OFFICE OF COMMUNICATIONS

Spectrum Usage Rights

Licence verification approaches

Consultation

Publication date: 9 January 2008

Contents

Section 1

Executive Summary

Context of this Statement

1.1 In December 2007 we published a statement on Spectrum Usage Rights (SURs) which set out modelling as our proposed approach to verify licensees' compliance with SUR licence terms. In that statement we provided an example of how such verification might work but indicated that other cases would need further consideration.

1.2 This consultation sets out the additional cases needed along with a proposed approach to each and invites input as to whether the approaches are appropriate.

Types of modelling needed

1.3 We believe that the types of modelling needed are:

- From one downlink to another adjacent downlink.
- From one uplink to another adjacent uplink.
- From one downlink to an adjacent uplink.
- From one uplink to an adjacent downlink.

1.4 We believe that combinations of these cases can cover situations such as the use of Time Division Duplex (TDD) technology.

1.5 The first of these cases were set out in the SUR statement and is repeated in this consultation for ease of reference. The other cases are discussed in this consultation.

Uplink to adjacent uplink

1.6 In outline, the approach is to determine for each cell in the test area the maximum number of mobiles in the cell and their average transmit power. The approximate coverage area of the cell is then calculated and mobiles distributed evenly across the cell. The total interference from all mobiles to each test point in the measurement area can then be determined using the same propagation model as adopted for the downlink to downlink interference case.

Downlink to adjacent uplink

1.7 In outline, in this case the approach is to sum the interference from each of an operator's base stations at each test point across the measurement area. Both the transmitter and receiver are assumed to be at heights typical for base stations.

Uplink to adjacent downlink

1.8 In outline, in this case the approach is to model the interference occurring at each test point within the test area. This modelling is based on assessing the density and average power of mobiles within the test point and determining the interference

caused to multiple points throughout the test point using transmitter and receiver heights typical for mobiles. In practice, a simple formula can be provided such that if the density and average powers are known the interference can be quickly determined without needed to perform modelling.

Section 2

Verification approaches

Introduction

2.1 The SUR Statement set out our preference for compliance to SURs to be verified by modelling. It also gave an example of how that modelling might be performed based on an approach developed and consulted on as part of the "L-Band" award process.

2.2 This consultation extends the modelling approach to all other situations that we are aware of. We are seeking input on whether there are any cases that we have missed and whether the approach suggested here is appropriate.

Q1: Are there any situations not covered by the modelling approaches suggested here?

2.3 The approaches provided here are intended to be generic to all services and frequencies. As a result, it is not possible to specify particular parameters, such as the particular propagation model to be used. As set out in the SUR Statement, these parameters would be specified at the appropriate time such as during an auction process.

2.4 The cases of geographical interference and downlink to downlink interference have already been mentioned in the L-Band award consultation and SUR Statement. The text provided there is also presented in this consultation for ease of reference.

Terminology

2.5 The *test area* is an area covering at least 10 transmitters. Its size is determined based on how large it needs to be in any given location in order to enclose at least 10 transmitters, as set out in the SUR Statement. Generally, it might be expected to cover many square kilometres.

2.6 *Test points* are smaller locations within the test area. Their size will be set out in the licence and will typically depend on factors such as the resolution of the underlying mapping data. For example, a typical size for a test point might be 50m x 50m. In any test area there may be hundreds or thousands of test points.

Geographical interference

2.7 To verify compliance to a geographical PFD limit, the 'victim' licensee highlights a reference point on the geographical boundary where they believe that interference is occurring. The segment(s) of the geographical boundary that occurs within a radius R[1] from the reference point is then used for assessing compliance.

2.8 The aggregate PFD is determined at test points which can be distributed, for example, on the terrain data resolution used. The test points are expected to be located along the relevant segment(s) of the boundary.

2.9 The actual transmitters of the investigated licensee to be included in the modelling will be specified in the licence terms. In the extreme, all of its transmitters causing

[1] The radius R will be specified in the licence.

signal levels at the boundary higher than the UWB (ultra-wideband) mask (as defined in the European Commission Decision 2007/131/EC) will be considered in the modelling.

Downlink to downlink

2.10 To verify compliance to an in-band PFD limit due to a broadcasting or mobile downlink[2] type of service (excluding Time Division Duplex), information such as transmitter location and transmit power is requested from investigated licensees. A simulation is then run over a test area, in a location chosen by the 'victim' licensee. Only the neighbouring licensee's transmitters[3] in the test area will be considered in the modelling. At each of the test points distributed uniformly across the test area, an aggregate PFD value is calculated based on the sum of the predicted interference from each of the neighbour's transmitters at the relevant height which will typically be that of a mobile (eg around 1.5m). The PFD value is based on the transmit power specified and the propagation loss as predicted by the propagation model specified within the licence.

Uplink to uplink

2.11 To verify compliance to an in-band PFD limit due to a mobile uplink[4] type of service (excluding Time Division Duplex), the investigated licensee is requested to provide the maximum[5] number of simultaneous users for each base station within a test area and the average power[6] of each mobile on a per channel basis. The approximate coverage area of the cell is then determined as follows. At regular azimuthal intervals, the coverage radius of each base station is determined based on the minimum received signal level at which the service can be provided as set out in the licence. An average of the coverage radii is then taken and assumed across the entire cell, resulting in a circular coverage. The mobile terminals served by a base station are then evenly distributed within its coverage area. At each test point within the test area, the aggregate PFD at the height of the base station due to the mobile terminals is calculated using an appropriate propagation model as stated in the licence. Due to reciprocity, this model can typically be the same as the one used for the downlink to downlink interference case.

2.12 In practice, it is unlikely to be necessary to model the propagation from each mobile since the received signal level will be predominantly composed of the signal from a small number of nearby mobiles. Hence, approximations such as only considering the five closest mobiles could be adopted if desired by stakeholders.

2.13 To verify compliance to an out-of-band PFD limit, the out-of-band PFD can be derived from the in-band PFD according to a method specified in the licence. In some cases, if appropriate, this can be based on the Adjacent Channel Leakage Ratio (ACLR) or the transmitter spectrum mask or other attenuation mask as specified in the relevant standards or alternatively it can be based on actual measurements of a few transmitters.

[2] A mobile downlink refers to a case where the base station transmits and the mobile terminal is on receive mode.
[3] Indoor transmitters are excluded from the modelling.
[4] A mobile uplink refers to a case where the mobile terminal transmits and the base station is on receive mode.
[5] This is the maximum number of users that can be supported assuming a fully loaded network across the test area ie all cells in this area are at optimal load points to maximise capacity across the area.
[6] A number of simplifications occur here since power control will be used to change the power of each mobile.

Q2: Is this proposed methodology appropriate for modelling the uplink-uplink case?

Mixed downlink and uplink

2.14 There may arise situations when it is necessary to consider the interference caused by neighbours operating links of different directions. For example, one operator may be using a band as a downlink while their neighbour is using their band as an uplink. Or the neighbour might be using time division duplex (TDD), effectively using their band as both an uplink and a downlink simultaneously. This section sets out proposals to model these situations to ensure compliance with SUR levels.

2.15 Note that in general significant interference can occur if uplinks and downlinks are operated close to each other in frequency terms. When deriving SURs appropriate PFD levels will be set to reflect this. For example, the PFD that an uplink user is allowed to generate into the receiver of a downlink user will typically be set to very low levels. As a result of this, the uplink user may create a guard band or take other action to enable them to deliver an economic service while still meeting their PFD limits.

2.16 We firstly consider the two cases of uplinks interfering with downlinks and downlinks interfering with uplinks. We then show how these, coupled with the downlink to downlink and uplink to uplink modelling processes can be used for the case of TDD.

Uplink to downlink

2.17 Imagine the situation where two adjacent operators, OA and OB, are both using their bands for downlink transmissions with given SUR levels. OB now decides to change their downlink to an uplink[7]. In doing so they must respect their SUR levels, ensuring that OA suffers no more interference than would be the case if their link was used as a downlink[8]. The interference mechanism relevant to operator OA is now the interference from OB's transmitting mobiles into OA's receiving mobiles.

2.18 In outline, our proposal for modelling this interference is to determine a representative distribution of OB's mobiles, assign a representative transmit power to each mobile and then model the interference to a set of locations. Because mobile density can vary from location to location, this process needs to be performed at multiple locations across a test area. This process is now described in more detail.

2.19 The process starts in an identical fashion to the general uplink to uplink case described above by establishing a test area. Operator OB is then requested to provide details of all their base stations within this area. In addition, as with the uplink to uplink interference process, they will be requested to specify the number of active mobiles connected to each base station and their average power. Then, as with the uplink to uplink case, the mobiles are distributed evenly across the coverage area of the cell. It is at this point that the process departs from the uplink case.

2.20 Next, as for the downlink case, the interference in each test point within the measurement area is determined. However, instead of summing the interference from all the base stations in area A, as in the downlink case, we determine the local

[7] The analysis that follows also applies to an auction where there is a boundary between uplink and downlink usage.

[8] Note that in practice meeting these SUR requirements will impose severe operational restrictions on using the band as an uplink, and an operator would likely seek agreement with their neighbour for modified SURs or choose to set aside some of their band as a guard band.

interference due to all the mobiles in the test point. We first describe the full process by which this can be done, and then note that in practice a much simpler process can be followed.

2.21 Essentially, we now perform micro-level modelling in a tile of, say 50m x 50m. We take the mobile density and power levels determined earlier in the process and determine how many mobiles there are in the test point. We then distribute the mobiles evenly across the test point. We then "walk" a measurement point across the test point in a manner uncorrelated with the mobile distribution process[9]. At a suitable number of evenly spaced points along this walk, the interference from all the mobiles in the test point is calculated in a manner described shortly. This then gives a distribution of PFD levels. A single value is then taken from this distribution at an agreed level of probability, eg the 95% percentile point. This is the value ascribed to that test point. This process is then repeated for all test points to generate the overall interference distribution in the same manner as for the downlink process.

2.22 The mobile-to-mobile interference is calculated by determining the distance from the measurement point to each mobile in the test point and then using an agreed propagation model to determine the path loss. The model ITU P1411-2 appears to be a strong candidate model, with its frequency range 300MHz-100GHz it covers most situations of interest. Coupled with the assumed transmit power, the interference can then be found.

2.23 In practice, the interference levels for any density of mobiles and a certain transmit power level can be pre-calculated and a lookup table or simple algorithm used to translate the density of mobiles to a given interference level for the test point. Any difference in average transmit power can then be added or subtracted from this result to generate the final answer. This look-up table could be specified in the licence so that licence holders have no need to perform the modelling themselves. For example, such a curve is shown as the solid line for one particular case[10] below. This could readily be approximated by a straight line shown as the dotted line in the figure below and the equation for this line supplied in the licence.

[9] For example, if the mobiles are distributed on a square grid then the measurement point might be walked diagonally from one corner to another.
[10] This is based on 100mW transmissions at 2.6GHz.

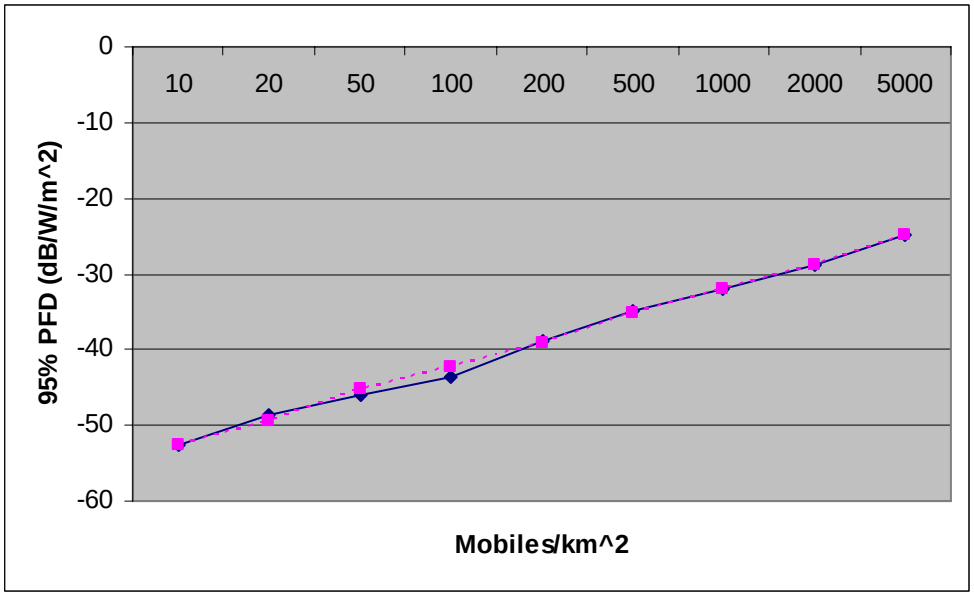

Figure 1: Solid line is modelling of PFD limits for various mobile densities with 100mW transmit power at 2.6GHz. Dashed line is best fit straight line to curve with equation $y=-62.7+10.2 \log_{10}$ (mobile density)

Q3: Is this proposed methodology appropriate for modelling the uplink-downlink case?
Q4: Is ITU P1411-2 a suitable model to use for this purpose where its frequency range is valid?

Downlink to uplink

2.24 Consider the situation where adjacent operators OA and OB are using their bands for uplink. Operator OB now wishes to change their use to downlink. As before, OB must not exceed its SURs and so must not cause any more interference to OA than before it made this change.

2.25 The interference mechanism of interest is now from the transmission from base stations of operator OB into the receivers in OA's base stations. The way that we propose to model this is as follows.

2.26 As with the uplink process, a test area A is established. However, now operator OB is requested to provide the locations and transmit power levels of its base stations. At each test point across area A the interference from OB's base stations is established as follows.

2.27 The propagation loss from each of OB's base stations to the test point is firstly established. This would typically use the same propagation model as for the downlink case, eg P1546-3, but with both terminal heights set to appropriate base station heights, eg 10m. The received signal level is then determined based on the transmit power and path loss for that base station and then the total powers from all base stations are added together. This process is repeated for each test point and a distribution of interference obtained from which the SUR parameters can be verified.

Q5: Is this proposed methodology appropriate for modelling the downlink-uplink case?

Changing an uplink or downlink to TDD

2.28 Now consider the case where operator OA is operating a downlink and operator OB wishes to change their downlink to a TDD link. OB can now potentially cause interference by two mechanisms. The first is downlink-downlink interference and the second is uplink-downlink interference. Both of these can be determined according to the processes set out above and then added together for each test point.

2.29 Similarly, in the case where OA is operating an uplink and OB wishes to change from an uplink to TDD then the interference is comprised of uplink-uplink interference and downlink-uplink interference. As before, both of these can be calculated for each test point and added together.

Q6: Is this proposed methodology appropriate for modelling the TDD to uplink and downlink cases?

TDD adjacent to TDD

2.30 Finally there is the case of SURs for two adjacent TDD users. In this case each operator will be concerned about:

- The interference to the downlink portion of their TDD operation, which comprises downlink-downlink interference and uplink-downlink interference.
- The interference to the uplink portion of their TDD operation, which comprises uplink-uplink interference and downlink-uplink interference.

2.31 The modelling approaches set out above are sufficient to cover these cases.

Q7: Is this proposed methodology appropriate for modelling the TDD case?

Directional and adaptive antennas

2.32 There may be cases where antennas are used that do not illuminate the whole cell or sector but instead seek to direct a narrow beam at a receiver. These may be fixed in their direction and beamwidth, for example as used in fixed link systems, or they may be adaptive, changing direction and beamwidth in accordance with subscriber behaviour.

2.33 We do not consider it likely that such antennas will be deployed on mobiles. There are many reasons for this including the difficulty in building directive antennas into small devices and the problems associated with correct antenna pointing in mobile devices. Hence, we only consider here the case of directional antennas in the downlink case.

2.34 When modelling a non-directional downlink the operator is requested to provide the transmitter power and also the antenna pattern of the antennas used such that the signal radiated in any direction can be determined. These antennas may actually be directive – for example they may illuminate a sector of a cell.

2.35 The process for modelling a directive link proceeds in the same manner. The operator provides the antenna pattern for the base station, which might, for example, consist of a high power radiated over a few degrees of coverage and a low power over the remainder as would be the case with a fixed link. Although such a deployment would generate a different coverage pattern to, for example, a

conventional cellular system, it would still need to meet the SUR requirements. This is appropriate because if a neighbour was basing their network on a particular signal strength only being exceeded in 5% of locations, say, they would not want this to change with the deployment of a more directional antenna.

2.36 In the case of adaptive antennas a base station might form a number of beams which move as they track subscribers. The number and direction of the beams may vary from moment to moment. These could be modelled as follows. The operator is requested to supply the maximum number of beams that could be supported in an optimally loaded network and the associated average beamwidth and power of these beams. A "composite" beam is then formed which equates to all the separate beams being placed "side-by-side". In practice this could be achieved by taking the average 3dB beamwidth of the beam and multiplying it by the number of beams resulting in a single beam with the same average power. This beam is then assumed to be static and oriented at the centre of the sector, or at 0^{o} if in an omni-directional cell. Modelling can then proceed in the same manner as for a static directional antenna.

Q8: Is this an appropriate way to model directional and adaptive antennas?

Mobile relay

2.37 In this case a mobile network is using some mobiles to relay the signals from others. This might be, for example, mobiles out of coverage of a base station whose signal is relayed through mobiles within the coverage zone to the base station.

2.38 For simplicity, we propose to assume that the density of the transmitting mobiles outside of the coverage area is lower than that inside – if this were not the case then there would likely be insufficient relaying capacity from the mobiles at the edge of the network. Because the density is of these mobiles is lower then the transmissions from them are unlikely to affect the overall statistics materially, especially where a relatively high PFD percentage such as 95% is adopted. Therefore, we suggest that such activity is ignored for the purposes of SUR calculation. However, the additional transmissions made by mobiles within the coverage area as part of the relaying process should be reported by the operator when requested to provide information on average mobile transmit power.

Q9: Is it appropriate not to have a specific approach to modelling the mobile relay case?

Mesh networks

2.39 An extension of the situation set out above is a pure mesh network where there are no base stations and mobile devices communicate between themselves. Our view is that such networks are unlikely to be deployed in licensed spectrum. Instead they would be deployed in licence-exempt spectrum where we do not currently propose to apply SURs. Nevertheless, we give them some consideration here.

2.40 If an operator did decide to deploy such a network it would still need to meet its SUR requirements. In a pure mesh there appears to be no easy way to control the mobile density or transmitted power. Therefore, it appears to us at the moment that an operator could not change from an existing licence to this type of deployment and still be able to demonstrate that they met their SUR requirements. However, if an operator wishes to make this change, and believes that they have appropriate mechanisms to control mobile density and transmit powers then we would be willing

to work with such an operator to define an appropriate modelling approach for verifying compliance to the SURs.

Q10: Is this an appropriate approach to pure mesh networks?

Annex 1

Responding to this consultation document

How to respond

A1.1 Ofcom invites written views and comments on the issues raised in this document, to be made **by 5pm on 8 February 2008**.

A1.2 Ofcom strongly prefers to receive responses using the online web form at http://www.ofcom.org.uk/consult/condocs/, as this helps us to process the responses quickly and efficiently. We would also be grateful if you could assist us by completing a response cover sheet (see Annex 3), to indicate whether or not there are confidentiality issues. This response coversheet is incorporated into the online web form questionnaire.

A1.3 For larger consultation responses - particularly those with supporting charts, tables or other data - please email william.webb@ofcom.org.uk attaching your response in Microsoft Word format, together with a consultation response coversheet.

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

Professor William Webb
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A1.5 Note that we do not need a hard copy in addition to an electronic version. Ofcom will acknowledge receipt of responses if they are submitted using the online web form but not otherwise.

A1.6 It would be helpful if your response could include direct answers to the question asked in this document, which is listed at Annex 4. It would also help if you can explain why you hold your views and how Ofcom's proposals would impact on you.

Further information

A1.7 If you want to discuss the issues and questions raised in this consultation, or need advice on the appropriate form of response, please contact Abdus Owadally on 020 7981 3000.

Confidentiality

A1.8 We believe it is important for everyone interested in an issue to see the views expressed by consultation respondents. We will therefore usually publish all responses on our website, www.ofcom.org.uk, ideally on receipt. If you think your response should be kept confidential, can you please specify what part or whether all of your response should be kept confidential, and specify why. Please also place such parts in a separate annex.

A1.9 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and will try to respect this. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A1.10 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's approach on intellectual property rights is explained further on its website at http://www.ofcom.org.uk/about/accoun/disclaimer/

Ofcom's consultation processes

A1.11 Ofcom seeks to ensure that responding to a consultation is easy as possible. For more information please see our consultation principles in Annex 2.

A1.12 If you have any comments or suggestions on how Ofcom conducts its consultations, please call our consultation helpdesk on 020 7981 3003 or e-mail us at consult@ofcom.org.uk . We would particularly welcome thoughts on how Ofcom could more effectively seek the views of those groups or individuals, such as small businesses or particular types of residential consumers, who are less likely to give their opinions through a formal consultation.

A1.13 If you would like to discuss these issues or Ofcom's consultation processes more generally you can alternatively contact Vicki Nash, Director Scotland, who is Ofcom's consultation champion:

Vicki Nash
Ofcom
Sutherland House
149 St. Vincent Street
Glasgow G2 5NW

Tel: 0141 229 7401
Fax: 0141 229 7433

Email vicki.nash@ofcom.org.uk

Annex 2

Ofcom's consultation principles

A2.1 Ofcom has published the following seven principles that it will follow for each public written consultation:

Before the consultation

A2.2 Where possible, we will hold informal talks with people and organisations before announcing a big consultation to find out whether we are thinking in the right direction. 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

A2.3 We will be clear about who we are consulting, why, on what questions and for how long.

A2.4 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 to give us a written response. If the consultation is complicated, we may provide a shortened version for smaller organisations or individuals who would otherwise not be able to spare the time to share their views.

A2.5 We will normally allow ten weeks for responses to consultations on issues of general interest.

A2.6 There will be a person within Ofcom who will be in charge of making sure we follow our own guidelines and reach out to the largest number of people and organizations interested in the outcome of our decisions. This individual (who we call the consultation champion) will also be the main person to contact with views on the way we run our consultations.

A2.7 If we are not able to follow one of these principles, we will explain why. This may be because a particular issue is urgent. If we need to reduce the amount of time we have set aside for a consultation, we will let those concerned know beforehand that this is a 'red flag consultation' which needs their urgent attention.

After the consultation

A2.8 Ofcom will assess the responses to this consultation and issue a Statement.

Annex 3

Consultation response cover sheet

A3.1 In the interests of transparency and good regulatory practice, we will publish all consultation responses in full on our website, www.ofcom.org.uk.

A3.2 We have produced a coversheet for responses (see below) and would be very grateful if you could send one with your response (this is incorporated into the online web form if you respond in this way). This will speed up our processing of responses, and help to maintain confidentiality where appropriate.

A3.3 The quality of consultation can be enhanced by publishing responses before the consultation period closes. In particular, this can help those individuals and organisations with limited resources or familiarity with the issues to respond in a more informed way. Therefore Ofcom would encourage respondents to complete their coversheet in a way that allows Ofcom to publish their responses upon receipt, rather than waiting until the consultation period has ended.

A3.4 We strongly prefer to receive responses via the online web form which incorporates the coversheet. If you are responding via email, post or fax you can download an electronic copy of this coversheet in Word or RTF format from the 'Consultations' section of our website at www.ofcom.org.uk/consult/.

A3.5 Please put any parts of your response you consider should be kept confidential in a separate annex to your response and include your reasons why this part of your response should not be published. This can include information such as your personal background and experience. If you want your name, address, other contact details, or job title to remain confidential, please provide them in your cover sheet only, so that we don't have to edit your response.

Cover sheet for response to an Ofcom consultation

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 ☐

Whole response ☐

Part of the response ☐

Name/contact details/job title ☐

Organisation ☐

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)

Annex 4

Consultation question

A4.1 This discussion document covers the verification process used to ensure compliance with SUR licences terms. Ofcom welcomes comments or views on any aspect of this discussion document, in particular to the following question.

Q1: Are there any situations not covered by the modelling approaches suggested here?

Q2: Is this proposed methodology appropriate for modelling the uplink-uplink case?

Q3: Is this proposed methodology appropriate for modelling the uplink-downlink case?

Q4: Is ITU P1411-2 a suitable model to use for this purpose where its frequency range is valid?

Q5: Is this proposed methodology appropriate for modelling the downlink-uplink case?

Q6: Is this proposed methodology appropriate for modelling the TDD to uplink and downlink cases?

Q7: Is this proposed methodology appropriate for modelling the TDD case?

Q8: Is this an appropriate way to model directional and adaptive antennas?

Q9: Is it appropriate not to have a specific approach to modelling the mobile relay case?

Q10: Is this an appropriate approach to pure mesh networks?