Mobile Phone Repeaters

Response by Vector Sum Consulting Ltd to Ofcom Consultation

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Non-confidential

1. Executive Summary

The mobile networks market in the UK is coalescing into two co-operating groups, Vodafone/O2 and EE/H3G. While these two groups are latterly (Q2, 2017) co-operating on infrastructure roll-out in the form of shared antennas on new masts for 3G and 4G build-out, each operator is for the time being maintaining their own spectrum and 'logical' network.

While 4G network rollout is largely complete in urban and suburban areas, many rural areas remain under-served on existing 2G infrastructure and completely unserved on 3G and 4G. EE, who have won the contract for the Emergency Services Network replacement, are aggressively building out LTE800 and LTE1800 coverage in sparsely-populated and rural areas, bringing H3G coverage in their wake to areas where there was no service before. Vodafone/O2 are responding, largely with statements of intent and planning applications at this stage in rural areas to roll out 4G and, where it does not already exist, 3G.

The EE coverage requirement will eventually have to be service to man-portable terminals either in cars or in buildings, and as a consequence EE is investing in over 200 new-build sites and upgrades to existing sites from low-gain omni to high-gain sector antennas. Clearly mobile phone repeaters will be of benefit to EE/O2 subscribers, but perhaps not to the same extent as Vodafone/O2 users, who in general will not benefit from the provision of new sites. These will continue to be served by a network of hilltop sites in rural areas, which were conceived in an era of higher-power and more capable 2G carphones. It is Vodafone/O2 subscribers who will most benefit from mobile phone repeaters.

The Ofcom consultation mirrors work by the Federal Communications Commission in the USA on 'signal boosters'. The FCC have issued orders and guidelines for both wideband and operator-specific equipment. The former amplify the signal across an entire band, providing equal benefit to all operators, the latter are 'frequency-specific', relying on the fact that all operators are allocated a fixed 'slice' of spectrum. The advantage of frequency-specific boosters is that, in general, they are not required to amplify signals from some base stations that may be close by and others farther away, and thus can much more readily employ closed-loop monitoring to ensure maximum gain and stability.

In the UK context, Ofcom have opted to promote frequency/operator-specific repeaters for fixed installation by consumers, and wideband repeaters for installation in vehicles. As these are already outdoors and therefore do not encounter in-building loss, the required gain of vehicular mobile repeaters is much lower.

VSCL are in favour of the rollout of both classes of repeaters, as there will be immediate benefit to consumers, so much so that these may even be able to make considerable savings by removing any fixed line connection; this would in turn pay for the entire repeater installation in only a few years. However, the maximum gain of fixed repeaters may be unrealistically high at up to 100 dB, 60-70 dB gain being more than sufficient in the vast majority of cases. Also the Ofcom requirement that the repeater be able automatically to calculate the pathloss between mast and User Equipment (UE) may lead to problems with UEs using umbrella cells.

Conversely, the gain proposed by Ofcom for in-vehicle repeaters may be too low, due to

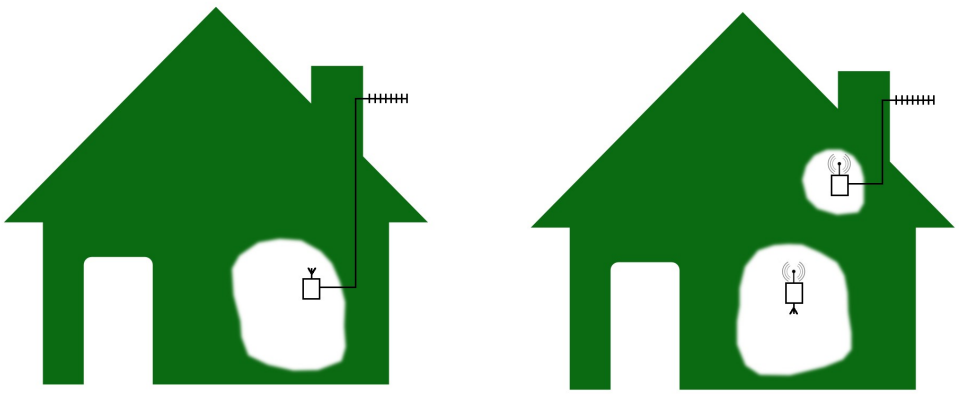
lack of prior knowledge where the UE antennas are located relative to the coupling points in the cradle. The current Ofcom-recommended values of 21/15 dB gain above/below 1 GHz may have to be raised to a more realistic 30 dB in order to provide useful gain for cradle-mounted UEs, or 45-50dB for free-roaming UEs within the passenger body.

2. Fixed Consumer Mobile Repeaters

In the USA, the FCC permit both wideband and operator-specific (i.e. frequency specific) mobile signal boosters. In contrast, Ofcom are only envisaging the rollout of frequency specific repeaters.

The reason for this is that there is a history of instability and noise problems with illegally-installed wideband amplifiers in the UK, that have the effect of impairing or, in extreme, completely denying service to other mobile subscribers in the locality where they are used.

Two usage scenarios are possible, the first where donor cell antenna and recipient side equipment are connected via conventional coaxial cable; the second is where the connection between donor cell antenna and amplifier is made via a second system, usually operating in unlicensed spectrum e.g 2.4 GHz or 5 GHz ISM bands.



Mobile repeater connected via coaxial cable

Mobile repeater connected via unlicensed spectrum

For simplicity, only the first arrangement is considered here, and it is presumed that the vast majority of equipment available to and installed in the UK marked will be cabled.

Q1: Do you agree with Ofcom's proposal to authorise the use of static mobile repeaters intended for indoor use on a licence exempt basis?

VSCL is in favour of widespread deployment of mobile phone repeaters. In the Highlands and Islands where we are based, the distances and therefore pathlosses to hilltop masts installed by the four UK mobile operators can be considerable. The resulting poor coverage is exacerbated by local building traditions which can mean that thick-walled dwellings, that have good winter thermal insulation properties, have very high building penetration losses. The resulting signal attenuation can lead to mobile phones being unusable indoors.

Legalisation of mobile phone repeaters, and a market where responsible installers commission the consumer equipment and antennas in such a way as to minimise disruption to other mobile subscribers and maximise benefits of enhanced indoor signals, can only be of all round benefit.

Q2 Do you agree with technical requirements as set out in Table 1 above for licence exempt static mobile phone repeaters intended for indoor use?

VSCL agrees with the technical requirements for static mobile repeaters with the following exceptions:

The Call for Inputs document envisages cell sectors addressing a large number of installed repeaters, around 50 of which are estimated to be active and generating signals and noise at any one instant. This leads to a calculation of 17 dB noise above a single source (incoherent noise addition) or a requirement for 27 dB reduction on signal amplification relative to the Base Station Coupling Loss (BSCL) if the noise rise at the base station receiver input connector is to be less than 10% (i.e. 10 dB + 17 dB). Ofcom then adds a further noise margin of 3dB to account for a scenario where a UE is used in proximity to the recipient-side antenna, and the noise generated by the UE's power amplifier traverses the mobile repeater chain.

The figure of BSCL – 30 dB is used throughout Ofcom's documentation to define the maximum gain permitted by the repeater, or 100 dB if BSCL – 30 dB works out to be greater than 100 dB. To determine BSCL, it is envisaged that the repeater will contain sufficient receiver intelligence, perhaps even to the point of incorporating a self-contained UE, that will read the system information from the donor cell and calculate BSCL based on transmitted power levels and received signal strength.

A problem with this scenario is that amplification levels greater than 80 dB are extremely difficult to achieve in practice; mobile operators, when providing outdoor repeaters that extend a cell's coverage range find figures in excess of 90 dB very tricky to achieve in the controlled environment of a dedicated mobile mast, never mind in the constantly-changing scenario of the indoor environment.

It is VSCL's opinion that it would be sufficient to achieve amplification to overcome the in-building penetration loss, which is likely to be of the order of 30-50 dB. There will be further gain from the antenna used to couple to the donor cell, as this will necessarily have sufficient directivity to define the donor unambiguously in a scenario where there are multiple cell-sites of the operator present in the locality.

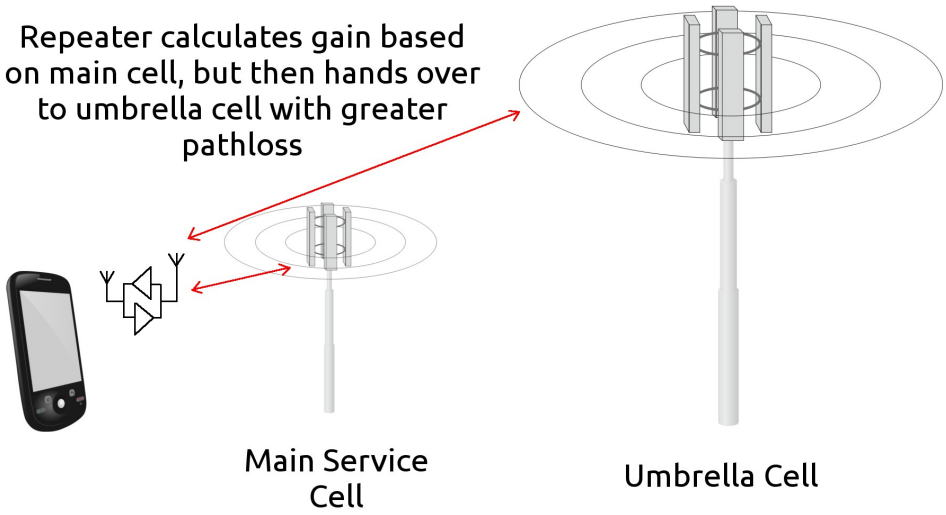
There may also be flaws with the calculation of the noise rise; in rural setting such as the Highlands and Islands where we are located, it is unlikely that repeaters will be installed in numbers sufficiently large to mean that 50 are simultaneously active. A more likely scenario would be 15-20 repeaters at most, giving noise backoff figures of 10 + 11.8/13 dB = 21.8/23 dB respectively. Adding Ofcom's 3dB UE noise margin gives 24.8/26 dB gain backoff, which is at least 4 dB less than that necessary in urban areas. This extra gain could be useful particularly in ensuring high 4G data throughputs in rural areas.

Umbrella Cells

An 'umbrella cell' is a large cell that deliberately covers all of the area of one or more smaller cells; the usual usage scenario is for fast-moving UEs, where rather than handing over the call or data session to many smaller cells as the UE moves along, the system hands the call/session up to the umbrella cell where handovers will occur much less frequently.

The system can also hand calls/data sessions up to the umbrella cell for traffic reasons,

e.g. if there is a momentary traffic peak in one of the smaller cells enclosed by the umbrella cell.



The issue this will cause is that UEs, and therefore also the repeater, should not 'camp on' any umbrella cells in their vicinity. A flag is set in the cell's System Information to prevent this. The repeater will therefore calculate its system gain based on the much lower pathloss to the nearby main service cell, which will be insufficient to provide service in the event of any system-commanded handover to the umbrella cell. Therefore there should be a means manually to over-ride the automated gain setting, and set up appropriate gain for the umbrella cell if it is known by the installer that one is configured in the vicinity.

There may also be issues in multi-band mobile repeaters. At the moment most LTE UEs are limited to a single carrier in a single band, but future Ues will use first of all multiple carriers in the same band, then eventually multiple carriers over a number of disparate bands. If the gain is not levelled across all bands used in such multi-carrier/multi-band LTE deployments there could be further instability issues both for the indoor UE and also for the donor cell if noise rise becomes excessive.

3. In-vehicle Repeaters

Q3 Do you agree with Ofcom's proposal to authorise the use of low gain mobile phone repeaters intended for in-vehicle use on a licence exempt basis?

VSCL agrees that properly installed in-vehicle repeaters will be of benefit to both user and mobile network. In the former case service will be far more predictable without the in-car penetration loss to contend with. For the latter, lower transmitted power levels will free up power particularly on WCDMA 3G to provide capacity to more users than would be the case if the car penetration loss had to be overcome on the link.

Q4 Do you agree with technical requirement set out in Table 2 above for licence exempt low gain mobile phone repeaters intended for in-vehicle use?

The gain values of 21 dB above 1 GHz and 15 dB below 1 GHz assume a UE at rest in a cradle, with the TX/RX antenna in intimate contact with coupling points on the cradle. A more likely scenario is that the UE will have several antennas for MIMO, none of which are in particularly intimate contact with the cradle coupling points. Higher gains may therefore be necessary properly to unlock the benefit of the car repeater.

Ofcom also does not seem to envisage service to other UEs distributed around the passenger compartment; in this scenario, complementary FCC work estimates a repeater gain of 50 dB blind / ~ 60 dB with closed loop gain control and it is unclear why this usage scenario cannot also be considered for the UK/European market.