# Coverage obligations in the 700 MHz and 3.6-3.8 GHz spectrum award

Ofcom's approach to verifying compliance

**CONSULTATION:**

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Closing Date for Responses: 12 March 2019

# Contents

## Section



## Annex

# 1. Overview

**We want to see good quality mobile broadband available from a choice of providers, wherever people live, work and travel. In December 2018, we proposed to provide strong incentives for the companies participating in the award of the 700 MHz and 3.6-3.8 GHz spectrum bands to invest in providing better quality services in rural areas, furthering our ambition to achieve comprehensive mobile coverage for people right across the UK.**

In this document, we set out for stakeholders the criteria and methodology we propose to impose for assessing compliance with the proposed coverage obligations, including the coverage model we intend to use.

## What we are proposing

In December 2018, we set out our proposals to offer two coverage obligations in the award of 700 MHz and 3.6-3.8 GHz spectrum. Our proposed coverage obligations would require an obligated operator, within four years of the award, to: (a) provide a good quality mobile service outdoors in at least 90% of the UK landmass, including at least 90% of England, 90% of Northern Ireland, 74% of Scotland and 83% of Wales; (b) provide a good quality service outdoors for at least 140,000 premises to which it currently does not provide good coverage; and (c) deploy at least 500 new wide area mobile sites. We now set out our plans for assessing compliance with these obligations in order to ensure that real improvements are delivered for consumers. In doing so, we specify a process that we consider is robust and equivalent across different operators, and practical for us to assess.

We have developed a coverage prediction model which we propose to use to assess compliance with the **geographic coverage requirement**. The coverage threshold for compliance using this model will be calibrated with reference to each obligated operators' own coverage predictions at the time of the award. Our verification exercise for assessing the final coverage level may include on the ground testing in a number of locations.

We propose to use the outputs of operators' own models with a verification exercise for assessing compliance with the **premises requirement**. Operators' predictions will provide us with a list of locations in which geographic coverage has been added and in which these premises are contained. We will verify the addition of this geographic coverage through the same processes used to test compliance with the geographic requirement.

We proposed that the **500 new sites** should all provide wide area coverage in rural areas, with a minimum distance from existing sites. To safeguard that these sites are equivalent to 'macro' wide area coverage sites, we are proposing to only count sites towards this obligation where they operate at a power consistent with a wide area coverage macro site (at least 43 dBm). Operators will be required to provide Ofcom with a list of qualifying sites at the time of our compliance assessment, which Ofcom will validate through site surveys.

**This overview is a simplified high-level summary only. The approach that we are minded to impose and our reasoning are set out in the full document.**

# 2. Our proposed approach

## Introduction

2.1 On 18 December 2018, we published a consultation on our proposals for the auction of spectrum in the 700 MHz and 3.6-3.8 GHz bands (the "**December 2018 consultation**")[1], in which we set out our proposals to include two coverage obligations in the award. Both of our proposed coverage obligations would require the obligated operator, within four years of the award, to:

- provide a good quality mobile service outdoors in at least 90% of the UK landmass, including at least: 90% of England, 90% of Northern Ireland, 74% of Scotland and 83% of Wales (the "**geographic coverage requirement**");
- provide good quality service outdoors for at least 140,000 premises to which it currently does not provide good coverage (the "**premises requirement**"); and
- deploy at least 500 new wide area mobile sites (the "**new sites requirement**").

2.2 We set out a high-level overview of our proposed approach to assessing compliance with our proposed obligations in the December 2018 consultation.[2] We indicated that we expected to use a combination of coverage models and on the ground testing to assess compliance with the proposed coverage obligations. To support this, we proposed to require obligated operators to provide us with their own coverage predictions and data on their physical network immediately after the spectrum award. We also indicated that we expected our 'new sites' requirement to be met by 'wide area' or 'macro' sites.

2.3 In this section, we explain in more detail the criteria and methodology that we propose to impose for assessing compliance with each element of our proposed obligations, and the reasons for them.

2.4 Annex 5 of this document is a draft of the compliance methodology document we are minded to use.

## The geographic coverage requirement

2.5 Our proposed coverage obligations would require the obligated operator(s) to deliver good quality coverage across 90% of the UK landmass, including at least 90% of England, 90% of Northern Ireland, 74% of Scotland and 83% of Wales. In the December 2018 consultation[3], we set out our view that good service is likely to be provided where:

[1] Ofcom's consultation document of 18 December 2018, entitled "Award of the 700 MHz and 3.6-3.8 GHz bands"; https://www.ofcom.org.uk/__data/assets/pdf_file/0019/130726/Award-of-the-700-MHz-and-3.6-3.8-GHz-spectrum-bands.pdf

[2] Paragraphs 4.158 – 4.168 of the December 2018 consultation.

[3] Paragraph 4.45 and Annex A14 of the December 2018 consultation.

- more than 95% of voice calls can be made without interruption; and
- a connection speed of at least 2Mbps is available with a more than 95% probability to provide the throughput needed for more demanding data services such as video streaming.

2.6 As we said in our December 2018 consultation[4], we expect that an average predicted 4G signal strength[5] of -105 dBm would be needed to meet our proposed coverage obligations through 4G technology. This is the approach which Ofcom has taken to defining good quality coverage since our Connected Nations 2017 report.[6] We consider this level would deliver the quality of experience we are seeking, with 95% or more calls succeeding and a better than 95% probability that a good data service can be accessed. We explain below why we rely on these signal strength predictions to determine the service experience, and how we will apply this approach to assess compliance.

## Why we rely on a mixture of coverage predictions and a verification process

2.7 In principle, comprehensive on the ground testing would be the most accurate approach to assessing coverage levels across the UK and the nations, but the amount of testing required to do this makes it impractical. Predictive methods provide an alternative and efficient means of assessment which overcomes some of the challenges of comprehensive on the ground testing, such as the scale of the measurement exercise that would be needed and accessing difficult terrain. We consider that such predictive methods provide a practicable assessment methodology in terms of scale of effort and accuracy, which we intend to complement with a verification process that may include on the ground testing.

2.8 This mirrors the approach Ofcom has taken to verifying compliance with mobile coverage obligations in the past, where we have used a combination of modelled coverage and on the ground testing. We also use a combination of coverage predictions generated by operators' models, and our own verification, for the coverage information we use in our annual Connected Nations reports and to populate the coverage maps for our 'mobile checker app'.

## A single model for assessing compliance

2.9 As set out in the December 2018 consultation[7], we consider it is important that, for any obligations placed in operators' licences as a result of this award, Ofcom has a clear, robust and consistent approach to check this has been delivered. This will support informed bidding for parties interested in acquiring the obligation. In light of these

[4] Paragraph A14.30 of the December 2018 consultation.
[5] LTE reference signal received power (RSRP).
[6] Ofcom's Connected Nations 2017, page 16; https://www.ofcom.org.uk/__data/assets/pdf_file/0024/108843/summary-report-connected-nations-2017.pdf
[7] Paragraphs 4.160.

objectives, we have considered whether our starting point for assessing compliance with our geographic coverage requirement should be the outputs of the operators' own predictive radio planning tools[8] used for their own coverage planning purposes,[9] a single model issued by Ofcom,[10] or a combination of these approaches.

2.10 In 2013, we provided bidders for the 800 MHz award, which included a coverage obligation, with a single model that would be used to measure compliance with the obligation. We believe there is merit in taking a similar approach for this award, since a single model will ensure that the coverage provided by each of the obligated operators will be assessed against the same criteria, and that the incremental coverage provided to meet the obligation can be robustly assessed. Specifically, using a single model would enable us to address concerns that, because individual operators use different models and underlying assumptions, the coverage that an operator might ultimately be required to roll out could vary depending on how their model behaves. This could impact outcomes for consumers, and the extent of benefit delivered in exchange for the discount we are proposing to offer in the auction.

2.11 A single coverage model also mitigates the risk of operators' models changing during the course of the process. This could happen because operators choose to amend their models, or procure different solutions, for a number of reasons. These reasons could also include changes in operators' incentives to accurately report coverage faced with the requirement to meet a coverage obligation, and that some operators may wish to update or change these models before the obligation falls due.

2.12 However, we also recognise that operators have developed their own processes for measuring the coverage that they provide today and we undertake testing to satisfy ourselves that their coverage predictions are reasonable.[11]

2.13 On balance, we consider it appropriate to provide operators with a single model developed by Ofcom for estimating their geographic coverage. This model will provide a single measure of the coverage increment that each of the obligated operators will deliver in order to comply with the coverage obligations and ensure, therefore, a consistent approach. To take account of the operators' own view of their coverage, we will calibrate the compliance threshold for Ofcom's model for each of the obligated operators so that it reflects the increment between the operator's own baseline and our requirements (i.e. 90% for the UK, and specific thresholds in each nation).

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[8] By this we mean the software, topography datasets and propagation models used by operators for network planning i.e. provision of coverage and capacity in any given area of the UK.

[9] This would be in line with the approach to verifying compliance with the coverage obligations agreed between the UK's four Mobile Network Operators (MNOs) and Government in December 2014. See Ofcom's document of 30 January 2015 entitled "Voice Coverage Obligation Notice of Compliance Methodology".

[10] This would be in line with the approach to verifying compliance with the coverage obligation won by Telefónica UK Ltd (O2) in the UK 4G auction. See Ofcom's document of 24 November 2017, entitled "4G Coverage Obligation Notice of Compliance Verification Methodology".

[11] See paragraph 4.158 onwards of the December consultation.

2.14 This document sets out in more detail how we are minded to implement the approach described above. We are also making Ofcom's model available (on request), and providing details on our underlying methodology.

## Calibrating Ofcom's model to measure the 90% coverage requirement

### Developing the baseline

2.15 We intend to gather information from obligated operators shortly after the auction that will include operators' own coverage predictions (i.e. the outputs of their predictive radio planning tools) and the underlying network parameters (information about the location, and operational properties of each site). To establish the level of good coverage predicted by the operators, we will exclude any areas with an average 4G signal strength lower than -105 dBm according to the operators' own coverage predictions. We will then run our compliance model based on each of the obligated operators' underlying network parameters to determine a second geographic coverage prediction based on our model.

### Calculating the difference between the two models and establishing a threshold for our model

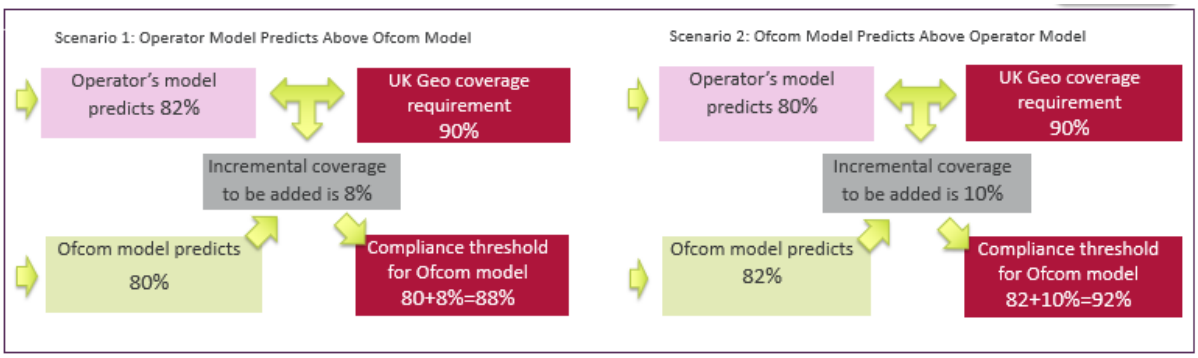
2.16 We will then establish the difference (in percentage points) between each of the obligated operators' predicted view of their coverage based on their own models and the predicted coverage levels resulting from our model, which will be used to inform compliance.

2.17 This difference (in percentage points) will be used to establish the coverage level that must be met for the obligated operators using our model, when this model is run again at the time of the compliance deadline. If our model predicts a lower or higher coverage level at the time of the auction than the operators themselves predict, we will adjust the minimum threshold for compliance with the geographic coverage requirement to be measured using our model. We will do this by reference to the difference (in percentage points) between the operators' own predicted coverage levels at the time of the auction and the 90% threshold.

2.18 For example, if an operator's own model indicates its UK wide coverage is at 80% of landmass at the time of the award and Ofcom's model indicates that it is at 82% (a difference of 2 percentage points) then at the time of verifying compliance Ofcom's model would need to show the operator's coverage at 92% (i.e. 90% + 2 percentage points). Put another way, the incremental coverage increase that must be achieved on Ofcom's model must be the same as the difference between the operator's baseline coverage prediction at the time of the award and the UK threshold of 90% (i.e. in this case an uplift of 10 percentage points).[12] An illustration of this process is provided below.

[12] If an operator predicts that its own coverage is already above the minimum thresholds for the UK or the Nations at the time of the award, the obligation holder would be required to maintain its coverage at a level that meets the obligation requirement on our model. For example, if an operator predicts 91% coverage using its own model and Ofcom's model

**Figure 2.1: Illustration of our process for establishing the compliance threshold in Ofcom's model**




2.19 Operators will be able to calculate the difference between their predicted view of their coverage based on their own models and the predicted coverage levels resulting from our model in advance of the award by comparing their own coverage predictions and those generated by Ofcom's model, which we are now making available on request.

2.20 We would expect any difference in the predictions for the UK-wide and nation-wide geographic coverage levels resulting from the operators' models and Ofcom's model to be relatively small. If a large difference is observed, we would seek clarifications from the relevant operator and engage with them in order to achieve greater alignment of the two models.

2.21 If Ofcom's model predicts a significantly greater coverage level than an operator's own predictions (which we currently consider unlikely), we propose to cap the level of coverage that the relevant operator would have to meet on Ofcom's model at 95%.[13]

## Minimum thresholds for each nation

2.22 As part of our December 2018 proposals, we also set out minimum targets for coverage levels that need to be achieved in each nation. As set out above, these requirements are to deliver at least: 90% coverage in England, 90% coverage in Northern Ireland, 74% coverage in Scotland and 83% coverage in Wales.

2.23 To account for these requirements, we will undertake the same process set out above at both a UK and a national level.

predicts 89% coverage, coverage would have to remain at least at 88% on Ofcom's model at the time compliance is assessed (i.e. coverage must remain at a level on Ofcom's model that is consistent with the incremental change needed from the operator's baseline to provide 90% coverage).

[13] For example, if an operator predicted 84% coverage and our model predicted 91% coverage, the requirement would be set at 95% on the Ofcom model.

## Use of publicly funded sites, including the 'Extended Area Sites'

2.24 As set out in the December 2018 consultation, the Home Office is intending to build around 300 new sites (the "**EAS sites**") to improve coverage in remote areas.

2.25 In the December 2018 consultation, we recognised that there is still significant uncertainty about how and when the EAS sites would be made available to operators. Therefore, in estimating the costs of the proposed geographic coverage requirement, we did not factor in potential cost savings that operators might derive from use of these sites. In line with this approach, we provisionally considered that if these sites were built and made available to all operators before the deadline for compliance with the proposed obligations, it would be consistent not to include the coverage provided by these sites within our assessment of compliance with the 90% coverage obligations that we proposed.[14]

2.26 In consequence, when we require the obligated operators to supply us with their coverage predictions and underlying network information, we will require them to identify any EAS sites within their network and any coverage that they provide using those sites. We propose to exclude these EAS sites from the inputs into our coverage model. We also propose to exclude any coverage predicted by the operators to be provided from these sites from the operators' own predictions that inform the delta between the operators' models and our model.

2.27 As proposed in our December 2018 consultation, coverage added from deployments on other publicly funded infrastructure will count towards the coverage requirement.

## Roaming

2.28 In the December 2018 consultation[15], we said that good quality coverage delivered through roaming could count towards delivering the obligation. Any operator acquiring the obligation will need to provide us with the same evidence for any and all networks they are using to deliver the required coverage (including for any parts of the obligation they deliver through roaming).

2.29 Since the purpose of the proposed coverage obligations is to secure the provision of good quality voice and data services, we are minded to include the effect of roaming only so long as we are satisfied that this provides a meaningful good quality service and seamless transition as customers move from the operator's network to the roaming network and vice versa.

[14] Paragraphs 4.60-4.61 and 4.111-4.115 of the December 2018 consultation.
[15] Paragraphs 1.7, 4.43 and 4.166 of the December 2018 consultation.

2.30 We would expect operators to demonstrate that a seamless roaming service had been implemented and that qualifying coverage would be equivalent to that provided over their own network.

2.31 We consider seamless roaming to mean a seamless transition between the coverage of two (or more) operators, i.e. no additional disruption at the time of transition between the home and the visited networks. This includes maintaining calls or data sessions that are in progress at the time of a transition.

### Verifying compliance

2.32 Operators provide us with their coverage predictions on a monthly basis for our mobile checker app and three times a year for our Connected Nations reports. We regularly monitor operators' predictions[16] and currently consider them to provide a reasonably accurate representation of the level of mobile coverage which is actually provided on the ground.

2.33 As set out above, we intend to gather information from obligated operators shortly after the auction that will include operators' own coverage predictions (i.e. the outputs of their predictive radio planning tools). We will use these predictions to calculate the baselines for our compliance model.

2.34 If we considered that the coverage predictions provided by the obligated operators shortly after the award showed unusual deviations from their current coverage trends, we would ask the relevant operators to explain the reasons for such deviations together with any supporting evidence.

2.35 We will also continue to monitor the coverage predictions that we regularly receive from the operators for our mobile checker app and Connected Nations reports until the coverage obligations have been met, and after that date. If these predictions show any significant deviations from current coverage trends, we would investigate further.

2.36 At the time of verifying compliance, we will undertake a verification exercise which may include on the ground testing in a sample of locations, including in different nations.

2.37 The purpose of this verification exercise is to confirm that the new coverage delivered by the obligated operator(s) is being delivered on the ground.

## The premises requirement

2.38 Our proposals for coverage obligations include a requirement that the obligated operators provide good quality outdoor coverage to at least 140,000 premises to which they do not currently provide good quality outdoor coverage. This is intended to safeguard that the new coverage delivered by the obligation is in places where people live, work and visit -

[16] Including our assessment of operators' compliance with the coverage obligations that fell due on 31 December 2017; see https://www.ofcom.org.uk/spectrum/information/cellular-coverage

and therefore results in meaningful benefits to citizens and consumers. We set out below our proposed approach to assessing compliance with this element of the obligation.

## Using outputs of operators' radio planning tools to assess compliance

2.39 As discussed above, we propose to assess compliance with the geographic coverage requirement using a combination of an Ofcom model and the outputs of operators' own models. This is intended to ensure that the evaluation of coverage gains which operators deliver is the same across the operators.

2.40 We have considered whether we should also use this approach for measuring compliance with our proposed premises requirement. This would mean that we would start from the coverage levels operators are predicting at the time of the award, and then run our single model from this point at the time of verifying compliance.

2.41 We consider our model to be well suited to defining and measuring large coverage areas. However, differences inherent between all models are likely to mean that at the very local level (i.e. a pixel where a premises is located) the predicted results of our model could be different from the predictions of the models of the mobile operators. If we were to focus only on those premises that were unserved according to both operators' own models and our model, we may artificially cap the number of premises predicted to be without coverage.

2.42 Instead, we are minded to use operators' own predictions, at the time of the auction and at the time of verifying compliance, as the means for identifying the premises they believe they have brought into coverage to meet the obligation. We think this is an appropriate approach for verifying compliance with the premises obligation because we recognise the challenge that any single model would face in predicting this kind of very local coverage.

## Verifying compliance

2.43 Immediately after the award, we would ask the obligated operators to provide us with their coverage predictions for the UK landmass (i.e. the same information we are requesting to support our geographic coverage assessment). We will overlay their predicted coverage footprint with a dataset of UK premises. We will use a dataset based on the premises data (residential and business) from the Ordnance Survey (OS) Addressbase® Premium dataset and the OS Addressbase® Islands dataset. We will then identify for each obligated operator all the pixels with unserved premises in them (i.e. where the average predicted signal strength is lower than -105 dBm), and the number of unserved premises associated with them. We will share this list of unserved pixels and premises contained within them with the relevant operators.

2.44 At the time of the compliance assessment, we will then request the updated coverage predictions. We will compare these with the baseline predictions to determine the inhabited areas predicted to have gained good quality coverage within the deadline for compliance with the coverage obligations. We will use the verification process for the

geographic coverage requirement, which may include on the ground testing, to confirm that new coverage has been added at the levels indicated by the operators' predictions.

# The new sites requirement

2.45 In the December 2018 consultation[17], we proposed a requirement to deploy a minimum of 500 new wide area macro sites in order to help achieve all the wider benefits of extending coverage, including overspill benefits of better indoor and in-vehicle coverage. We said that we expected that these new sites would need to be macro sites in rural areas and that we would specify minimum requirements as part of our compliance methodology.

2.46 We set out below our more detailed proposals for defining the characteristics of a new site that would qualify to meet this requirement, and the process that we expect to use for verifying compliance.

## Requirements for new sites to meet the obligation

### New sites

2.47 Each of these sites must be a new site, i.e. in addition to the sites which comprise the electronic communications network which the obligated operator uses to provide mobile telecommunications services as at the date on which the licence containing the coverage obligation is first issued.

### Sites located in rural areas

2.48 In line with our policy objective of securing improvements in rural coverage, in the December 2018 consultation[18] we said that we expected that these new sites would need to be (macro sites) in rural areas. For greater clarity, we propose to specify this requirement in the coverage obligation by adding the words "in rural areas".[19]

2.49 To define which parts of the UK constitute a "rural area" for the purpose of meeting the new sites requirement, we intend to use the Rural Urban Classification used by the UK Government, which defines areas as rural if they are outside settlements with more than 10,000 resident population.[20] A dataset that delineates the rural areas of the UK that will qualify as rural for the purposes of this obligation is available alongside this publication.[21]

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[17] Paragraphs 4.35-4.38 of the December 2018 consultation.
[18] Paragraph 4.35 of the December 2018 consultation.
[19] See paragraph A5.1 of Annex A5.
[20] https://www.gov.uk/government/collections/rural-urban-classification
[21] A more detailed breakdown of the data that underpins this footprint can be found in the following locations: (i) for England and Wales https://ons.maps.arcgis.com/home/item.html?id=3ce248e9651f4dc094f84a4c5de18655; (ii) for Scotland,) (encompassing classifications 3-6) https://www2.gov.scot/Resource/0054/00544929.csv ; and (iii) for Northern Ireland, http://www.ninis2.nisra.gov.uk/Download/People%20and%20Places/Urban%20Rural%20Status%202015.ods.

### A minimum operating power and inter-site distance

2.50 In the December 2018 consultation, we proposed that 500 new sites would have to be 'wide area macro' sites. To ensure that these new sites support improved wide area coverage in rural areas, we proposed to require that any of these new sites must be at least 1-2 km away from any of the obligated operator's existing sites.[22]

2.51 To ensure that a new site provides coverage akin to what is normally described as a 'macro' site, we propose to require that any qualifying site must have a minimum operating power of at least 43 dBm operating from an antenna system above the local clutter. We consider this transmit power requirement is likely to be at the low end of what a typical operator would configure for new wide area coverage sites, whilst allowing flexibility to deploy in more localised coverage gaps where appropriate.

2.52 We consider it appropriate to exclude smaller cells from counting towards this requirement because the primary purpose of this requirement is to safeguard the delivery of new wide area coverage and secure the incremental overspill benefits we envisage our proposals delivering. Whilst we recognise there may be some cases where a very small cell provides a useful infill solution, it is unlikely to safeguard significant coverage gains.

2.53 In line with allowing operators a significant level of flexibility in relation to where new sites are located, we propose to set the minimum inter-site distance requirement at the low end of the range that we proposed in our December 2018 consultation (i.e. 1km). This inter-site requirement is intended to avoid scenarios in which new sites are co-located with existing sites, and in conjunction with our operating power requirement ensure new sites provide meaningful coverage. Our provisional view is that a minimum distance of 1km from the obligated operator's existing (macro site) network inter-site would mitigate this risk and allow for appropriate flexibility. For example, these sites could still serve a small valley community that is close to existing infrastructure but receives poor coverage because of local topography.

## Use of existing infrastructure

2.54 We support the efficient use of existing infrastructure to improve mobile coverage for consumers and businesses, and recognise that there may be significant opportunities for operators to improve their coverage by deploying on another operator's infrastructure (including infrastructure operated by neutral hosts). We are minded to allow sites added to an operator's network in this way (i.e. through infrastructure sharing) to count towards the new sites requirement where the relevant site meets the other conditions for this requirement (e.g. the site must be in a rural area, operate at or above the minimum power

[22] See paragraphs 4.35 (footnote 43) of the December 2018 consultation, paragraph 12(b) of Schedule 1 to the draft licence for 700 MHz spectrum which is set out in Annex A22 of the December 2018 consultation, and paragraph 17(b) of the Schedule 1 to the draft licence for 3.6-3.8 GHz spectrum which is set out in Annex A23 of the December 2018 consultation.

output level and be at least 1km away from any of the existing sites of the obligated operator).

2.55 We also acknowledge that, whilst 4G rollout has continued at pace, there are significant numbers of existing sites that operators own but from which they do not currently provide 4G coverage. We are not minded to allow new 4G coverage being added on these existing sites to count towards this requirement, because we think that in due course many such sites would be upgraded under commercial incentives, and we do not think this approach would support our policy objective of securing the overspill benefits envisaged from the coverage requirement.

## Use of publicly funded sites, including the EAS sites

2.56 In the December 2018 consultation[23] we said that, given our provisional decision not to count the EAS sites towards the proposed coverage obligations, we would not envisage operators deploying on these sites as meeting the new site requirement. We note that over the coming year, one operator will be deploying on these EAS sites through existing arrangements under the Emergency Service Network ("**ESN**") contract. Other operators may also have incentives to deploy on these sites either now or in the future as part of competing for future ESN contracts.

2.57 Allowing operators to count deployments which may well happen anyway, either imminently or at some point in the future, would not maximise the benefits for consumers from the discount we are proposing to offer. It might also not be an effective way of securing the overspill benefits we are aiming to safeguard with this proposal, given the high number of masts this would involve (up to around 300) and in some cases their relatively remote location.

2.58 However, as we said in the December 2018 consultation[24], we envisage that deployments on other publicly funded infrastructure, or existing infrastructure owned by other operators or third parties could count towards the new sites requirement. Within this, we envisage including sites that the Scottish Government is considering building under its proposed '4G Infill Programme', where anchor tenants have not been secured, and individual sites that certain UK local authorities are considering supporting. We are proposing to count deployments on these other publicly funded locations towards meeting the obligation because, at the time of our consultation, we understand that all operators would be equally placed in terms of their opportunity to deploy on such sites, and that there are currently no firm plans for any specific operator to do so.

[23] Paragraph 4.168 and footnote 73.
[24] Paragraph 4.168 and footnote 73.

### Roaming

2.59 As set out above, we are minded to allow roaming to count towards meeting the 90% geographic coverage requirement. We also envisage that the new sites requirement could be met where operators can demonstrate that they have deployed on infrastructure that is new to them and that deployments on existing infrastructure owned by other operators or third parties could count towards this requirement. However, for the avoidance of doubt, we consider that a roaming arrangement would not qualify as a deployment on a new site. Therefore, any sites that an obligated operator roamed onto could not be used to meet the new sites requirement.

2.60 We believe it is appropriate to exclude roaming arrangements from the new sites requirement because there is a significant risk they would not deliver the benefits we envisage for consumers from these new sites (i.e. significant coverage improvements). Since providing additional coverage through roaming arrangements could involve significantly lower upfront costs than building or sharing new sites, we consider that an operator seeking to provide additional coverage through roaming arrangements would have less incentives to provide additional coverage which is meaningful to consumers. In addition, the actual consumers' experience would depend on the detail of the network handover arrangements that have been put in place.

2.61 We note that, since we consider that 500 new sites falls towards the lower end of the range of sites that a typical operator would need to meet 90% geographic coverage, there should continue to be opportunities for operators to includes some local roaming agreements in meeting our proposed geographic coverage requirement.

### Information gathering and testing

2.62 When the proposed obligation falls due, we intend to require the obligated operators to submit to Ofcom a list of sites that they believe meet the new sites requirement. This will include a full breakdown of the physical and technical characteristics of each of these new sites, as well as their location, the date when they started providing service, and any other supporting evidence.

2.63 We would then physically check a sample of these new sites and measure the coverage they are providing to verify whether this aligns with the evidence provided on their physical and technical specifications, and that they are in practice providing new coverage.

## Keeping pace with technological development

2.64 Our current compliance methodology is based on the provision of good quality coverage by means of 4G technology. For example, we currently expect that an average 4G signal strength of -105 dBm would be needed to meet our proposed coverage obligations through 4G technology.

2.65 We would also consider reasonable requests to meet the obligation with alternative mobile broadband technologies, such as 5G. Should this be requested, then we would develop an additional relevant compliance verification methodology to determine whether the expected service of a better than 95% call success rate and a better than 95% chance of accessing 2 Mbps is available. In order to ensure that it is consistent with this 4G-based methodology, we will ensure that consistent principles are applied.

## Ensuring continued compliance

2.66 Once the proposed obligations fall due (i.e. four years after completion of the auction, according to our proposals), the obligated operators will be required to continue to maintain at least the level of coverage required by their licences for the duration of their licences. Therefore, in addition to verifying compliance with the coverage obligations when these obligations fall due, we will also consider repeating this testing and verification process from time to time to ensure operators continue to comply with the coverage obligations.

2.67 In the event that we identify any concerns with the basis and information on which the obligated operators have relied to ensure compliance with the coverage obligations, we would expect to commence a formal investigation into the potential compliance failure in accordance with our Enforcement Guidelines[25].

## Consultation question

**Question 1:** Do you have any comments on the compliance methodology set out in this document? Please give reasons for your views, supported by evidence.

2.68 We invite responses to this consultation by **12 March 2019**, so that we can take these into account before reaching a final decision.

[25] https://www.ofcom.org.uk/__data/assets/pdf_file/0015/102516/Enforcement-guidelines-for-regulatory-investigations.pdf

# A1. Responding to this consultation

## How to respond

A1.1 Ofcom would like to receive views and comments on the issues raised in this document, by 5pm on **12 March 2019**.

A1.2 You can download a response form from https://www.ofcom.org.uk/consultations-and-statements/category-2/coverage-obligations-in-the-700-mhz-and-3.6-3.8-ghz-spectrum-award. You can return this by email or post to the address provided in the response form.

A1.3 If your response is a large file, or has supporting charts, tables or other data, please email it to radiospectrum.award@ofcom.org.uk, as an attachment in Microsoft Word format, together with the cover sheet (https://www.ofcom.org.uk/consultations-and-statements/consultation-response-coversheet).

A1.4 Responses may alternatively be posted to the address below, marked with the title of the consultation:

700 MHz and 3.6-3.8 GHz award
Spectrum Group
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A1.5 We welcome responses in formats other than print, for example an audio recording or a British Sign Language video. To respond in BSL:

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

A1.6 We will publish a transcript of any audio or video responses we receive (unless your response is confidential)

A1.7 We do not need a paper copy of your response as well as an electronic version. We will acknowledge receipt if your response is submitted via the online web form, but not otherwise.

A1.8 You do not have to answer all the questions in the consultation if you do not have a view; a short response on just one point is fine. We also welcome joint responses.

A1.9 It would be helpful if your response could include a direct answer to the question asked in the consultation document, and set out at annex 4. It would also help if you could explain why you hold your views, and what you think the effect of Ofcom's proposals would be.

A1.10 If you want to discuss the issues and questions raised in this consultation, please contact John Glover on 020 7981 3000, or by email to radiospectrum.award@ofcom.org.uk.

## Confidentiality

A1.11 Consultations are more effective if we publish the responses before the consultation period closes. In particular, this can help people and organisations with limited resources or familiarity with the issues to respond in a more informed way. So, in the interests of transparency and good regulatory practice, and because we believe it is important that everyone who is interested in an issue can see other respondents' views, we usually publish all responses on our website, www.ofcom.org.uk, as soon as we receive them.

A1.12 If you think your response should be kept confidential, please specify which part(s) this applies to, and explain why. Please send any confidential sections as a separate annex. If you want your name, address, other contact details or job title to remain confidential, please provide them only in the cover sheet, so that we don't have to edit your response.

A1.13 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and try to respect it. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A1.14 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's intellectual property rights are explained further at https://www.ofcom.org.uk/about-ofcom/website/terms-of-use.

## Next steps

A1.1 Following this consultation period, Ofcom plans to publish a statement.

A1.2 If you wish, you can register to receive mail updates alerting you to new Ofcom publications; for more details please see https://www.ofcom.org.uk/about-ofcom/latest/email-updates

## Ofcom's consultation processes

A1.3 Ofcom aims to make responding to a consultation as easy as possible. For more information, please see our consultation principles in annex x.

A1.4 If you have any comments or suggestions on how we manage our consultations, please email us at consult@ofcom.org.uk. We particularly welcome ideas on how Ofcom could more effectively seek the views of groups or individuals, such as small businesses and residential consumers, who are less likely to give their opinions through a formal consultation.

A1.5 If you would like to discuss these issues, or Ofcom's consultation processes more generally, please contact Jacqui Gregory, Ofcom's consultation champion:

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

# A2. Ofcom's consultation principles

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

### Before the consultation

A2.1 Wherever possible, we will hold informal talks with people and organisations before announcing a big consultation, to find out whether we are thinking along the right lines. If we do not have enough time to do this, we will hold an open meeting to explain our proposals, shortly after announcing the consultation.

### During the consultation

A2.2 We will be clear about whom we are consulting, why, on what questions and for how long.

A2.3 We will make the consultation document as short and simple as possible, with a summary of no more than two pages. We will try to make it as easy as possible for people to give us a written response. If the consultation is complicated, we may provide a short Plain English / Cymraeg Clir guide, to help smaller organisations or individuals who would not otherwise be able to spare the time to share their views.

A2.4 We will consult for up to ten weeks, depending on the potential impact of our proposals.

A2.5 A person within Ofcom will be in charge of making sure we follow our own guidelines and aim to reach the largest possible number of people and organisations who may be interested in the outcome of our decisions. Ofcom's Consultation Champion is the main person to contact if you have views on the way we run our consultations.

A2.6 If we are not able to follow any of these seven principles, we will explain why.

### After the consultation

A2.7 We think it is important that everyone who is interested in an issue can see other people's views, so we usually publish all the responses on our website as soon as we receive them. After the consultation we will make our decisions and publish a statement explaining what we are going to do, and why, showing how respondents' views helped to shape these decisions.

# A3. Consultation coversheet

## BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

## CONFIDENTIALITY

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

Nothing ☐

Name/contact details/job title ☐

Whole response ☐

Organisation ☐

Part of the response ☐

If there is no separate annex, which parts? _____

_____

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

## DECLARATION

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

Ofcom seeks to publish responses on receipt. If your response is non-confidential (in whole or in part), and you would prefer us to publish your response only once the consultation has ended, please tick here.

Name Signed (if hard copy)

# A4. Consultation question

**Question 1:** Do you have any comments on the compliance methodology set out in this document? Please give reasons for your views, supported by evidence.

# A5. Draft Notice of compliance methodology

## Introduction

A5.1 Certain spectrum licences authorising the use of spectrum in the 3.6-3.8 GHz and 700 MHz bands include the following coverage obligation (the "**Coverage obligation**"):

"***Coverage Obligation***[26]

*[11]. The Licensee shall by no later than [X] 2024 provide, and thereafter maintain, an electronic communications network that provides with a high level of confidence:*

*a) a mobile telecommunications service with a sustained downlink speed of not less than 2 megabits per second, to users; and*

*b) a mobile telecommunications service on which 90 second voice calls can be made without interruption, to an area covering at least:*

*(i) 90% of the geographic landmass of the United Kingdom;*

*(ii) 90% of the geographic landmass of England;*

*(iii) 90% of the geographic landmass of Northern Ireland;*

*(iv) 74% of the geographic landmass of Scotland; and*

*(v) 83% of the geographic landmass of Wales"*

*[12]. In addition, the Licensee shall by no later than [X] 2024:*

*a) provide the services described in condition [11] above to an area which covers at least 140,000 premises in the United Kingdom to which the Licensee does not provide outdoor coverage that meets the requirements set out in condition [11](a) and (b) above as at the date of first issue of this licence; and*

*b) deploy at least 500 wide area coverage sites [in rural areas][27] in addition to the sites which comprise the electronic communications network which it uses to provide mobile telecommunications services as at the date on which this licence is first issued. Each of these new sites shall be at least [1 kilometre][28] away from any of the Licensee's existing sites.*

*[13]. Where relevant, words and phrases used in conditions [11] and [12] of this Licence shall have the meaning ascribed to them in the document "[2019 Coverage Obligation Notice of Compliance Methodology]" published by Ofcom on [X] 2019.*

[26] The numbering in this condition (i.e. paragraphs 11 – 15 of Schedule 1) reflects the coverage obligation set out in the 700 MHz licences. In the 3.6-3.8 GHz licences, the coverage obligation is set out in paragraphs 16 – 20 of Schedule 1.
[27] We are proposing to add the words "in rural areas". See paragraph 2.48 of this consultation document.
[28] See paragraph 2.50-2.53 of this consultation document.

*[14]. For the avoidance of doubt the Licensee is permitted to meet the obligations set out in this condition using any frequencies and technologies available to the Licensee.*

**Assessment of compliance with coverage obligation**

*[15]. Ofcom will assess the Licensee's compliance with the obligations set out in condition [X] above by reference to the document "[2019 Coverage Obligation Notice of Compliance Methodology]" published by Ofcom on [X] 2019.".*

A5.2 There are three distinct elements to each coverage obligation:

- a requirement to provide a good quality mobile service outdoors in at least 90% of the UK landmass (the "**geographic coverage requirement**");
- a requirement to provide good quality service outdoors for at least 140,000 premises to which the obligation holder does not provide good coverage at the date of the auction (the "**premises requirement**"); and
- a requirement to deploy at least 500 new wide area mobile sites in rural areas, to be located at least 1km from existing sites (the "**new sites requirement**"). For the purpose of this notice, we interpret the words "*wide area coverage site*" as meaning that each of the new 500 sites shall have a minimum "**EIRP**" of 43dBm.

A5.3 In accordance with the principle of technology neutrality, the Coverage obligation does not impose the use of any specific technology. Therefore, the obligation holders may use any of their portfolio of licensed mobile spectrum in order to meet the Coverage obligation, as long as their customers have access to good quality coverage.

A5.4 For the purpose of this notice, "**good quality coverage**" means access to an electronic communications network that provides "with a high level of confidence" a mobile telecommunications service to users (i) with a sustained downlink speed of not less than 2 megabits per second, and (ii) on which 90 second voice calls can be made without interruption. We interpret the words "*high level of confidence*" as meaning a confidence level of more than 95%.

A5.5 Below we set out our approach to monitoring and verifying compliance with the Coverage obligation based on a service provided using current **4G technology** (i.e. Long Term Evolution technology or "LTE"). As set out above, it will also be open to the obligation holder to meet the obligation with alternative mobile broadband technologies, such as 5G, if they wish. Should this be requested, then we will provide an additional relevant compliance verification methodology for that technology. In order to ensure that it is consistent with this methodology, we will ensure that consistent principles are applied.

A5.6 As discussed in more detail below, if the obligation holder wishes to meet the geographic coverage requirement and the premises requirement using roaming, we expect a seamless transition with no service disruption at the time of transition between the home and the visited networks and vice versa. This includes maintaining voice calls or data sessions that are in progress at the time of a transition.

## Assessment of the geographic coverage requirement

A5.7 We will assess compliance with the geographic coverage requirement using a combination of a coverage prediction model developed by us ("**Ofcom's compliance model**" or "**our compliance model**") and the obligated operator's own predictive radio planning tools used for their own coverage planning purposes (the "**Operator's model**").

A5.8 We will require the obligated operator to supply the following information under our formal information gathering powers:

a) details of the coverage provided by the obligation holder by using 4G technology, specifying which frequency band is used to predict such coverage by the **Operators' model** as a result of all on-air[29] sites. We envisage that we would request this information to be provided in the format used for the purposes of Ofcom's on-line mobile coverage checker (i.e. signal strength and associated best server Site/Cell ID on a grid of 100m x 100m pixels, referenced against the OSGB national grid system[30]); and

b) details of each on-air site on which the above coverage predictions are based, including the parameters listed in Table 3 of this notice. We will use this information to predict obligated operators' good quality coverage with Ofcom's compliance model.

A5.9 We envisage that we will require this information immediately after the award of 700 MHz and 3.6-3.8 GHz spectrum (the "**award**"), when the Coverage Obligations fall due and for any subsequent compliance verification exercise.

### After the award

A5.10 To determine the levels of good quality geographic coverage predicted by the Operator's model ("$\boldsymbol{GeoCoverage_{Operator}}$"), we will apply a minimum 4G average "**RSRP**"[31] threshold of -105 dBm to the information set out in paragraph A5.8a) provided by the obligated operator.

A5.11 We will then use the information set out in paragraph A5.8b) provided by the obligated operator with the Ofcom compliance model in order to estimate the operator's good quality geographic coverage ("$\boldsymbol{GeoCoverage_{Ofcom}}$").

A5.12 We will use the difference between the geographic coverage levels predicted by the Operators' models and Ofcom's compliance model (the "**delta**") to establish the minimum geographic coverage threshold (the "**Adjusted geo coverage threshold**") for compliance.

[29] By 'on-air site' we mean a mobile site that is active at the relevant time as opposed to a site that has been built but is not yet operating or has been decommissioned.
[30] https://www.ordnancesurvey.co.uk/resources/maps-and-geographic-resources/the-national-grid.html
[31] 3GPP TS 36.214: RSRP is defined as the linear average over the power contributions (in [W]) of the resource elements that carry cell-specific reference signals within the considered measurement frequency bandwidth.

$$delta\ (\%) = GeoCoverage_{Operator}(\%) - GeoCoverage_{Ofcom}(\%)$$

$$Adjusted\ geo\ coverage\ threshold\ (\%)\ = \min(90\% - delta, 95\%)$$

A5.13 In addition, we will use the process set out above to calculate the adjusted coverage thresholds for each of the Nations.

### At the time of verifying compliance

A5.14 At the time of verifying compliance, we will again request the information set out in paragraph A5.8b) and any further subsequent clarifications that we may need. We will then use Ofcom's compliance model to determine whether the obligated operator has met the adjusted geographic coverage thresholds for the UK and each of the Nations.

A5.15 In order to assess whether the obligated operator has met the minimum thresholds for geographic coverage in the UK and in each of the nations, we will take account of the coverage predictions calculated on the basis of Ofcom's compliance model rounded down to the nearest two decimal places.[32]

## Overview of Ofcom's compliance model

A5.16 Our compliance model will predict the level of coverage provided by the obligated operators using the technical parameters of their on-air sites (e.g. location, power, height, antenna patterns etc.). The level of coverage provided by any site depends, among other things, on the surrounding terrain and land usage (clutter or ground cover) as they impact the way in which airwaves travel (i.e. radio wave propagation).

### Propagation model

A5.17 Our compliance model is based on the propagation model as set out in the Recommendation ITU-R P.1812-4[33], which is capable of effectively modelling the impact of diverse UK terrain and land usage to estimate the coverage provided by the obligated operators. We recognise that the obligated operators are likely to use their own propagation models for their network planning purposes and the provision of information set out in paragraph A5.8a). However, using our compliance model for the adjusted coverage thresholds ensures that the coverage provided by each of the obligated operators will be assessed against the same criteria.

A5.18 We will calculate the median path loss by using Recommendation ITU-R P.1812-4 that predicts signal levels at the median of the multipath distribution exceeded for a given percentage of time and a given percentage of locations. For this assessment, we will use a time percentage of 50%.

[32] Rounding down towards negative infinity, commonly known as the floor function, means that 89.9973% would be rounded down to 89.99%. Similarly, 89.9914% would also be rounded down to 89.99%.
[33] Recommendation ITU-R P.1812-4 "A path-specific propagation prediction method for point-to-area terrestrial services in the VHF and UHF band" https://www.itu.int/rec/R-REC-P.1812/en

A5.19 In line with the Recommendation ITU R. 1812-4, we will base the pathloss predictions on the terrain profile and clutter along the path at a prediction resolution of 100m. We will apply a clutter end correction at both the transmitter and the receiver. This is based on a representative clutter height that is assigned to each clutter category. The representative clutter height depends not only on the typical physical height of the clutter objects, but also on the horizontal spacing of objects and the gaps between them. The default parameters for representative clutter heights that we will use are set out in Table 1.

**Table 1: Default parameters for representative clutter heights in Recommendation ITU-R P.1812-4**

| Clutter Type | Representative Clutter Height (m) | |
|---|---|---|
| | Add to Profile equation for $i = 2 \ldots n-1$ | Terminal clutter losses, and add to profile equation for $i = 1$ and $n$ |
| **Water / Sea** | 0 | 10 |
| **Open / Rural** | 0 | 10 |
| **Suburban** | 10 | 10 |
| **Urban / Trees / Forest** | 15 | 15 |
| **Dense Urban** | 20 | 20 |

### 95% confidence level

A5.20 As set out in paragraph A5.4, the obligated operators are required to meet the Coverage obligation by providing good quality coverage with a confidence level of more than 95%. We will apply the "location variability of losses[34]" framework to median pathloss predictions for assessing compliance with this 95% confidence level.

A5.21 In Recommendation ITU-R P.1812-4, and generally, the standard deviation $\sigma_L$ (in dB) of spatial statistics of local ground cover variations is referred as location variability and considered to be approximately a log-normal distribution with zero mean.

A5.22 In our compliance model, we have implemented the additional losses due to location variability by using $\sigma_L$ within a Monte-Carlo process that creates the RSRP distribution. We use this distribution to determine if the 95% location availability criterion has been met.

A5.23 Our approach is to calculate the RSRP distribution for a hypothetical test terminal at a particular location (within a pixels of 100 x 100m), taking into account signals from the 20 closest base stations operating in one of the 4G bands, or all base stations within 50 km, whichever is smaller.

[34] Recommendation ITU-R P.1812-4, section 4.8.

A5.24 In line with Recommendation ITU-R P.1812-4, we will calculate $\sigma_L$, which is dependent on the locations (clutter type) and frequency, using the following formula:

$$\sigma_L = K_L + 1.3\log(f) \quad \text{dB}$$

where:

$K_L$= 5.1, for suburban, urban/trees/forest or dense urban clutter types;

$K_L$= 4.4, for receivers in all other clutter types;

$f$: required frequency (GHz).

A5.25 $\sigma_L$ varies between approximately 4 and 6 dB for different frequency bands (below 3 GHz). A value of 6 dB relates to 10 dB margin (additional loss applied to median path loss predictions) for 95% location availability. Therefore, an RSRP threshold of -105 dBm at 50% location availability applied to operators' model is equivalent to an RSRP threshold of -115 dBm applied to our compliance mode (i.e. the output of the Monte Carlo distribution at 95% location availability).

A5.26 For the purpose of verifying compliance with the Coverage obligations, we will use -115 dBm as the minimum RSRP threshold in our compliance model.

### RSRP calculation

A5.27 Table 2 lists the parameters that we will use for RSRP calculations in our model with reference to the 4G technology in channels of 5, 10, 15 or 20 MHz. Should assessment be required for any other channel bandwidths or other technologies, suitable parameters will be set by Ofcom upon request from the licensee with the Coverage obligation.

**Table 2: Key Parameters for LTE channel bandwidths**

| Parameter | Bandwidth(MHz) | | | |
|---|---|---|---|---|
| | 5 | 10 | 15 | 20 |
| **# Resource Blocks (BS)** | 25 | 50 | 75 | 100 |
| **# Subcarriers per RB** | 12 | 12 | 12 | 12 |
| **Total # Subcarriers** | 300 | 600 | 900 | 1200 |
| **RSRP (dBm)** | EIRP – Pathloss – 10*$\log_{10}$(Total # Subcarriers) [35] | | | |
| **Test terminal parameters** | | | | |
| **Antenna Gain** | 0 dBi | | | |
| **Body/Orientation Loss** | 0 dB | | | |
| **Terminal height** | 1.5 m | | | |

[35] This definition of RSRP assumes no power boosting of reference signals.

### Antenna radiation pattern

A5.28 In our pathloss calculation we will apply theoretical radiation patterns taken from 3GPP TR36.814 and tuned to 3 dB beamwidths of the supplied antenna information of each of the obligated operators:

Azimuth pattern: $A_H(\varphi) = -\min\left[12\left(\frac{\varphi}{\varphi_{3\ dB}}\right)^2, A_m\right]$;

Elevation pattern: $A_V(\theta) = -\min\left[12\left(\frac{\theta-\theta_{tilt}}{\theta_{3\ \mathrm{dB}}}\right)^2, SLA_v\right]$,

where the values of $\varphi_{3\ \mathrm{dB}}$, $\theta_{3\ \mathrm{dB}}$ and $\theta_{tilt}$ are supplied by the obligated operators, and $A_m = 25$ dB and $SLA_v = 20$ dB.

### Compliance model calculation overview

A5.29 Our compliance model will undertake the following calculations to estimate the coverage provided by the obligated operators, commencing with the lowest frequency band used by each of the obligated operators. This process is also illustrated in Figure 1.

A5.30 For the first frequency band, the model will assess each location of the UK landmass as follows:

a) The 20 base stations transmitting on the frequency band under assessment which are nearest to the location being assessed and within a maximum distance of 50 km are identified;

b) For each of the identified base stations, the path loss to a test terminal (1.5m above ground level) at the location being assessed is calculated;

c) For each sector of these identified base stations, the median downlink power that would be received by the test terminal at the location is calculated. For this calculation, a theoretical antenna radiation pattern tuned to the beamwidths provided in the site data is applied to each sector;

d) To account for the location variability, a Monte Carlo process is used to calculate the receive power from each sector of each base station, assuming 0.5 location variability cross-correlation between the sites.

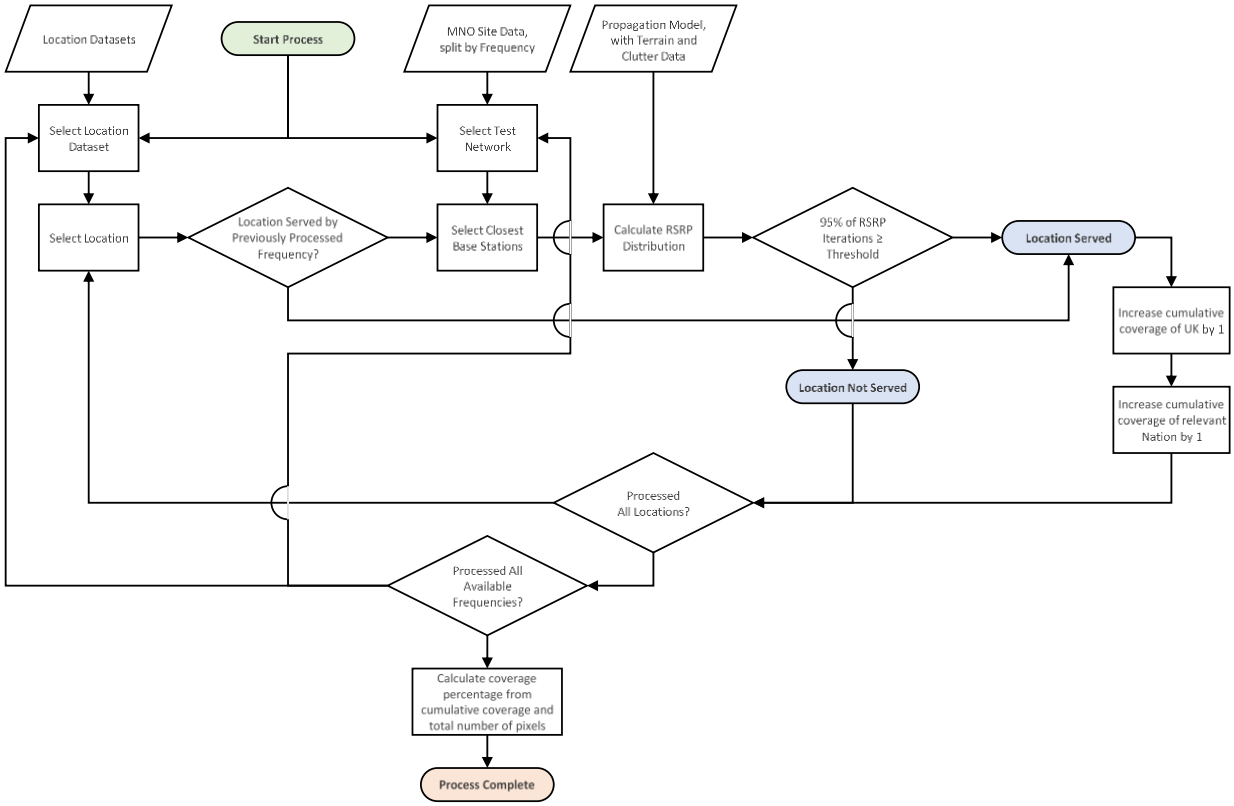
e) The base station sector providing the highest received power at each iteration of the calculation is designated as the serving sector;

f) A serving sector received power distribution is created using the serving sector received power result from each iteration, and is scaled to an RSRP distribution dependent on the number of LTE subcarriers in the frequency band under test;

g) If 95% of the resultant RSRP distribution is calculated to be greater than or equal to the RSRP threshold of -115 dBm, then the location is deemed to be served with good quality geographic coverage;

h) If the first frequency band does not serve the location, it is assessed against the next and subsequent carriers on other frequency bands, until all provided carriers are exhausted. If one of the frequency bands meets the criteria, then the location is deemed to be served with good quality geographic coverage.

**Figure 5.1: Illustrative process for Ofcom's compliance model**




## Network Information required for our compliance model

A5.31 Table 3 lists all parameters that are required as set out in paragraph A5.8b) by the compliance model.

**Table 3: Site data required for Ofcom's compliance model**

| Field ID and heading | | Units | Comments/description |
|---|---|---|---|
| b | Physical site ID | - | Unique site reference (where a new site is a defined for each frequency band) |
| c | Easting | - | British national grid to 1 metre resolution |
| d | Northing | - | British national grid to 1 metre resolution |
| e | Carrier frequency | MHz | Centre frequency of the LTE band |
| f | Antenna height | m | Antenna height above ground level |

| | | | |
|---|---|---|---|
| g | Channel bandwidth | MHz | Bandwidth of the LTE carrier |
| h | Number of sectors | - | Number of sectors on the site |
| The following information should be provided for each sector of a site | | | |
| i | Azimuth | degrees | Antenna boresight direction in degrees east of grid North |
| j | Boresight gain | dBi | Antenna boresight gain relative to an isotropic antenna |
| k | Total downtilt | degrees | Combined mechanical and electrical downtilt, using positive values for down-tilt and negative values for up-tilt |
| l | Vertical 3dB beamwidth | degrees | Half power beamwidth of vertical antenna pattern, |
| m | Horizontal 3dB beamwidth | degrees | Half power beamwidth of horizontal antenna pattern, |
| n | EIRP | dBm | Effective Isotropic radiated power. Power at the output of antenna including the antenna gain |
| Note: An example format template file is available with the model. | | | |

## The Extended Area Sites

A5.32 The Home Office is building new sites to improve coverage in remote areas, known as the Extended Area Service sites (the "**EAS sites**").[36]

A5.33 When we require the obligated operators to supply us with their coverage predictions and underlying network information, we will require them to identify any EAS sites within their network and any coverage that they provide using those sites. We will exclude these EAS sites from our compliance model. We will also exclude any coverage predicted by the operators to be provided from these sites from the operators' own predictions that inform the delta between the operators' models and our compliance model.

## Roaming

A5.34 We will include the effect of roaming on geographic coverage only, and only so long as we are satisfied that this provides a meaningful good quality service and seamless transition to the customers of the obligated operators.[37]

[36] See Home Office's Guidance entitled "Emergency Services Network: overview", updated on 30 November 2018; https://www.gov.uk/government/publications/the-emergency-services-mobile-communications-programme/emergency-services-network

[37] Any impact of roaming on geographic coverage delivered by seamless roaming may also be counted towards the premises requirement (i.e. geographic coverage where premises are located).

A5.35 We would expect operators to demonstrate that a seamless roaming service had been implemented and that qualifying coverage would be equivalent to that provided over their own network.

A5.36 We consider seamless roaming to mean a seamless transition between the coverage of two (or more operators), i.e. no additional disruption at the time of transition between the home and the visited networks and vice versa. This includes maintaining calls or data sessions that are in progress at the time of a transition.

### The minimum thresholds for each nation

A5.37 As part of the geographic coverage requirement, operators must meet individual coverage levels in each of the Nations: at least (i) 90% of the landmass in England, (ii) 90% in Northern Ireland, (ii) 74% in Scotland and (iv) 83% in Wales. The same process will be used to determine compliance with the target for each nation, as for the UK as a whole.

## Assessment of the premises requirement

### Summary of our compliance approach

A5.38 We will use the outputs of obligated operators' own coverage prediction models (the "**Operator model**") to assess compliance with the premises requirement. The premises dataset set out in paragraph A5.52 will be used for this assessment.

#### After the award

A5.39 In line with the geographic coverage requirement, we will determine the levels of good quality coverage predicted by the Operators' models ("$\boldsymbol{GeoCoverage_{Operator}}$") by applying a minimum 4G average "**RSRP**" threshold of -105 dBm to the information set out in paragraph A5.8a) provided by the obligated operators.

A5.40 We will calculate the number of premises without good quality outdoor coverage located in areas where operators' models predict the average RSRP to be weaker than -105 dBm. We will confirm this assessment with the obligated operators.

#### At the time of compliance

A5.41 At the time of verifying compliance, we will again request the information set out in paragraph A5.8a) and follow the processes set out in paragraphs A5.39 and A5.40 above to determine the number of premises without good quality outdoor coverage.

A5.42 In order to determine whether the obligated operators have met the premises requirement, the number of premises calculated to be outside coverage at the time of compliance must be at least 140,000 less than the number of premises without good quality outdoor coverage calculated at the time of award.

# Assessment of the new sites requirement

## Compliance criteria

A5.43 In order to comply with the new sites requirement, the obligated operators will be required to deploy at least 500 sites that meet the following conditions:

a) **new site** - each of these sites must be a new site for the obligated operator i.e. in addition to the sites which comprise the electronic communications network which the licensee uses to provide mobile telecommunications services as at the date on which the licence containing the Coverage obligation is first issued;

b) **rural areas** – each site must be placed in a rural area as set out in paragraph A5.53;

c) **minimum operating power** - each site must be a "wide area coverage site". As set out above (paragraph A5.2), for the purpose of this notice, we interpret the words "wide area coverage site" as meaning that each of the new 500 sites shall have an effective isotropic radiated power ("EIRP") of at least 43 dBm per sector;

d) **minimum inter-site distance** – each site must be at least 1km from other transmitting sites.

## The EAS sites

A5.44 We will not count the sites that the Home Office is building to improve coverage in remote areas, known as the Extended Area Service sites (the "EAS sites")[38], towards compliance with the new sites requirements.

## Roaming

A5.45 We will not count the sites of a hosting network used by the obligated operator towards compliance with the new sites requirement.

## Information to be provided by the obligated operator

A5.46 At the time of verifying compliance, the obligated operators must submit to Ofcom a list of sites that they believe meet the new sites requirement (see paragraph A5.43), including details of each new site according to the parameters listed in Table 3 of this notice.

# Verification process

A5.47 At the time of our compliance assessment, we will also undertake a verification exercise to confirm that coverage has been added in accordance with the requirements above. This

[38] See Home Office's Guidance entitled "Emergency Services Network: overview", updated on 30 November 2018; https://www.gov.uk/government/publications/the-emergency-services-mobile-communications-programme/emergency-services-network

may include on the ground testing, including drive and walk testing, to measure the signal strength in a sample of areas representative of various network deployment scenarios across the UK, including in different nations. We will also carry out a physical site survey to verify the presence and operation of new sites deployed to meet the 500 new sites requirement.

# Databases for verifying compliance

## Geographic coverage requirement

### UK landmass and locations

A5.48 The extent of the UK landmass shall be defined based on vector lines that define the extent of the UK. The vector lines shall be taken from the following source datasets:

a) Great Britain: Ordnance Survey Boundary Line[39]

b) Northern Ireland: OSNI 1:50,000 Northern Ireland outline[40]

A5.49 The version of each source dataset that was current on 31 December 2018 shall be used for the information to be provided immediately after the award and for verifying compliance when the Coverage obligations fall due. For any subsequent compliance verification exercises, the version of the dataset that is current one calendar year prior to the date of the verification shall be used. For the avoidance of doubt, locations on islands that are part of the UK and are inhabited are included, but islands that are part of the UK and are uninhabited are excluded.

### Terrain database

A5.50 We will use the following data which will define the extent and nature of the terrain for the purposes of the obligation:

a) Ordnance Survey's "OS Terrain 50[41]" 50m resolution digital terrain map data for Great Britain (England, Wales and Scotland); and

b) Ordnance Survey of Northern Ireland's "OSNI Open Data 50m Digital Terrain Model (DTM)[42]" 50m resolution digital terrain map data for Northern Ireland.

### Clutter database

A5.51 We will use the land usage classification (clutter) dataset developed by Siradel for Ofcom[43]. This dataset identifies 17 clutter classes. For the calculation of path loss and modelling of

[39] https://data.gov.uk/dataset/boundary-line
[40] https://www.opendatani.gov.uk/dataset/osni-open-data-largescale-boundaries-ni-outline1
[41] https://www.ordnancesurvey.co.uk/business-and-government/products/terrain-50.html
[42] https://www.nidirect.gov.uk/articles/osni-open-data-product-list
[43] https://www.siradel.com/.All right, title and interest in the Siradel dataset are owned by Siradel. Land usage classification has been developed as per Ofcom's requirements for radio wave propagation studies.

location variation for 95% coverage reliability these are mapped to the Recommendation ITU-R P.1812-4 clutter designation and set out in the table 4 below.

**Table 4: P.1812-4 clutter mapping to Siradel clutter categories**

| ITU-R P 1812-4 Clutter Categories | Siradel Clutter Categories | Siradel Code |
|---|---|---|
| Water/Sea | Sea | 1 |
| | River | 2 |
| | Lake | 3 |
| Open/Rural | Open | 4 |
| | Low density vegetation | 5 |
| | Airport | 17 |
| Suburban | Village | 8 |
| | Residential | 9 |
| | Dense residential | 10 |
| Urban | Urban | 11 |
| | Industrial | 15 |
| | Dense urban | 13 |
| | Mean dense urban | 12 |
| Trees/Forest | High density vegetation | 6 |
| | Park | 7 |
| Dense urban | High dense urban | 14 |
| | Building blocks | 16 |

## Premises requirement

### Premises dataset

A5.52 We will use the premises data from the Ordnance Survey (OS) Addressbase® Premium dataset[44] (August 2018, Epoch 60) and the OS Addressbase® Islands dataset (August 2018, Epoch 60). This is combined with additional geographic classifications from the ONS National Statistics Postcode Lookup (NSPL)[45] (August 2018) and Urban and Rural categories derived using the UK Government's Rural-Urban Classification.

[44] https://www.ordnancesurvey.co.uk/business-and-government/products/addressbase-products.html
[45] http://www.ons.gov.uk/ons/guide-method/geography/products/postcode-directories/-nspp-/index.html

## New site requirement

### Rurality dataset

A5.53 We will use the Rural Urban Classification, which is an official statistic used to distinguish rural and urban areas. The classification defines areas as rural if they are outside settlements with more than 10,000 resident population. Sites will only be eligible to meet the new sites requirement where they are deployed in pixels corresponding to an area classified as rural[46].

[46] The dataset applies the definition used in the Urban Rural Classification official statistic https://www.gov.uk/government/collections/rural-urban-classification