3 (paragraphs 3.49 to 3.50) a registration or light licensing scheme would require a significant administration regime with consequent costs, that would need to be passed on. This would only be justified if the expense and administrative burden were proportionate and necessary. We do not believe this is the case.

4.61 Having considered all the evidence and the responses of stakeholders, we see no reason why the paired 700 MHz spectrum should be treated differently to any other mobile spectrum bands. We have therefore decided to add the 700 MHz band to the Interface Requirement as proposed in the 2021 Repeaters Consultation.

Additional technical points raised by respondents

4.62 Some respondents urged us to go further than we proposed through the 2021 Repeaters Consultation.

Use of 5G bands by repeaters

4.63 Frequency 3G Telecomm also urged the inclusion of 5G TDD bands for mobile phone repeaters under licence exemption. Following the introduction of 5G technology by all of the UK MNOs, it said the use of frequencies between 3.4 GHz and 3.8 GHz should be an option as these signals will not penetrate buildings well, and will only add to the already known poor in-building experience.

4.64 Nextivity also said it was the right time for Ofcom to start work on how to liberalise the use of repeaters in this spectrum, either by full licence exemption, or by having other schemes such as a lightweight notification regime for reporting the installation locations of such devices.

4.65 It said the gigabit/s plus capacity of 5G TDD networks will likely only be available outdoors in a high percentage of geographical coverage, without a cost-effective indoor coverage solution. Widely available 5G TDD repeaters could *"open up this huge outdoor capacity (with the enhanced services that it brings) indoors".* It was *"the only feasible solution"* in many instances, it said.

Ofcom assessment

4.66 The proposals set out in the 2021 Repeaters Consultation focussed on enabling licence exemption for additional types of repeaters that already met the relevant ETSI standards. There is currently no TDD repeater standard and, given the need for everything in the network to synchronise timing of uplink and downlink transmission switching (including any allowance for propagation delay), it would be a very different design principle from the types of FDD repeaters considered here.

4.67 Consequently, we are not currently minded to develop regulations for licence exemption of TDD repeaters, in part because of the disproportionate time and resources involved in developing appropriate standards. However, we may review this position if suitable standards are developed subsequently, for instance by 3GPP or ETSI.

Noise figure requirement

4.68 In a further response to the 2021 Repeaters Consultation, Nextivity said it would like to raise a point regarding the noise figure requirement for licence exempt provider specific devices.

4.69 It noted that IR2102.1 currently states: *"The repeater system noise figure shall not exceed 7 dB"*. Nextivity requested a relaxation in the noise figure requirement, to state that *"The repeater system noise figure shall not exceed 8 dB"*.

4.70 Nextivity said as devices incorporate more bands, the front-end loss when combining multiple signals is greater - and so the challenge of meeting the 7 dB noise figure is significantly greater. There is a cost implication of meeting the 7 dB limit in 'provider specific' devices supporting several bands.

Ofcom assessment

4.71 We have considered the arguments put forward by Nextivity. However, we consider the 7 dB noise figure is an important element in making sure that uplink noise power does not exceed recommend noise floor levels, and that it is therefore appropriate and proportionate to include this requirement. Further, it ensures the ETSI EN 301 908-11 and ETSI EN 301 908-15 emission mask requirements will be met.

Summary of our decisions on limits and requirements for repeaters

4.72 In summary, we have decided:

- For 'single operator'/'provider specific' repeaters: we will retain the current requirement that 4G signals can only be repeated when a 3G and/or 2G signal is being repeated;
- For 'multi-operator' repeaters: we will introduce a requirement that the repeater must also 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);
- The 2.6 GHz band will not be included in the licence exemption conditions for consumer repeaters;
- The 703-733 MHz uplink and 758-788 MHz downlink frequencies will be included in the Interface Requirement with the same limits on maximum uplink and downlink power as those that will apply in the 800 MHz band.

5. Improving consumer awareness and information

5.1 We remain concerned about the sale and use of illegal devices in the United Kingdom which frequently cause interference to other wireless telegraphy, including the mobile networks. There are many non-UK based websites selling static indoor repeaters into the UK that do not comply with our regulations. Many of these claim falsely in their advertising that their products are legal and compliant. Some fraudulently claim to be compatible with and/or endorsed by the MNOs.

5.2 In this section, we explain the proposals put forward in our 2021 Repeaters Consultation to improve consumer awareness and information, the responses that we received on this from stakeholders and our final decisions.

Consultation proposals

5.3 We said in our 2021 Repeaters Consultation that we needed to raise consumer awareness about devices. This would help us address the current risk of consumers unwittingly purchasing non-compliant repeaters. At present, we recognise that buyers without technical knowledge may struggle to understand what is legal and what is illegal.

5.4 We said we would like to improve this situation in future by providing clear and unambiguous information on those devices that comply with the Exemption Regulations. We said this was in line with our objective to understand, assist and inform our stakeholders, as set out in our spectrum management strategy for the 2020s.

5.5 We explained that we do not consider it appropriate to simply identify specific manufacturers/suppliers of compliant devices on our website by, for example, publishing their names on our website. We are mindful that some manufacturers could make some products that are legal in the UK and some which are not.

5.6 However, in our 2021 Repeaters Consultation we considered whether it would be helpful for us to identify on our website specific equipment that we understood to be compliant with the Exemption Regulations. This could help people improve their mobile reception without them unwittingly purchasing unauthorised illegal repeaters, which may cause undue interference to mobile networks or other spectrum users.

5.7 Ofcom is not set up to operate as a commercial test house and conduct compliance tests on behalf of manufacturers. Furthermore, it is important that Ofcom remains entirely independent and it would risk a conflict of interest if we were to offer such a service. Specifically, 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 regulations.

5.8 On the other hand, we recognise there are independent commercial test houses (e.g. accredited by UKAS) that might be able to provide this type of testing. If we were able to

establish a voluntary testing standard – by working with relevant industry partners – then manufacturers and suppliers would be able to seek their own accreditation from a test house.

5.9 In the 2021 Repeaters Consultation we said this process would give us sufficient reassurance regarding a specific mobile phone repeaters' compliance with the Exemption Regulations to enable us to list that device on our website.

5.10 The voluntary testing standard 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.

5.11 We said we were not proposing that manufacturers would be *required* to have their devices tested by an independent test house against the Exemption Regulations. However, it would be necessary in order for a manufacturer to have its device listed on Ofcom's website as licence exempt.

5.12 We asked stakeholders the following question:

> 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?

Consultation responses

5.13 There was almost universal support for our proposal to develop a voluntary testing standard and to publish a list of compliant devices on our website – even from respondents who did not support any extension of licence exempt use of repeaters.

5.14 BT said it supported our proposals and agreed they would help to give consumers confidence that the products they bought would comply with applicable regulations. It noted that the process was intended to be voluntary, but suggested we should also consider including the UK requirements in ETSI harmonised standards, so they became part of the certification process.

5.15 Telefónica also supported an approach to indoor mobile repeaters *"that involves a robust technical testing process"*. It said it was important that such a process sat alongside a pro-active enforcement regime, led by Ofcom. However, it reinforced its overall argument that it did not support the use of licence exempt repeaters on an unregistered basis.

5.16 Vodafone too expressed support – but was more guarded in its response. It said our proposed testing regime would "go some way" to addressing the problem of illegal repeaters, but suggested suppliers of non-compliant equipment would continue to market non-compliant products.

5.17 It said the "real solution" would be for Ofcom to work with Government to make the import and sale of such equipment illegal – and to enforce that law. Vodafone said it saw our proposed testing regime as a "stopgap measure" that represented a step in the right

direction. The new system needed to be well-communicated to potential purchasers. It said Ofcom should do all it can to optimise its web presences, so that internet searches for mobile repeaters were taken to Ofcom's advice page.

5.18 The Ofcom Communications Consumer Panel and the Advisory Committee for Older and Disabled People said they welcomed our proposal to work with relevant industry partners to develop a voluntary testing standard. They said including a list of compliant mobile repeaters on Ofcom's website will allow consumers to refer to a trusted source, without fear of being duped or scammed.

5.19 They added that making consumers, citizens and micro-businesses aware of connectivity solutions available to them was paramount to improving mobile coverage across the UK. Consumers needed to be clearly informed about what a repeater can and can't do. The panel and committee said there were benefits from sharing information with consumers, citizens and micro-businesses via trusted, well-known sources, such as third sector organisations and price comparison websites.

5.20 Other organisations expressing support for our proposals included CellPhone-Mate/SureCall, Frequency 3G Telecom, Freshwave, Herbert In-Building Wireless, Smart Cell Forum, and Wireless Infrastructure Group.

5.21 CellPhone-Mate/SureCall said its experience of other markets suggested that third party test processes worked well. Freshwave said a list should be made available as soon as possible and before any further relaxation of the repeater regulations. However, it also recommended that Ofcom provide a link to a repeater page for each MNO, allowing the MNO to state its position on the use of repeaters; to recommend installers; and to inform businesses of possible alternatives such as femtocells or Wi-Fi calling.

5.22 Only Colt Technology expressed opposition to our proposals. It said it agreed that a voluntary testing standard could be beneficial in tackling illegal repeaters, but said it did not support the validation process or the publishing of a list of compliant repeaters without us limiting the size of deployments permitted. It said the 2021 Repeaters Consultation *"appears to have no regard to the possible problems caused by large scale deployments"*.

Ofcom assessment

5.23 We note the almost universal support for the proposals on improving consumer awareness and providing information as set out in our 2021 Repeaters Consultation. Having considered all the stakeholder responses, we are satisfied the proposals will support people in making better choices if they wish to purchase an indoor static repeater.

5.24 Our early engagement with relevant stakeholders has indicated a general willingness to participate in the creation and implementation of a voluntary testing standard. We believe the voluntary process represents a relatively simple way for manufacturers and suppliers of repeaters to have their compliant devices listed on our website. The listing will help to reassure people that devices are compliant with the Exemption Regulations, and therefore legal to install and use.

5.25 We recognise that providing a list of licence exempt repeaters on our website will not necessarily resolve all the issues surrounding the use of illegal repeaters. We are aware that the advice currently available is not sufficient to help all people understand the difference between a repeater that complies with the Exemption Regulations and one that does not (and is therefore illegal to use without a licence).

5.26 We will aim to improve this situation by providing clear information on our website so people can make informed choices if they wish to purchase a mobile phone repeater.

Our decisions on improving consumer awareness and information

5.27 We have decided to adopt the approaches on consumer awareness and information set out in our 2021 Repeaters Consultation. We are now working to develop our voluntary testing standard for licence exempt repeaters, in consultation with manufacturers, suppliers, accredited test houses, and other stakeholders.

5.28 Under the process, manufacturers and suppliers of repeater equipment may, if they choose, submit a device to an accredited test house to establish whether its operation complies with the requirements for licence exemption (when tested in accordance with the voluntary testing standard).

5.29 If the test house confirms that it does, a manufacturer/supplier may request that the device they are marketing be listed on our website as compliant with the licence exemption conditions. Such requests should be accompanied by a copy of the testing certificate from the accredited test house. Full details of the process will be set out on our website, once the process is established.

5.30 To be clear, a listing on our website will not represent an authorisation or endorsement of any products by Ofcom. Nor will it mean that we consider that a particular device will provide a suitable solution to any coverage issues a potential purchaser may face. Any decision to install a repeater or not remains a matter for a consumer to assess for themselves, alongside consideration of alternative possible solutions.

5.31 The list will be designed simply to inform consumers that a particular device has been assessed by an accredited test house as being compliant with the technical requirements of our licence exemption regime.

5.32 Alongside the development of our voluntary testing standard and the publication of the list on our website, we will continue to combat the sale and purchase of illegal and potentially harmful repeaters through enforcement action, consumer advocacy and information campaigns.

5.33 It should be noted that all radio equipment placed on the market in the UK (including mobile phone repeaters) must also comply with the Radio Equipment Regulations 2017.

6. Next steps

6.1 This statement has set out the decisions we have taken to extend the range of static indoor repeaters available for people to buy and install themselves without a licence. In particular, our decisions to allow the use of provider specific and multi-operator repeaters.

6.2 We are now beginning the process of making necessary changes to our Exemption Regulations in order to implement our decisions. Alongside this process we are finalising the development of our voluntary testing standard for licence exempt repeaters.

6.3 In summary, the steps we are taking to implement our decisions are as follows:

- **EC Notification:** The position of Northern Ireland as a continuing part of the EU single market means we will notify the European Commission of the Interface Requirements included in the Exemption Regulations. The EC has three months to comment.
- **Consultation on Exemption Regulations:** We will conduct a statutory four-week consultation on the draft Exemption Regulations. This will take place after the notification period for the Interface Requirements has passed. The regulations will not come into force until we have considered any consultation responses.
- **Finalisation of our voluntary testing system:** We expect to start working with key stakeholders to finalise our voluntary testing standard for licence exempt repeaters shortly after publication of this statement. We will publish a document setting out the final standard at the same time as our final decisions on the Exemption Regulations.
- **List of compliant devices:** We expect to start listing devices that we understand comply with the technical requirements of our licence exemption regime – following testing by an accredited testing house in accordance with our voluntary testing standard – once we have made the Exemption Regulations. We will regularly update the list, which we expect to be limited in its early stages but will expand over time.

6.4 We expect the decisions set out in this document to be fully implemented before the end of March 2022.

A1. Legal framework

A1.1 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 "**WTA**"). 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

A1.2 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.

A1.3 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 desirability of encouraging the availability and use of high speed data transfer services throughout the United Kingdom, (iv) 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 (v) the different interests of persons in the different parts of the United Kingdom, of the different ethnic communities within the United Kingdom and of persons living in rural and in urban areas.

A1.4 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 WTA 2006

A1.5 In carrying out our spectrum functions we have a duty under section 3 of the WTA 2006 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.

A1.6 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.

A1.7 Under section 8(1) of the WTA, it is illegal 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 WTA. 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.

A1.8 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.

A1.9 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

A1.10 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.[15]

A1.11 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

[15] 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

must be constructed such that it uses the relevant radio spectrum so as to avoid harmful interference.

A1.12 One way in which these requirements may be satisfied is by meeting an applicable 'harmonised' or 'designated' standard (as applicable).[16] 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.

A1.13 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 the absence of licence exemption by Ofcom, they cannot therefore be used in the UK without a wireless telegraphy licence. In order for consumers to use self-installed repeaters on a licence exempt basis, Ofcom may identify a set of technical requirements which are additional to those in the relevant harmonised or designated standards.

Impact Assessment

A1.14 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.

A1.15 The analysis presented in this document as a whole constitutes our impact assessment.

Equality Impact Assessment

A1.16 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.

A1.17 The decisions set out in this document will apply equally to all users of mobile phone repeaters. We have not identified any differential impact of our decisions in relation to the

[16] 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).

identified equality groups and, in our assessment, they would not disproportionately affect any group of consumers.

A2. (Draft) Changes to the UK Radio Interface Requirement for Licence Exempt Provider Specific Static Mobile Phone Repeaters for Indoor Use

A2.1 Using 'tracked changes' this annex shows the changes we are making to **IR 2102.1.** We have taken the following approach to show the changes clearly:

a) the words in yellow highlights (and in bold font) are those that we are inserting (e.g. "**example**");

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

A2.2 These changes – and the Interface Requirements for multi-operator static mobile repeaters set out in Annex 2 – are in draft form at present because they are subject to EC Notification, as explained in section 6 of this document. The EC has three months to comment. The Interface Requirements will then form part of the Exemption Regulations, which will be subject to a statutory 4-week consultation period.

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**s**	**700**	**703-733 MHz (Uplink)** **758-788 MHz (Downlink)**
		800	791-821 MHz (Downlink) 832-862 MHz (Uplink)
		900	880-915 MHz (Uplink) 925-960 MHz (Downlink)
		1800	1710-1785 MHz (Uplink) 1805-1880 MHz (Downlink)
		2100	1920-1980 MHz (Uplink) 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	Channel access and occupation rules	**Transmit Gain Control** 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. The uplink and downlink system gain of a repeater shall not exceed 100 dB. 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 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 Repeaters must detect and mitigate (i.e. by automatic gain reduction or shut down) any oscillations in uplink and downlink **frequency** bands. Oscillation detection must occur automatically within: 0.3 seconds in the uplink band; and 1 second in the downlink band. 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

		~~The amplified frequencies shall be limited to those licensed to a single mobile network operator.~~ **Where a repeater is only capable of amplifying frequencies licensed to one mobile network operator at a time, the Transmit Power/Power Density and Transmit Gain Control requirements shall be calculated and applied individually for each uplink and downlink frequency band (as defined in Mandatory 3) that is being amplified by that repeater.** ~~The equipment may be re-configured to alternate frequencies but may only operate using frequencies licensed to a single operator when configured.~~ **Where a repeater is capable of amplifying frequencies licensed to more than one mobile network operator at the same time, those requirements shall be calculated and applied individually for each of the uplink and downlink frequency bands licensed to each mobile network operator that is being amplified by that repeater.**
		Noise Figure The repeater system noise figure shall not exceed 7 dB.
9	Authorisation regime	Licence Exempt[17] The deployment of a 4G only **provider specific static mobile phone repeater** ~~transmitters~~ is not permitted. **When amplifying a 4G signal licensed to a mobile network operator,** all **provider specific static mobile phone** repeaters must also ~~transmit~~ **amplify** a 2G and/or a 3G signal **licensed to that mobile network operator**.
10	Additional essential requirements	Nil
11	Frequency planning assumptions	Not specified
Informative (12-15)		
12	Planned changes	Nil
13	Reference	EN 303 609 EN 301 908-11 EN 301 908-15

[17] See remarks

14	Remarks	Nil
15	Notification Number **(in respect of Northern Ireland)**	~~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
900 & 1800	LTE & WiMAX	23 dBm EIRP	PSD 10 dBm / 5 MHz EIRP; and Total 17 dBm EIRP
2100	Technology Neutral	24 dBm EIRP	PSD 10 dBm / 5 MHz EIRP; and Total 17 dBm EIRP
Where PSD is power spectral density			

A3. (Draft) UK Radio Interface Requirement for Licence Exempt Multi-Operator Static Mobile Phone Repeaters for Indoor Use

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

		composite received signal power in dBm at the repeater donor port, for all base stations in the band of operation. A repeater shall provide the same uplink and downlink system gain. The uplink and downlink system gain of a repeater shall not exceed 100 dB.
		Automatic Standby 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 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: 0.3 seconds in the uplink frequency band; and 1 second in the downlink frequency band. 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 The repeater system noise figure shall not exceed 7 dB.
		Intermodulation due to signals within the frequency band(s) of operation For each frequency band that is being amplified by the repeater, transmitted intermodulation products due to input signals within that band shall not exceed −19dBm at the uplink and downlink ports.
9	Authorisation regime	Licence Exempt[18] All multi-operator static mobile phone repeaters must transmit the entirety of the 900, 1800 and 2100 frequency bands as defined in **Mandatory 3**.

[18] 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.
10	Additional essential requirements	Nil
11	Frequency planning assumptions	Not specified
Informative (12-15)		
12	Planned changes	Nil
13	Reference	EN 303 609 EN 301 908-11 EN 301 908-15
14	Remarks	Nil
15	Notification Number (in respect of Northern Ireland)	TBC