An Coimisiún um
Rialáil Cumarsáide
Commission for
Communications Regulation

Response to Consultation on Permitting the General Use of Mobile Phone Repeaters

Submissions to Consultation 17/103

Reference: ComReg 18/58s

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Content

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Response to ComReg Consultation:
Permitting the General Use of Mobile Phone Repeaters

ComReg Document 17/103

19 January 2018

DOCUMENT CONTROL

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The comments submitted in response to this consultation document are those of Eircom Limited and Meteor Mobile Communications Limited (trading as ‘eir’ and ‘open eir’), collectively referred to as ‘eir Group’.

INTRODUCTION

We acknowledge the recommendation of the Mobile Phone and Broadband Taskforce and welcome the opportunity to respond to the proposals set out in ComReg consultation document 17/103 on permitting the general use of mobile phone repeaters.

eir recognises that reliable mobile phone coverage is an important consumer issue and is one which we are continuously working on with our customers. Our mobile network extends to over 2000 sites with continued investment in technology and service improvement that reaches over 96% of the population for LTE with GSM and UMTS at 99%. We plan, develop, monitor and optimise our network to ensure continuous improvement in our customer experience as independent measurement consistently demonstrates. In 2017, eir also introduced the Wi-Fi Calling service to improve mobile coverage for eir customers. We are currently the only Irish network to have launched this service, which allows eir customers across Ireland to use their smartphone to call and text over any WiFi connection so our customers are already getting better mobile coverage. We are also continuously adding more phones to the list of supported devices.

Internal reporting shows that, in the period between ✂

We also understand that other mobile operators have similar plans to roll out such services in 2018.

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Engagement from ComReg on how to further improve mobile phone coverage for the benefit of Irish consumers is welcomed by eir. However, we have concerns about the proposals being put forward by ComReg in this consultation without any prior discussion with the mobile network operators. We are also surprised at the views expressed by ComReg that mobile operators are likely to prefer Option 3 and that Option 3 offers better protection to mobile operators and existing spectrum users.[1] Until now, this matter has not been discussed with mobile operators. For the reasons set out in our responses below, we do not accept that Option 3 is the best option and we have serious concerns in relation to the interference that will be caused on our network should ComReg proceed to implement these proposals in the manner set out in the consultation document. From a network interference perspective Option 3 is the worst of the options presented.

eir's preferred option is Option 1 with enhanced processes to detect and remove repeaters that are interfering with MNO networks. However, in the event that ComReg proceeds to introduce a licence exemption, Option 2 is preferred over Option 3 for the reasons set out in our responses below. We would also only support Option 2 on the condition that the use of repeaters is properly controlled and monitored to ensure that devices interfering with our network can be detected and removed as efficiently as possible.

We firmly believe that a workshop with all relevant stakeholders is required to discuss the technical issues surrounding the widespread use of repeaters before any final decision is made by ComReg to allow their general use. It appears to us that appropriate consideration may not have been given to the network risks associated with these far reaching proposals. It is disappointing that ComReg did not seek the views of MNOs whilst developing potential options.

RESPONSE TO CONSULTATION QUERIES

Do you agree with ComReg's proposal for the license exemption of mobile phone repeaters?

eir does not agree with ComReg's proposal in its current form. Option 3 is, in eir's opinion, the least attractive option described in the consultation document.

[1] Paragraphs 66 to 69 of ComReg 17/103

eir has first-hand experience of deploying approved repeaters in particular instances within its network and knows the benefits and limitations of same. In eir's experience, even when trained radio network engineers deploy repeaters, having surveyed a location and reviewed the impact on the radio plan, problems can arise from the use of such repeaters. This design and deployment process needs to be managed extremely carefully in order to protect the network. The current use of repeaters by eir is very limited and controlled.[2] An example of recent issues encountered with the professional installation of a repeater on our network is included at **Annex 1**.

Option 1 leaves the deployment of repeaters in the hands of the MNOs thereby ensuring a quality product is used in a controlled and planned way and is tested and monitored for performance. ComReg's current proposals on the other hand eliminate any oversight on the part of the MNOs in relation to the purchase and deployment of repeaters on their own networks.

Under the current regime the MNOs select more expensive but better functioning repeaters to secure network performance. Should a license exemption be put in place for repeaters, consumers are not likely to be aware of issues such as CE approval (and CE approval marks can be faked) and consumers are likely to opt for cheaper and less robust devices. Consumers and manufacturers are also not likely to be aware of the definition of the terms "Repeater" and "Booster" as set out by ComReg in the consultation document. In this regard, ComReg should confirm whether it intends to undertake any form of advertising campaign with a view to ensuring that consumers are aware of the differences between authorised and unauthorised repeaters. Given the scope for serious interference on MNO networks by the widespread use of repeaters an awareness campaign is, in eir's view, very important.

The recommendation of the Mobile Phone and Broadband Taskforce was to develop a licensing scheme allowing the use of accredited mobile phone repeaters to help address the issue of indoor coverage. However, we do not see any detail in the consultation document on the accreditation process. In our view, there must be a suitable accreditation scheme for these repeaters to demonstrate that they conform to the technical specifications implemented by ComReg, including a labelling scheme to make it clear to customers that the repeater is in fact

[2] The BEREC and RSPJ joint report on facilitating mobile connectivity in "challenge areas" (BoR (17) 185) recognises that correct installation and good hardware are important when working with repeaters to minimise the noise impact.

accredited to the standards set by ComReg. In circumstances where the MNOs will no longer have any oversight in relation to repeaters being deployed on their networks, that oversight must be carried out through an appropriate accreditation scheme, as recommended by the Taskforce. The accreditation scheme should be administered by ComReg.

In the event that ComReg proceeds with a license exemption of mobile phone repeaters, Option 2 is seen as the preferred option as it limits the repeater to the MNO's licensed spectrum, limiting the impact on neighbouring spectrum of other MNOs. However, a rigorous administration and control process must be deployed to protect the mobile networks designed and deployed by operators who currently have exclusive authority for the broadcast of their licensed spectrum. Any repeater purchased and deployed by a party other than an MNO must be registered in a central database which records details such as the repeater model, operator band and geo location of the repeater. The information should be captured at the point of sale.

A rigorous process must also be put in place to have any repeater found to cause interference to an MNO's network turned off and the costs for same must not be passed to the MNO affected. The same applies to illegal boosters. The illegal use of boosters or non-type approved products is a real problem for MNOs today and it can take considerable time from first report to when a source of harmful interference is switched off. ComReg's procedures and processes need to be enhanced to address this ensuring that sources of interference to mobile networks, including accredited repeaters, can be rapidly eliminated. eir's support for Option 2 is therefore contingent on ComReg committing that it will increase resources in the interference investigation and enforcement teams to deal with the widespread use of repeaters. We would also like to see a service level agreement in place for investigating network interference. In eir's view, 5 working days is sufficient time to investigate and remove/turn off an offending repeater and we would like to see some commitment from ComReg in this regard given the risk that our network will be exposed to as a result of these proposals.

eir is concerned that in the consultation document there is no detail on any such processes for tracking or monitoring the deployed repeaters or indeed any process to turn off repeaters that have been determined by the relevant MNO to degrade the network performance.

As stated above, when an MNO installs a repeater today it is done in a controlled manner with proper radio design and performance considerations taken into account. The deployment includes full testing and so any issues found result in the modification of the design or indeed

turn off of the repeater. ComReg would not necessarily be aware of issues seen to-date with such deployments.

ComReg states in the Draft Exemption Order that it reserves the right to inspect the Mobile Phone Repeater at the licensee's own expense prior to and during operation if necessary. In the opinion of eir this expense needs to be borne by ComReg and/or the consumer who purchased and deployed the repeater. As the control of the sale/purchase and deployment of these repeaters will be out of the hands of the MNOs (the legal licensee of the spectrum), the cost for analysis and subsequent turn off or replacement of a repeater adversely affecting the network cannot be borne by the MNO.

As pointed out in the consultation document and as set out in the introduction above eir has other solutions such as WiFi Calling to combat the need for repeaters that may adversely affect the surrounding network should they be deployed in a hap hazard manner or indeed go faulty over their lifetime. ComReg points to the edge of the network or poor service areas for the use of repeaters but this is exactly where careful management of technical solutions is needed to ensure delivery of service is not at the expense of the rest of the network or at the expense of other users served within good coverage areas. It is important to remember that any deployment of a radio unit will add to the noise floor thus affecting the radio plan.

Currently MNOs experience 'black spots' of poor service due to the difficulty in acquiring and building base stations and support structures in certain areas. The MNOs are liaising with the local authority Broadband Officers to support the identification of local authority land to build the structures. Governmental support is needed here to support an affordable solution for the MNOs to rollout in these areas where financial payback may not be possible on the base station rollout due to low levels of population density. A full base station rollout is far more preferable to multiple repeaters as overall it provides enhanced services for more of the population without the associated quality risks from repeater deployment. The existence of multiple repeaters at the edge of the network could significantly impact the effectiveness of deploying a new mobile network site beyond the current edge. This further underlines the need for a database to record the location of repeaters to facilitate mobile network planning and the need for a mechanism to rapidly order the shutting down of repeaters that cause interference to the mobile network.

Option 3 is more problematic because wide band amplifiers amplify all signals coming in, regardless of the input quality. A consumer may have one of these units installed to improve

service for a particular MNO's service. They will locate the antenna such that it is in the best location for that MNO's donor service and does a good job at improving service for that operator. However, the location of that antenna may not be suitable for the base stations of other MNOs and could end up causing quality issues for those other operators. Feeding in a poor quality signal will only lead to poor quality amplification.

While filtering and interference mitigation features are beneficial and desirable, all repeaters cumulatively cause an increase in noise power in the base station receiver. A large number of repeaters will lead to large noise rises and potentially drive further demand for repeaters to deal with cell shrinkage, leading to even further noise rises.

At paragraph 68 of the consultation document, ComReg states:

> *There is also an increased risk of interference, from Option 2 over Option 3, if a premise were to install multiple devices to cover bands used by different Operators. (i.e. oscillation increases significantly). Adopting Option 3 and permitting the general usage of wideband repeaters offers better protection to MNOs and existing spectrum users.*

eir does not agree with this statement. In our view, multiple Option 2 repeaters, each for a different MNO, would work more independently than a single Option 3 multi-operator (full band) repeater. An Option 2 repeater filtered to one MNO's frequencies should not go into oscillations due to the presence of a second Option 2 repeater tuned to a different MNO's frequencies. Furthermore, independent Option 2 repeaters would have separate gain control, and so fewer instances of RF problems would be expected. A single Option 3 repeater would share the same amplifier, with the same gain for both MNOs (per band), and so would be far more prone to RF problems such as intermodulation, RF overload, higher UL noise levels, etc.

We are also of the view that the upfront cost of €200-€500 would not cover the costs of a system (antennas, repeater unit, cabling, install) which meets the specifications proposed by ComReg. Even for Option 3, these price estimates are extremely optimistic, especially given the costs of install with an approved installer following full HSA approved working at height procedures.

Whilst ComReg has attempted to address the risks by prohibiting any booster use and limiting the exemption to smart repeaters only, this still does not fully address the risks to quality issues in the network. Under today's regime the MNOs control repeaters placed in the

network. The location and performance is well known, the impact on the radio plan is analysed in advance and the performance of the product is tested. Due to the costs of quality repeaters it is true that this applies mostly to corporate type deployments. However, in eir's case, WiFi Calling was launched to tackle the residential and SME sectors.

As stated above, if ComReg does decide to move forward with a licence exemption, then Option 2 is preferred. Repeaters that are tuned to individual MNO networks have less of an effect on radio networks.

We note that ComReg's proposals are largely based on a scheme that is being introduced in the UK. We note from the UK consultation process that the MNOs raised a number of concerns regarding the use of repeaters in the manner proposed. We believe it would be prudent for ComReg to allow sufficient time to pass so that the effectiveness of the UK scheme (and effectively the proposed scheme for Ireland) can be assessed in practice. It must be acknowledged that the widespread deployment of repeaters in an uncontrolled manner is not a panacea to mobile coverage issues but could in fact lead to a reduction in quality of service for many mobile users. As stated at the outset, we also believe that a workshop with relevant stakeholders is necessary before any decision can be made.

Do you agree with ComReg's proposed technical conditions set out in Table? If not, please provide reasons and supporting evidence for your answer.

We have comments on some of the specifications as follows:

Protection against Oscillation:

The Draft Exemption Order states that detection and mitigation must occur within 0.5 seconds. However, the table of technical conditions states that detection and mitigation must occur within 0.3 seconds. In eir's view the table is correct, i.e. it should be 0.3 seconds. The quicker the response of the unit to account for any oscillations, the more it can compensate for the noise.

Power:

Each technology and frequency band has different maximum uplink output powers, e.g. GSM900 @33dBm, UMTS900 @21dBm, LTE1800 @21dBm. The maximum uplink gain allowed should be specified per frequency band and per technology.

The uplink power level is still too high. An unregulated, unmonitored system where consumers can buy these units off the shelf and install themselves is prone to poor quality installs which could and will cause excessive noise rise in the MNO's licenced frequency bands.

If one MNO's signal is significantly stronger than the others, the repeater will use its automatic gain control to limit the output power at or below 17dBm. For example, if one operator's input single was at -45dBm, but the other was at -80dBm, the repeater may set its output power with automatic gain control from 70 down to 62dBm (70-45=25dBm-12=8dB. 70dBm-8dB= 62dB repeater gain). This would keep the MNO1 output power at 17dBm. But for MNO2 @ input of -80dBm, it would limit their output power to -18dBm (-80+62dB gain).

ComReg's recommendations on uplink gain do not consider the gain of the donor antenna. If repeater units are sold with much higher gain direction antennas, e.g. a 21dB direction yagi antenna, the overall uplink output power is greatly increased and so could cause significant noise in the system. The maximum uplink and downlink EIRP should consider the cabling and antenna gain and not just the repeater specifications alone.

The levels of power the proposed repeaters will utilise are only a small margin less than that utilised by Approved Repeater installers today. Even with approved installers following strict

approval processes with the MNOs, quality issues occur due to noise rise on the MNO network when these units are powered on. As they are approved and tracked, the MNOs have the opportunity to request further optimisation of the repeater units to reduce the noise rise from the repeater, effectively powering down their maximum power output.

Gain Control:

Is this based on aggregate power or the power from each separate base station? For instance, MNO1 may be very strong, but MNO2 and MNO3 may be weak at the area in question. Unless the repeater looked at each base station input separately, it would power off based on MNO1's input.

Comments on the Draft Exemption Order:

The definition of "Mobile Phone Repeater" includes both repeaters that are used indoors and in-vehicle. However, the recommendation of the Mobile Phone and Broadband Taskforce was to develop a licensing scheme allowing the use of accredited mobile phone repeaters to help address the issue of indoor coverage only. We also note that in-vehicle repeaters are not referenced anywhere else in ComReg 17/103. Please confirm whether this is an error or whether ComReg also intends to allow the general use of in-vehicle repeaters without setting any technical specifications specific to in-vehicle use.

If ComReg intends to also exempt in-vehicle repeaters, we believe that further consultation is required to address this separate issue.

Annex 1

Recent example of network interference

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2 Multicom Technologies Limited

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Thursday, January 18, 2018

RE: Consultation on Permitting the General Use of Mobile Phone Repeaters

Dear Mr. Craine,

Many thanks for the opportunity to respond to ComReg's Consultation on Permitting the General Use of Mobile Phone Repeaters.

We have read through the document and have given our opinion on the technical merits of the proposal of implementing licence exempt repeater solutions

We have included our comments on the following pages with reference to the paragraph number in the document.

If you have any questions or we can be of any further help please do not hesitate to get in touch with us.

Yours sincerely,

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Multicom Response – ComReg 17/103

4. If a business or household can install a licence exempt device to improve mobile coverage at their premises, will there be a record/database of all licence exempt installations in the country? A database of licenced repeater installations is already kept by operators and enables troubleshooting if there are any interference problems in areas where repeaters are operational. Who will undertake the installation of repeater systems? Will there by a list of operator approved installers that a customer can use?

7. The definition of the difference between a “booster” and a “repeater” can sometimes be blurry, for example a Nextivity Cel-Fi unit would be classified as a booster but would have AGC and interference mitigation to limit interference effects on the macro network.

20. Not all customers are currently aware that they need a licence for mobile repeaters, education and information would need to take place to ensure that customers know what is legal and what is not. The cost factor may still see some customers go down the “illegal” booster unit route, even though they know a more expensive legal option is available to them.

22. The provision of indoor mobile phone coverage should be seen as a utility which needs to be implemented. Operators cannot guarantee indoor coverage with the high levels of insulation used in modern buildings and therefore the building owner will need indoor systems implemented to provide an acceptable level of coverage.

25. A third option exists to overcome this problem, the use of small cells. 3G femtocell’s using a customer broadband were very successful over the last number of years. These legacy units have interoperability issues with the 4G network. New small cells are being looked at by the operators, these would provide a better level of service to customers provided there is

reasonable backhaul, and these small cells would also provide more visibility and management to the operator.

54. If a wideband repeater is used and not installed correctly, it may inhibit competition. At a donor antenna level, each operator received level would vary and the level of coverage provided internally will also vary, one operator may have a low level of coverage compared to another operator.

93. Is there any guidelines on other passive equipment that is required for the operation of a repeater system, such as antennas (donor and service, cables and connectors). The gain of a donor antenna would need to be noted to ensure the system remains within the guidelines for uplink gain.

3 Stella Doradus

Stella Doradus Engineering report
Response to Comreg report on permitting the use of mobile phone repeaters.

stella doradus

Contents.

1. The RED Standard.
2. Stella Doradus input report.

The Radio equipment directive (RED) standards for mobile phone repeaters are:

ETSI EN 303609 V12.5.1 (2016-04) for GSM

ETSI EN 301908-11 V11.1.2 (2017-01) for UMTS

ETSI EN 301908-15 V11.1.2 (2017-01) for LTE

ETSI EN303609 V12.5.1 covers:

4.2.1 Conducted spurious emissions, -36dBm from 9kHz to 1GHz, -30dBm from 1GHz to 12.75GHz. This applies with no CW input, CW input that results in maximum power at the repeater output.

4.2.2 Radiated spurious emissions, -36dBm from 9kHz to 1GHz, -30dBm from 1GHz to 12.75GHz. This applies with no CW input, with CW input that results in maximum power at the repeater output

4.2.3 Intermodulation attenuation, intermodulation products must not exceed -36dBm from 9kHz to 1GHZ, -30dBm from 1GHz to 12.75GHz. 2 tones are injected into the repeaters pass band that result in maximum power at the output. The test is repeated with the input tone powers increased by 10dB.

4.2.4 Out-of-band gain, limits

50dB at 400kHz offset and greater

40dB at 600kHz offset and greater

35dB at 1Mhz offset and greater

25dB at 5Mhz offset and greater

4.2.5 Frequency error. Applies to repeaters using frequency shift.

ETSI EN310908-11 V11.1.2 covers:

4.2.2 Operating band unwanted emissions. This applies to the pass band +/-10Mhz each side of the pass band. A general limit of -16dBm for <1GHz and -15dBm >= 1GHz applies. I addition an operating band mask applies. For a broadband repeater 2 WCDMA signals are fed into the repeater and the mask must not be broken for signal input levels such that the repeater operates at maximum power, and also for input signal levels 10dB above this level.

4.2.2.2.3 Protection of the base station receiver. Applies to the uplink of the repeater at maximum gain. The level is -53dBm with a RBW of 100kHz. In addition there are limits for Protection of DTT, limits for operation in band 32.

4.2.2.3 Spurious emissions. -36dBm from 9kHz to 1GHz, -30dBm from 1GHz to 12.75GHz. For a broadband repeater, 2 WCDMA signals are injected into the repeater pass band. The above limits must not be exceeded. The test applies with no input signals, with input signals that produce maximum power at the repeater output, a 10dB increase in these levels. In addition there is a section on co-existence with other systems.

4.2.4. Maximum output power. The maximum output power of the repeater is measured under normal and extreme conditions and must remain within certain limits

4.2.5 Input intermodulation. Two -40dBm tones are injected into the pass bands of the repeater such that the lowest order intermodulation product is positioned in the centre of a pass band. For a broadband repeater there are many pass bands so the test must be repeated for different pass bands. The limit for the increase in power in the pass band is 11.2dB. In addition there is a section on co-existence with other systems.

4.2.6 Out-of-band gain. Limits:

60.5dB at 0.2Mhz -1Mhz offset

45.5dB at 1Mhz - 5Mhz offset

45.5dB at 5Mhz -10Mhz offset

35.5dB greater than 10Mhz

This roll off is considerably less extreme than the GSM standard.

4.2.7 Adjacent Channel rejection ratio. Does not apply to a broadband repeater covering all bands

4.2.8 Output intermodulation. This measures the repeaters ability to inhibit the generation of intermodulation products due to an interfering signal reaching the repeaters output port.

ETSI EN 301908-15 V11.1.2 is very similar to ETSI EN 301908-11, except many more tests must be carried out to take account that there are many different bandwidths for LTE (1.4Mhz, 3Mhz, 5Mhz, 10Mhz, 15Mhz, 20Mhz) and only one for UMTS (5Mhz).

The operating band unwanted emissions, protection of the base station receiver (-53dBm/100kHz), Spurious emissions, maximum output power, Input intermodulation, Out-of-band gain, adjacent channel rejection ratio and output intermodulation all have the same limits. There are some additions to do with DTT and co-existence with other systems.

All broadband repeaters must fully comply with the above ETSI RED standards to comply with European legislation. The GSM bands are the 900 band and the 1800 band, the UMTS bands are the 900 and the 2100 band, and the LTE bands are the 800, 900, 1800, 2100, 2600. Currently LTE is not the 900 or 2100 bands, but it has to be assumed that in the future it might be.

Suggested alterations to the standard proposed by Comreg:

1). Proximity control.

To be used instead of the proposed shutdown level of RSSI > = -40dBm.

The ETSI EN301908-11 and EN301908-15 limit the uplink noise to less than -53dBm/100kHz. At this level, assuming a 15dBi base station antenna, a 10dBi outdoor antenna and no cable loss between the repeater port and the outdoor antenna, this noise power would be detected by a 900Mhz base station almost 1.5Km away (assuming free space loss), and by a 2100Mhz base station about 700meters away. A broadband repeater must reduce its uplink noise power when in the presence of a strong downlink signal such that this noise power never reaches the base station. A formula to allow for this could be -103dBm/Mhz-RSSI. If the repeater can no longer meet this specification, then it must shut down. For the uplink this can ensure that the uplink noise always falls short of the base station being able to detect it by 22dB. This also means that more than about 100 repeaters would have to be installed close to a base station sector before the combined noise could be detected. Repeaters installed far away would have a greater than 20dB safety margin and thus would only marginally effect to combined noise power. Please see the attached excel document which expands on the results of using this formula.

This is much safer than just requiring a repeater to shut down if in the presence of a combined RSSI of greater than -40dBm. A repeater with an uplink gain of more than 60dB would be generating a high enough noise power to be detected by the base station, if it was installed close enough to receive an RSSI of -40dBm.

2). Out of band gain.

The ETSI GSM standard, EN303609 band edge roll off requirement is much tighter than for the UMTS and LTE standards, and requires much larger and more expensive non-standard filters. GSM is only used in the 900 and 1800 bands, and this is the case right across Europe. Also, GSM, or 2G, is a legacy standard, not as efficient as the new 4G LTE standard, and it is very unlikely to be used in the 800, 2100 or 2600 bands, and again, this is the case right across Europe. We would suggest that the roll off requirements for GSM only apply to the 900 and 1800 bands, and the UMTS/LTE requirements (see above) apply to 800, 2100, 2600 bands. (2600 not applicable in Ireland yet)

3). Gain limits in the uplink. The transmit power of user equipment is controlled by the base station. It requests the handset to increase or decrease transmit power. If the repeater has fixed uplink gain, and is installed close to a base station, a situation can arise where the handset is already transmitting as its minimum power but due to the repeater fixed gain is received by the base station at too high a level. The base station requests the handset to reduce power further but it can't. This de-sensitises the base station to other users signals, especially 3G and 4G signals. However to meet the proximity control equation above, uplink gain must be reduced and this will be sufficient to ensure a gain problem will not occur. However, if the regulator wishes to include a gain limit equation, the very simple formula:

Uplink maximum gain <-RSSI, with a maximum gain level of 70dB would be sufficient.

3). Intermodulation requirements. There is no need to mention these as they are already covered in the existing RED standards. Radiated emissions, interestingly, these are in the ETSI GSM standard, but not in the UMTS or LTE standard. A maximum power UMTS or LTE signal should be injected into the input port of the repeater and out of band emissions tested in the relevant bands, and the test should apply to the uplink and the downlink.

Results of applying the formula -103-RSSI, assuming free space loss

assuming a 33dBm base station transmitter, 15dBi base station antenna, 10dB donor antenna at repeater site, no cable loss between repeater and donor antenna.
noise floor =-114dBm/1Mhz

Calculations for 900Mhz

for uplink noise not to be detected by base station

RSSI DL power at 900Mhz in dBm	-103dBm/1MHz -RSSI proposed uplink noise limit	path loss needs to attenuate the uplink noise by:		distance from base station repeater could be detected	path loss from base station to repeater		actual distance from base station	headroom
-65dBm	-38dBm	114-38+10+15	101dB	**3000 meters**	33+15+10+65	123dB	**40Km**	22dB
-60dBm	-43dBm	114-43+10+15	96dB	**1500 metes**	33+15+10+60	118dB	**20Km**	22dB
-55dBm	-48dBm	114-48+10+15	91dB	**900 meters**	33+10+15+55	113dB	**12Km**	22dB
-50dBm	-53dBm	114-53+10+15	86dB	**500 meters**	33+10+15+50	108dB	**7Km**	22dB
-45dBm	-58dBm	114-58+10+15	81dB	**300 meters**	33+10+15+45	103dB	**3500 meters**	22dB
-40dBm	-63dBm	114-63+10+15	76dB	**180 meters**	33+10+15+40	98dB	**2000 meters**	22dB
-35dBm	-68dBm	114-68+10+15	71dB	**90 meters**	33+10+15+35	93dB	**1200 meters**	22dB
-30dBm	-73dBm	114-73+10+15	66dB	**50 meters**	33+10+15+30	88dB	**600 meters**	22dB
-25dBm	-78dBm	114-78+10+15	61dB	**30 meters**	33+10+15+25	83dB	**350 meters**	22dB
-20dBm	-83dBm	114-83+10+15	56dB	**15 meters**	33+10+15+20	78dB	**200 meters**	22dB
-15dBm	-88dBm	114-88+10+15	51dB	**9 meters**	33+10+15+15	73dB	**120 meters**	22dB
ETSI limit	-43dBm	114-43+10+15	96dB	**1600 meters**				

Calculations for 2100Mhz in dBm

RSSI DL power at 2100Mhz in dBm	-103dBm/1MHz -RSSI proposed uplink noise limit	path loss needs to attenuate the uplink noise by:		distance from base station repeater could be detected	path loss from base station to repeater		actual distance from base station	headroom
-65dBm	-38dBm	114-38+10+15	101dB	**1500 meters**	33+15+10+65	123dB	**17Km**	22dB
-60dBm	-43dBm	114-43+10+15	96dB	**700 meters**	33+15+10+60	118dB	**9Km**	22dB
-55dBm	-48dBm	114-48+10+15	91dB	**400meters**	33+10+15+55	113dB	**5Km**	22dB
-50dBm	-53dBm	114-53+10+15	86dB	**220 meters**	33+10+15+50	108dB	**3Km**	22dB
-45dBm	-58dBm	114-58+10+15	81dB	**120 meters**	33+10+15+45	103dB	**1500 meters**	22dB
-40dBm	-63dBm	114-63+10+15	76dB	**70 meters**	33+10+15+40	98dB	**900 meters**	22dB
-35dBm	-68dBm	114-68+10+15	71dB	**40 meters**	33+10+15+35	93dB	**500 meters**	22dB
-30dBm	-73dBm	114-73+10+15	66dB	**20 meters**	33+10+15+30	88dB	**300 meters**	22dB
-25dBm	-78dBm	114-78+10+15	61dB	**12 meters**	33+10+15+25	83dB	**150 meters**	22dB
-20dBm	-83dBm	114-83+10+15	56dB	**7 meters**	33+10+15+20	78dB	**90 meters**	22dB
-15dBm	-88dBm	114-88+10+15	51dB		33+10+15+15	73dB	**50 meters**	22dB
ETSI limit	-43dBm	114-43+10+15	96dB	**700 meters**				

ALL COMMUNICATIONS NV

PATH LOSS : LINE OF SIGHT FREE AIR ATTENUATION IN dB

FREQ. MHz	51	145	435	900	1250	1840	2140	2350	2450	5,5 G	10,5 G
USAGE:	VHF	VHF	UHF	GSM	ATV	GSM	UMTS	ATV	WIFI	WIFI	ATV
AFST. M.											
1	6,6	15,7	25,3	32	34,5	37.5	39	40	40,3	47,3	53
2	12,6	21,7	31,3	38	40,5	43,5	45	46	46,3	53,3	59
3	16,2	25,3	34,8	41,5	44	47.3	48.5	49,5	49,8	56,8	62,5
4	18,6	27,7	37,3	44	46,5	49.5	54	53	53,3	59,3	65
5	20,6	29,7	39,3	46	48,4	51.7	53	54	54,3	61,3	67
6	22,2	31,3	40,8	47,5	50	53.3	54.5	55,5	55,8	62,9	68,5
7	23,5	32,6	42,2	48,9	51,3	54.6	55.8	56,8	57,1	64,2	69,8
8	24,6	33,7	43,3	50	52,5	55.5	57	58	58,3	65,3	71
9	25,7	34,8	44,3	51.1	53,5	56.8	58	59	59,3	66,4	72
10	26,6	35,7	45,3	52	54,5	57.7	59	60	60,3	67,3	73
15	30,2	39,3	48,18	55.5	58	61.3	62.5	63,5	63,8	70,8	76,5
20	32,6	41,7	51,3	58	60,5	63.7	65	66	66,3	73,3	79
30	36,2	45,3	54,18	61.5	64	67.3	68.5	69,5	69,8	76,8	82,5
40	38,6	47,7	57,3	64	66,5	69.7	71	72	72,3	79,3	85
50	40,6	49,7	59,3	66	68,4	71.7	73	74	74,3	82,3	87
60	42,2	51,3	60,8	67.5	70	73.3	74.5	75,5	75,8	82,9	88,5
70	43,5	52,6	62,2	68.9	71,3	74.7	75.8	76,8	77,1	84,2	89,8
80	44,6	53,7	63,3	70	72,5	75.7	77	78	78,3	85,3	91
90	45,7	54,8	64,3	71.1	73,5	76.8	78	79	79,3	86,4	92
100	46,6	55,7	65,3	72	74,5	77.7	79	80	80,3	87,3	93
200	52,6	61,7	71,3	78	80,5	83.7	85	86	86,3	93,3	99
300	56,2	65,3	74,8	81.5	84	87.3	88.5	89,5	89,8	96,8	102,5
400	58,6	67,7	77,3	84	86,5	89.7	91	92	92,3	99,3	105
500	60,6	69,7	79,3	86	88,4	91.7	93	94	94,3	101,3	107
600	62,2	71,3	80,8	87.5	90	93.3	94.5	95,5	95,8	102,9	108,5
700	63,5	72,6	82,2	88.9	91,3	94.6	95.8	96,8	97,1	104,2	109,8
800	64,6	73,7	83,3	90	92,5	95.7	97	98	98,3	105,3	111
900	65,7	74,8	84,3	91.1	93,5	96.8	98	99	99,3	106,4	112
1 km.	66,6	75,7	85,3	92	94,5	97.7	99	100	100,3	107,3	113
2 km.	72,6	81,7	91,3	98	100,5	103.7	105	106	106,3	113,3	119
3 km.	76,2	85,3	94,8	101	104	107.3	108.5	109,5	109,8	116,8	122,5
4 km.	78,6	87,7	97,3	104	106,5	109.7	111	112	112,3	119,3	125
5 km.	80,6	89,7	99,3	105.5	108,4	111.7	113	114	114,3	121,3	127
6 km.	82,2	91,3	100,8	107	110	113.3	114.5	115,5	115,8	122,9	128,5
7 km.	83,5	92,6	102,2	108.5	111,3	114.6	115.8	116,8	117,1	124,2	129,8
8 km.	84,7	93,8	103,3	110	112,5	115.7	117	118	118,3	125,4	131
9 km.	85,7	94,8	104,3	110.6	113,5	116.8	118	119	119,3	126,4	132
10 km.	86,6	95,7	105,2	111.5	114,4	117.7	118.9	119,9	120,2	127,3	132,9
20 km.	92,6	101, 7	111,2	117.5	120,4	123.7	124.9	125,9	126,2	133,3	138,9
40 km.	98,6	107,7	117,2	123.5	126,4	129.7	130.9	131,9	132,2	139,3	144,9
80 km.	104,6	113,7	123,2	129.5	132.4	135.7	136.9	137,9	138,2	145,3	150,9

dubbele afstand = + 6 dB
50% meer afstand = + 3,5 dB

no antenna

att in dB: 20 X log(41 X PI X F X AFST) /3
F in MHz - AFST in Km

KTB 1MHz @ 300K = −114 dBm - noise floor (−174 dBm/Hz)

$PL = 10 \log_{10} \left(\frac{4\pi d}{\lambda} \right)^2 \frac{1}{G_1 G_2}$

ETSI LIMIT −43 dBm/MHz

113 − 43 = 70

4 Three Ireland

Mobile Phone Repeaters

Doc 17/103

Response from Three

Three.ie

Introduction

Three recognises the difficulty posed for mobile phone networks to provide coverage indoors in some locations, particularly where the nearest mast might be some distance away, or where the building structure introduces significant signal attenuation. We agree that the use of repeaters can have a role to play in improving indoor coverage in some cases, provided this is done in the correct way so as to avoid any side effects like reducing signal quality generally or causing interference.

In addition, changing user habits; changing vehicles, and the use of Bluetooth has meant that some users perceive poor in-vehicle call quality. This is something that we believe should also be addressed by ComReg at this time.

We agree that it is not practical to have every consumer-deployed repeater listed on operator licences, as this is impractical for all but the largest use cases. It is also the case that despite the fact that it is illegal to do so at present, consumers can and do buy unapproved boosters which are more likely to cause interference than properly specified repeaters. We believe this practice will continue for as long as there is no properly specified alternative reasonably available to consumers.

For the above reasons, Three cautiously supports the proposal to permit licence exempt repeaters, subject to our comments below. It is important that we get the specification right at this time, as it will be very difficult to correct or recover later if it is wrong from the start.

Three's view is that some additional measures will be needed to ensure that repeaters can be introduced in a way that minimises the risk of interference, or facilitates its identification where it does occur. We also have the view that ComReg should provide for an in-vehicle system at this time similar to that proposed by Ofcom for the UK. If properly specified, this could significantly improve the quality of in-car calls without causing interference. Failure to include such systems now would be a missed opportunity, as we do not believe this matter will be reviewed in the short to medium term.

Our detailed comments are below.

Some Interference is Inevitable

The principal question raised by ComReg's proposal is whether or not it is appropriate to allow licence exempt repeaters. On the one hand, there are certainly many cases where repeaters can improve the quality of indoor coverage without degrading the quality of mobile service in other locations. It is also true however that repeaters can and will increase the noise floor within the serving cell, and they can also cause widespread interference. We agree that a properly specified repeater is less likely to cause interference than the "boosters" that can be bought over the

internet, however it is inevitable that the widespread introduction of consumer installed repeaters will bring an increase in the number of incidents of network interference. It should be noted that one repeater causing interference can eliminate service to the entire service area of one or multiple masts. The fact that these repeaters will be licence exempt increases the difficulty of tracking them down when the interference does actually occur, as there is no record of the installation location.

Having considered the above matter, Three is of the view that on balance the benefits to consumers can outweigh the detriment to network performance overall, provided certain safeguard measures are in place.

Investigation and Elimination

While steps can be taken to minimise occurrences of interference, it is inevitable that there will be some increase in the frequency of these cases as a result of the widespread introduction of repeaters. It is key that when these cases of interference arise, ComReg can quickly track down the source and eliminate it. ComReg has traditionally suffered from a lack of resources available to track down and eliminate interference, though we acknowledge that improvements have been made in this area recently. Three is concerned that an increase in the number of interference cases would undo any progress that has been made, unless ComReg is prepared and ready to handle a higher workload of interference investigations.

Three seeks reassurances from ComReg that it will be able to quickly identify and eliminate any properly reported cases of interference to mobile or other networks prior to introducing licence exempt repeaters.

In addition to the above, we note that in the case of interference from illegal sources there may be restrictions on ComReg's ability to share the results of their investigation with operators as legal proceedings may be planned. This is not the case for licence exempt repeaters, which will allow ComReg to share information regarding the nature of any interference found; model number of equipment; installation details; etc. This information in turn will help operators to quickly identify and eliminate possible future causes of interference. Three recommends that ComReg provide periodic information to mobile network operators summarising any trends that emerge from the deployment of licence exempt repeaters.

Registration of Installation Location

While the use of properly compliant repeaters that are correctly installed will minimise the incidents of interference, it is inevitable that there will be some. For the few cases that do become a source of interference, the process required to track them down can be difficult and time-consuming. Three suggests that a simple

registration of the intended location of each repeater could be a significant aid to identifying the source. This could be as simple as a requirement that the date of purchase and the intended location for installation is recorded at the time of sale in order for the apparatus to be licence exempt. In practical terms only a date and Eircode would be required to record this information, and a very simple web accessible database could be provided by ComReg to record the information. It would then be available to ComReg to assist in interference investigations. It would also be possible to make the data available to operators to assist with preliminary investigations of interference cases.

Option 2 vs Option 3

On balance, Three supports Option 3 – multi-operator repeaters, though we disagree with some of ComReg's analysis on this question. We would note that under Option 3, a single operator repeater will also be permitted and will be licence exempt just as multi-operator ones will. Three believes there will be some cases where it will be preferable to use a single-operator repeater though.

We disagree with ComReg's opinion in paragraph 68 that multi-operator repeaters are less likely to cause interference. Wider bandwith repeaters are inherently more susceptible to amplification of spurious noise and to intermodulation products. They can also be less effective in some cases, as the presence of a high power but unused carrier from a network other than the customer's own network will have the effect to suppress the overall gain of the system. This will reduce the amplification of the signal that it is intended to improve.

In paragraph 74, ComReg expresses the opinion that the use of single-operator repeaters "corrupts the competitive process". This is not correct. Under the general exemption proposed, all operators will have equal freedom to provide, supply or sell repeaters that operate on their own network, as will other independent vendors. The conditions under which they can be provided are equal for all, and there is no particular barrier or obstacle to any operator. The use of single-operator repeaters does not in any way hamper competition in the retail mobile services market.

Overall, Three believes that multi-operator repeaters will be more likely to cause interference, however this down-side appears to be outweighed by the benefit of being able to improve coverage for customers of all operators. For this reason, Three supports option 3, however we note that a single operator repeater will be more appropriate in some cases.

Specific Technical Comments

Three agrees with ComReg's proposals in relation to Automatic Standby/Shutoff; Anti-Oscillation; and Power. In relation to Gain and Gain Control, it seems that ComReg has erred in the specification. ComReg will be aware that Ofcom has carried out an analysis and consultation on the use of repeaters in 2017. The analysis carried out by Ofcom would seem to be more robust than that which has been possible within the timeframe that was available to ComReg. For this reason, we would caution against changing any of the technical parameters proposed by Ofcom without further analysis.

Ofcom has proposed that the maximum gain should be limited to 30dB less than the repeater coupling loss in order to maintain the aggregate noise increase to below an acceptable level. The maximum gain which achieves this result has been set by Ofcom at 100dB. ComReg, has proposed a maximum gain of 70dB, yet it is unclear how this proposed limit was derived. Three is aware of some circumstances where a gain of over 70dB is appropriate, and we have deployed these repeaters (under licence), which have operated interference free. We believe the proposed 70dB gain restriction is unnecessarily restrictive, and will rule out many cases where repeaters will be able to solve consumer reception problems. ComReg should adopt the maximum gain of 100dB as specified by Ofcom.

In Vehicle Repeaters

Three has noticed that a considerable source of complaints regarding mobile coverage relate to voice calls made within vehicles. There is a perception of decreasing coverage, despite the fact that all operators have been investing and building additional coverage in recent years. There are many possible reasons for this perceived reduction in coverage, including:

- Changed handsets – most handsets are now multiband smartphones. The demands placed on them are far greater than was the case for a simple GSM handset. This can lead to reduced receiver sensitivity in some cases.
- Changed Installation – the advent of Bluetooth has meant that the traditional docking stations are now all but gone. The advantage of docking stations is that they connect to an external antennae as opposed to the internal handset one, which can often be at a low level within the car and can also be shielded by the car bodywork.

A voice call requires continuous connection whereas a data session can easily "smooth out" momentary drops in signal by buffering data. Drivers making voice calls must redial to re-establish the connection. This leads to some frustration which disproportionately contributes to the perception of poor quality coverage.

Three is of the view that a low-gain repeater could contribute significantly to improving in-car voice call reception. We also believe it is unlikely that ComReg will revisit the exemption order in the short to medium term, and if the issue is not addressed at this time then the opportunity will be lost. We believe Ofcom has taken a pragmatic approach to this issue, with a permitted maximum gain of 21dB/15dB (depending on band). We recommend that ComReg includes within its exemption order provision for licence exempt in-vehicle repeaters that conform to the specification as listed in IR2102.2 of Ofcom's Statement (24th October 2017).

5 Vodafone

Consultation on Permitting the General Use of Mobile Phone Repeaters.

Response to Consultation

19 January 2018

Introduction

Vodafone welcomes ComReg's consultation on Permitting the general us of mobile phone repeaters ComReg 17/103

We understand the demands of the customer to improve coverage and we continuously seek to improve our network and our customers experience.

From our extensive experience in Ireland and in other countries Vodafone believe that Repeaters can play a useful part in maximising service to customers, but there are inherent risks to installing these devices in the network which must be carefully managed to prevent a net degradation of service to customers.

In 17/103 Comreg refer to repeaters and boosters and try to draw a clear line between them. In practice there is no formal difference in definition between the terms repeater and booster. A well specified, well installed device will improve customer service without casing undue loss to other customers; a poor device, or a badly installed or badly maintained device will cause significant degradation to multiple customers.

We recognise that Comreg have tried in their consultation to put in place controls to prevent degrading of service to customers but we believe that further safeguards need to be put in place before the Draft Exemption Order is put in place.

We have had some discussions on the technical details with Vilicom, who have worked on repeaters for us. Vilicom are making a separate response which contains detailed technical analysis. We agree with their technical analysis believe it strongly supports the position that further work is needed.

In the following text we focus on how repeaters are used today, the issues that have arisen from a poor installation, and offer suggestions for further safeguards that need to be in place before we can safely proceed with changing the current Exemptions.

Current Operation of repeaters.

Repeaters in the Vodafone Network are currently installed by competent sub-contractors working directly with Vodafone.

These installations go through a proper planning process, identifying the donor cell, and ensuring that there are not too many repeaters already operating in one cell coverage area. A directional antenna is used to minimise unwanted interference to other cells, and the mobile side antenna is correctly situated indoors to minimise overlap coverage between signal received directly from the cell and from the repeater. Vodafone Network Operation staff are informed when the repeater is switched so that they can ensure no interference is being caused (and stop the installation if not). They then monitor the network in the area on an on-going basis.

When the network is reconfigured in the area- for example by the installation of a new site or the moving of cell site antenna the repeater has to be reconfigured by the installer.

Issues can arise from an incorrect installation

Unfortunately, we have frequently seen issues arising from repeaters operated illegally. Network power control ensure a mobile close to a cell will only operate at low power, but these illegal repeaters often transmit towards the base-station at powers appropriate for a mobile far from the base-station: This higher signal blocks the uplink from other mobile users who are further from the site, effectively reducing the cell coverage area.

Separately a repeater may work correctly for some time but become ineffective or even network damaging because of operator Network reconfiguration For example, we have seen cases where a new site is added close to the repeater. The higher mobile signal flooded the input stage of the repeater causing it to transmit continually back to the original donor. This interference was detected and resolved only because we knew of the location of the repeater.

Added noise

Every Repeaters will transmit a small amount of noise towards the Base-station. This lowers the signal-to-noise ratio for all other mobiles – reducing coverage and data speeds. While the added noise figure for a single repeater may be low if there is more than one repeater in the coverage area of a cell these Noise Figures will be cumulative. In an uncontrolled environment there is no restriction on multiple repeaters being in the same area creating a 'noisy' environment and reducing coverage of the sites.

Wide Band repeaters.

Multi-operator repeaters are a particular problem as the donor sites from each operator may be at different distances. Amplifier gain settings appropriate to reach the farther base-station will send signals that are too strong to the nearer site damaging the service to other customers.

Monitoring by Operators and Comreg.

Where issues with repeaters cause problems for customers the source of the interference will typically be difficult to track down. In the past 2 years we have seen serious issues with interference continue over weeks and even months as both operators and Comreg sought to identify and resolve. This has resulted in loss of service for many customers. This consultation does not address the issues that will arise with the monitoring of interference issues. Any additional issues arising will cause significant resource problems for Comreg as well as for the operators as finding and removing interference sources of interference has proven to be a very time-consuming process for all parties.

If these repeaters are licence exempt, then we need to have mechanism to shut them down if faulty installation or settings cause network interference.

Any new process that may introduces additional sources of interference must be accompanied by a commitment by Comreg to resource the solution to any problems that arise.

CE mark

We note that Comreg state in their text" boosters cannot carry the CE mark" (page 7 Comreg 17/103.)

The CE mark is primarily a safety check, e.g. that the device will not electrocute the installer/user – having a CE mark alone is no guarantee of radio quality. It is likely many devices with very poor radio characteristics will carry the CE mark.

Comreg options discussed.

Option 1

Comreg assume that Option 1 is not favoured by operators because illegal boosters are causing network issues. However, there is nothing in option 2 or 3 that will prevent these devices from continuing to be installed. Indeed, the approval by Comreg of some repeaters is likely to encourage the proliferation of these devices.

Option 2 v. Option 3

Based on the technical advice we have received we are strongly in favour of developing Option 2.

We believe that Option 3, a multi-operator repeater, is much more likely to cause network problems as optimum gain setting for different donor operators will not be aligned.

Further work is need to specify the repeaters

We have referred to the technical issues raised by Vilicom - these inputs need detailed consideration.

In addition, some minimum standards will need to apply to the installation as well as to the repeater device.

It would be a useful for Comreg to produce a guideline document on installation.

A register of repeater devices would also help in identifying where repeaters are in the network. This would help deal with any issues arising in a less labour intensive way.

Some work needs to be done to help the public identify complying and non-complying devices.

There is no formal difference in definition between the terms repeater and booster, and certainly they are not distinguished in the public mind. Any message from ComReg that repeaters are allowed will potentially promote multiple small dealers to sell poor quality devices – causing significant network problems for other customers as well as for the people who buy them. We believe that Comreg will have to intervene to stop suppliers selling illegal and potentially harmful devices.

We look forward to further engagement on this topic.

6 Vilicom

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15 January 2018

Dear Mr. Craine,

Thank you for the opportunity to respond to ComReg's consultation on permitting the general use of mobile phone repeaters.

The consultation deals with the ComReg's statutory functions, desirability of a license exemption scheme, the regulatory impact and proposed conditions of use. Our comments on the consultation are primarily limited to the technical impact of any license exemption scheme.

Our detailed comments are contained in the following pages, but it is our opinion that the third option outlined by ComReg will create significant problems for the mobile operators and their customers by creating harmful interference.

Consistent with ComReg's desire to promote openness and transparency, this response contains no confidential information and is presented to constructively contribute to the overall discussion of the subject matter.

We look forward to hearing the outcome of this consultation.

Yours Sincerely,

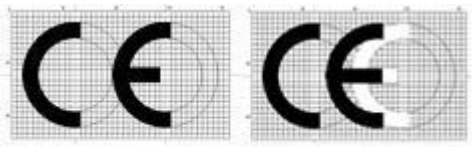
Seán Keating, CEO Director	Conor O'Callaghan, Head of Service Delivery	John Ryan, Snr. RF Consultant	Paul Donnelly, Technical

Response to Consultation by Numbered Paragraph

4. The taskforce has recommended the introduction of a regime that would permit the "orderly installation of mobile phone repeaters which would go some way to addressing the problem of indoor coverage." It is important to define the parameters of an "orderly" installation and associated rules and processes. The current proposed scheme correctly sets out the technical specification of any equipment required to meet any exemption. It would be beneficial to also define how faulty equipment should be dealt with post-installation, what adaptations are prohibited and permitted, and which configurations are desirable and undesirable.

7. The distinction drawn between boosters and repeaters seems somewhat arbitrary. There are many different configurations of repeaters available on the market from reputable and un-reputable suppliers. Booster would seem to be a colloquial term used by low-cost sellers (see note on paragraph 88 below).

There are some issues regarding the use of the CE mark. There are many imitation CE marks on equipment in circulation that is not in compliance with Conformité Européenne. It may be necessary to have some other mark to help consumers identify any equipment that is compliant with the terms of any exemption set out by ComReg.



13. Many repeaters are available with active gain control. Repeaters with manual gain control are likely to cause problems close to base stations when installed by inexperienced installers. All repeaters generate noise in excess of the signal amplification, i.e. the noise figure. In a typical repeater with automatic gain control, the end-to-end gain is normally controlled by attenuating the RF input to the amplifier while the amplifier stage remains at maximum gain. Therefore automatic gain control doesn't give maximum control over the noise output.

18. While ComReg draws a distinction between "boosters" and repeaters, poorly configured repeaters have been seen to cause problems. ComReg notes that no repeaters as defined in its document were encountered during the course of its interference investigations. Perhaps there may be an absence of such repeaters installed, due to general unavailability or relatively high costs?

19. In our opinion the creation of a legal route to purchase repeaters will only marginally affect demand for boosters as repeaters and boosters are in significantly different price categories. For example, at the time of writing a cheap booster kit with antenna is available on eBay for €63.92 while a Nextivity repeater compliant with Ofcom's proposed exemption is priced at €730. Interestingly, the manufacturer describes this equipment as a booster.

27. Base Station Coupling Loss (BSCL) is not something that can be adjusted. Rather, BSCL is a function of the location of the repeater unit and its distance from the base station. BSCL is made up of various factors such as the path-loss from the base station to the repeater, the penetration loss of any window or wall in the propagation path, the base station antenna gain and fading etc.

The Ofcom scheme seeks to limit *"the gain of the mobile phone repeater to be a maximum of 30 dB below the coupling loss between the base station and the repeater, "BSCL – 30 dB". This ensures that any noise arriving at the mobile phone base station receiver from any mobile phone repeater is at least 30 dB below the noise floor of the mobile phone base station receiver."*

It is important to note that all noise power is additive, that is to say that even if additional noise is added below the current noise floor, it still adds to the noise power and consequently raises the final noise power/noise floor. For example, noise received at 10dB below the noise floor raises the noise floor by 0.4dB.

55. A fourth option appears to be missing, that of community based solutions using more advanced equipment such as LTE relays amongst other things. There has been a

history of community organisations significantly expanding TV coverage in rural Ireland this way.

59. It is our view that a license exemption for a wideband or "multi-operator" repeaters outlined in Option 3 will create significant problems for the mobile operators and their customers by creating harmful interference.

A common issue with wide band amplifiers covering multiple services is that the gain is often reduced due to the strongest of the input signals. The table below illustrates an example of this potential problem that may occur where a consumer is a subscriber of MNO#2 and purchases an Option 3 repeater to improve their indoor coverage. However, if the signal from MNO#1 in the same band is significantly higher, this may cause the repeater gain to decrease (via AGC) in order to maintain the composite [1] output power at or below 17 dBm (to meet the ComReg specification. In this example, the gain of the repeater is decreased from 70 dB to 58 dB. If MNO#2's signal at the repeater's input is relatively low (-80 dBm in the example) then the available output power from the repeater for MNO#2 would be very low and probably inadequate for effective operation.

"Option 3" Multi-Operator Repeater Down Link Budget		
Repeater DL Input MNO#1	-41.0	dBm
Repeater Gain MAX	*70.0*	*dB*
Repeater O/P @ MAX Gain	*29.0*	*dBm*
AGC Reduction (for Max O/P 17 dBm)	*12.0*	*dB*
Repeater Gain with AGC	**58.0**	**dB**
Repeater O/P MNO#1	17.0	dBm
Repeater DL Input MNO#2	-80.0	dBm
Repeater Gain with AGC	**58.0**	**dB**
Repeater O/P MNO#2	**-22.0**	**dBm**

[1] The composite output power would be limited to 17 dBm, not just the output power of the strongest signal. Therefore, the gain may be even further reduced than in the example.

64. While filtering and interference mitigation features are beneficial and desirable, all repeaters cumulatively cause an increase in noise power in the base station receiver. A large number of repeaters will lead to large noise rises and potentially drive further demand for repeaters to deal with cell shrinkage and further noise rises. Should any exemption be put in place, it would be good to carry out an impact assessment at some fixed period after the license exemption comes into force, for example after 12 or 18 months.

68. The likelihood that unauthorised repeaters are replaced by compliant apparatus assumes that consumers are willing to pay a multiple of five to ten times the price to avoid breaking the law, and that those consumers understand the differences between illegal and legal repeaters when making a purchase.

ComReg also States: "There is also an increased risk of interference, from Option 2 over Option 3, if a premises were to install multiple devices to cover bands used by different Operators. (i.e. oscillation increases significantly). Adopting Option 3 and permitting the general usage of wideband repeaters offers better protection to MNOs and existing spectrum users."

Multiple Option 2 repeaters, each for a different MNO would work more independently than a single Option 3 multi-operator (full band) repeater. An Option 2 repeater filtered to one MNO's frequencies should not go into oscillations due to the presence of a second Option 2 repeater tuned to a different MNO's frequencies. Also, independent Option 2 repeaters would have separate gain control, and so fewer instances of RF problems would be expected. A single Option 3 repeater would share the same amplifier, with the same gain for both MNOs (per band), and so would be far more prone to RF problems such as intermodulation, RF overload, higher UL noise levels, etc.

69. For the reasons outlined above, it is our view that Option 3 significantly reduces interference protection versus Option 2.

88. The cost estimate of €200 to €500 appears to be for boosters that would not meet the repeater specification of either Option 1 or Option 2. Has ComReg identified any supplier of repeaters that are compliant with either Option 1 or Option 2, and the cost estimates for such repeater, and if so can this information be made available?

It is worth noting that the reference given is for the website of a Canadian company selling boosters in the UK that at face value appear to possibly be in breach of the UK's Wireless Telegraphy Act 2006.

93. The proposed repeater downlink output power limits seem reasonable. The repeater uplink maximum power is "limited to that of a mobile handset". However, this is dependent on the frequency band, the radio access technology and the mobile type. For example, for GSM900 the maximum mobile UL power is 33 dBm, whereas for UMTS900 a typical maximum mobile UL power is 21 dBm.
Also, for GSM1800, the maximum mobile UL power is 30 dBm, whereas for LTE1800 a typical maximum mobile UL power is 21 dBm.

As a repeater does not identify the type of signal it is re-transmitting, it would be preferable if the repeater uplink maximum transmit power was specified in absolute terms per band or per bandwidth.

Also, it is noted that repeater vendors typically package the repeater unit for sale with cables and antennas, including outdoor directional antennas. Do ComReg's specifications include all cable losses and antenna gains, or what conditions do ComReg propose to limit uplink and downlink EiRP which may be increased by a significant amount through the connection of high-gain antennas or other means?

The maximum gain in the proposed scheme is 70dB. Some installations will not work at this maximum gain. Though most the small repeaters for sale would around 70 dB or less, this still might not be sufficient in a lot of cases. The repeater input power would have to be -53 dBm to get the full output power of 17 dBm. If the consumer had that level of coverage outside, they probably wouldn't need the repeater in the first place.

Take for example an area with poor coverage with -80 dBm for a channel (outdoor, 10 dBi antenna). With 70 dB gain, this would give an output power of -10 dBm. While this might be sufficient in some cases, it might not always be enough to serve full house. Contrast this with Wi-Fi at +21 dBm). This might not be a good experience for the consumer, particularly given the investment required. In Ofcom's proposed exemption scheme for the UK, repeaters with 100 dB gain are allowed with a maximum power set to BSCL-30dB to protect the BTS receiver.

How is the gain to be set in any automatic gain control under Option 3? Is automatic gain to be set according to aggregate channel power? Will this lead to a breach of the BSCL-30dB condition for nearby base-stations? Will this lead to inadequate gain to ensure a sufficient radio link with distant base-stations? It is our view that automatic gain control under option 3 will lead to harmful interference.

The specification includes the requirement: "The repeater must power off if the receive level from the base station is -40 dBm or greater". Typically, repeaters will not decode and measure each base station signal separately, but will measure the signal level within a particular bandwidth, usually the full band of operation. Therefore, should this shutdown limit be defined as -40 dBm for the band of operation?

A potential issue with this shutdown mechanism is that it could result in intermittent service availability due a cycle of breaches of the limit. The transmit power of any base station is not constant but is dependent on factors including the traffic load for the cell and the path losses from the cell to each user being served. A cell with no user traffic on the downlink will transmit only common broadcast channels, and so this may be 8 to 10 dB lower (for UMTS or LTE) than when the same cell is transmitting at full power. Therefore, a repeater may operate if the DL receive level is less than -40 dBm but then switch off if the cell becomes more loaded and the composite power increase above -40 dBm. This may be caused by any user on that cell, even the user served by the repeater itself. This could lead to a very unsatisfactory service where the user gets intermittent service and will probably assume it is a MNO network problem rather than a problem caused by their own repeater setup.

This problem would be less common in the case of the Option 2 repeater, and more common in the case of the Option 3 repeater as with a wider bandwidth there is a higher likelihood of a strong (near -40 dBm) signal being present.