OFFICE OF COMMUNICATIONS

# Spectrum Usage Rights

## Technology and usage neutral access to the radio spectrum

**Consultation**

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# Contents

## Section 1

# Executive Summary

## Introduction

1.1 Under current legislation, users require authorisation to transmit radio signals. The rationale for this restriction is that unregulated use of spectrum is likely to lead to interference between transmissions. This destroys the value of the spectrum as a medium for communication. Authorisation may be granted on a class basis (known as 'general authorisation' or 'licence exemption') or to individual users (known as 'wireless telegraphy' or 'spectrum' licences). In such a licence, it is necessary to place some restrictions on their rights to transmit. Without such restrictions there would be a high risk that significant levels of interference might be caused to others. For example, if users had no restriction on the signal levels they were allowed to transmit outside their designated bands, they might transmit high levels to the detriment of neighbouring users.

1.2 There are many different ways in which technical restrictions on spectrum use can be formulated. The way in which this is done can have profound effects on the flexibility that exists for spectrum users, and on the incentives for efficient use of the spectrum. At the most general level, there is a trade-off between increasing the flexibility available to any one user of the spectrum and reducing the risk of interference to other users. However, this trade-off can be managed more or less effectively depending on the way in which the technical constraints are specified, and the way in which change to any given set of constraints is managed.

## General policy

1.3 Ofcom's general policy is to set technical restrictions that are the minimum necessary to provide adequate protection against harmful interference. This is because optimal use of the radio spectrum is more likely to be secured if users decide, rather than Ofcom dictates, what technology to use or service to provide in a particular frequency band. Imposing the minimum necessary constraints will increase users' flexibility and freedom to respond to changing conditions, and to make best use of the valuable spectrum resource.

1.4 This policy, known as 'liberalisation', is at the heart of Ofcom's Spectrum Vision, set out in the Spectrum Framework Review. As described below, we have already put in place a policy of progressively removing restrictions on spectrum use. This document seeks views on an approach that could be taken to the next phase of liberalisation. We term this method of specifying restrictions in licences spectrum usage rights (SURs). It is possible that specifying technical restrictions in terms of SURs could bring additional gains through extra flexibility of use, while maintaining standards of freedom from significant interference. However, Ofcom recognises that the issues are complex and require careful consideration before implementation.

1.5 This document addresses only the issues associated with specifying restrictions on spectrum use for technical reasons. It does not address other issues that may also be relevant to particular decisions that Ofcom may take on the terms of existing or new licences. These other considerations may include, for example, the effects of potential decisions on the promotion of competition, the protection of consumers, or

the availability of services such as electronic communications, television and radio across the UK.

1.6 Ofcom has made clear in its Spectrum Framework Review that it considers policy constraints on spectrum use should be kept to a minimum, and that they should only be used where there is a very clear justification. Ofcom will take into account all relevant statutory duties into account before taking any decision relating to the authorisation of spectrum use.

1.7 For the avoidance of doubt, where particular types of licences are discussed in this document, this is only by way of example in order to illustrate or clarify generic concepts. This document should not therefore be construed as indicating Ofcom's intentions on, or proposals for, future liberalisation in any specific licence class or for any specific spectrum use.

## Historic approach to licence restrictions

1.8 Spectrum has historically been managed on a 'command and control' basis, under which licences have often been very specific about the technology to be employed and the use that might be made of the spectrum. Under this approach, the characteristics of users in a given band could be defined very tightly and known with high degree of certainty. This allowed spectrum use to be planned in great detail.

1.9 This approach can be beneficial to technical efficiency, in the sense of maximising the capacity available for a given spectrum use, while avoiding harmful interference. But it is less satisfactory for delivering economic efficiency. Economic efficiency requires spectrum to be used in the way that delivers highest value to the society and economy at large. This use may not be the same as the use which has been planned in detail by the regulator, who knows less about the uses that could be made of the spectrum than the market. Moreover, change from one use, decided and planned by the regulator, to another use, decided and planned in the same way, is a time-consuming process that can be beset by regulatory uncertainty. These problems, of inflexibility, and poor economic efficiency in spectrum use, have been made more pressing by the pace of innovation in wireless technology, which means that more and more technologies and applications are now vying for access to spectrum.

1.10 A wide variety of different technical conditions can be found in existing licences for spectrum use. These include the following (which are not mutually exclusive):

- Licences that specify a particular technology. In this case, parameters such as maximum transmit levels and signals emitted in neighbouring bands are set in the standard which specifies the technology. This approach has the advantage of technically efficient use of the spectrum in the case where many adjacent users of the spectrum have the same restriction, because equipment standards are generally specified to maximise capacity in these situations. However, it is inflexible in not permitting different technologies (and uses insofar as technology dictates use). It requires the regulator to determine the optimum technology, which can have many adverse consequences. And if the optimum technology and use changes, these restrictions can severely restrict users' ability to respond.
- Licences that specify a particular type of use, such as "fixed" or "mobile". There may also be further restrictions on parameters such as transmitted power levels. This approach is more flexible than specifying a particular technology, in that many different technologies can typically be deployed under the heading "fixed" or "mobile". However, this approach can still act as a serious constraint on users'

ability to offer innovative services or to change use in response to market demand. Moreover, while categories such as “fixed” and “mobile” have been helpful historically in capturing some dimensions of spectrum use, they are less and less reflective of modern technologies and uses, which blur these boundaries.

- Licences that specify power limits. A licence might include a limit on the power transmitted within the allowed band, and outside this band. These limits are sometimes referred to as “EIRP limits” or “spectrum masks”. This provides much greater flexibility than either of the alternatives above. However, it is typically necessary to make assumptions about other key variables – such as the type of use and likely density of usage – in order to specify a power limit that will not cause harmful interference to neighbours. It is therefore possible for power limits to be specified either too liberally or too conservatively if actual behaviour departs from the assumptions.

## Liberalisation

1.11 Ofcom’s policy of liberalisation involves the reduction or removal of licence restrictions, while continuing to avoid unacceptable increases in interference. As discussed in the Liberalisation Statement and the Spectrum Framework Review, this process involves Ofcom taking into account a range of statutory duties and relevant factors in relation to each individual liberalisation decision. The process has three phases.

1.12 Phase One is currently in place. In this phase, users are able to ask Ofcom to change their licence, for example to remove the restriction to a particular technology. Ofcom will consider each request on its merit but has indicated in its publications on liberalisation various categories of change of use to which it would normally expect to agree while making clear that it also encouraged applications outside these categories.

1.13 Phase 2 proposals are expected to be published for consultation shortly. Ofcom is examining some classes of licence (such as some Private Business Radio licences), to see if restrictions can be lifted across a complete class. As in Phase One, Ofcom needs to be satisfied that this relaxation in restrictions is unlikely to lead to increased interference and is consistent with other relevant considerations. Hence there are limits on the level of relaxation that can be allowed. Ofcom will shortly be consulting on proposals to implement Phase 2 in certain Business Radio licence classes.

1.14 This document discusses the scope for moving to Phase Three, which would involve a new way of expressing technical restrictions on spectrum use.

## Spectrum usage rights

1.15 The existing approaches to specifying technical restrictions on spectrum use protect neighbouring users against harmful interference indirectly. They involve specifying or assuming a certain application or technology, and imposing technical limitations, based on the interference effect that the technology or application is likely to cause to neighbouring applications or technologies, which are likewise specified or assumed. The fact that both the interfering and victim characteristics are known makes it simpler to predict the interference that will result.

1.16 SURs would take the alternative approach of directly specifying the emissions that a licence holder may transmit in neighbouring bands or locations. This could bring two key advantages.

- Licensees would have greater flexibility since their licences would not restrict the technology or application.
- Neighbouring licence holders would have more clarity over the levels of emissions from neighbours they can expect, and more confidence that increased flexibility will not cause them to suffer interference above this level.

1.17 There are three main types of interference that must be considered in drawing up SURs.

- Interference caused by emissions across a geographical boundary to a licence holder using the same frequency in a different area. We term this “geographical interference”.
- Interference caused by out-of-band emissions from a licence holder, to licence holders using adjacent or near-adjacent frequencies. These may be both in the same geographical area and neighbouring areas, although in practice the effect in neighbouring areas is normally negligible.
- Interference caused by in-band emissions from a licence holder, to licence holders using adjacent or near-adjacent frequencies. This can be due to the inability of the receivers of neighbouring licence holders to fully remove the signal transmitted within the band of the licence holder.

1.18 For each of these types of interference there are a number of ways that the maximum allowable emissions could be specified. Each of these is discussed below.

1.19 Geographical interference. Possible ways to specify this include:

- A limit on the transmit power allowed. However, this does not directly specify the interference caused and if a user increases the density of transmitters near a boundary then the interference caused across that boundary can rise.
- Coordination of base stations between users. In this case, the users agree on the placement of each base station. If users can reach agreement this can be technically efficient but this could place an excessive burden on licence holders.
- A limit on the power level that can be caused at any point beyond the boundary. A licence holder would not be allowed to transmit in such a way as to cause a signal level above a particular limit at, or beyond a specified boundary. This directly controls interference and appears to us to be the best approach.

1.20 Interference caused by out-of-band emissions. Possible ways to specify this include:

- A limit on transmitter power allowed outside of the band. This does not directly specify the interference caused and if a user increases the density of transmitters inside their coverage area then the interference caused can rise.
- Coordination of base stations between users. In this case, the users agree on the placement of each base station. If users can reach agreement this can be technically efficient but we feel places an excessive burden in licence holders.
- An allowed distribution of signal across a geographical area. A licence holder would be allowed to transmit in a neighbouring band up to a certain level, specified in a probabilistic fashion. A suitable specification might be that within a given area the licence holder must not exceed a set signal level for more than a certain percentage of time at a certain percentage of locations. This directly controls the overall levels of emissions in neighbouring bands, although not the specific location in which

emissions might occur. It does not allow interference to rise. This appears to us to be the best approach.

1.21 Interference caused by in-band emissions. The mechanisms for specifying this are identical to those for those specifying interference caused by out-of-band emissions and hence we prefer an identical approach.

1.22 Aggregating the preferred approach under each of the above headings, licences adapted to the SUR method would be specified in the following way.

- The aggregate power flux density (PFD) at or beyond [definition of boundary] should not exceed $X_1$ dBW/m$^2$/[reference bandwidth] at any height up to H m above local terrain for more than P% of the time.
- The out-of-band PFD at any point up to a height H m above ground level should not exceed $X_2$dBW/m$^2$/MHz for more than Y% of the time at more than Z% of locations in any area A km$^2$.
- The in-band PFD at any point up to a height H m above ground level should not exceed $X_3$dBW/m$^2$/MHz for more than Y% of the time at more than Z% of locations in any area A km$^2$.

1.23 Changing licence restrictions to SURs in the form discussed above would have a number of implications. These include:

- Licence holders would have increased flexibility to change technology and usage compared to many current licences.
- Licence holders would have the same levels of certainty about the quality of the spectrum they occupy. The degree of certainty might be enhanced in some cases.
- However, under some circumstances, licence holders might have less ability to significantly increase deployment density than they do at present.

## Negotiation and trading

1.24 This document also considers how SURs could be changed, once they have been established, to reflect the changing preferences of neighbouring licensees. Ofcom's preference would be to find a way in which the process of change could be left to the market as much as possible, rather than mediated by the regulator.

1.25 Ofcom considers that it should in principle be possible to agree many changes through commercial negotiation. A holder wishing to make a change that would cause the technical limits to be exceeded could negotiate with, and secure the agreement of, all affected neighbours. As with current licences, it would be then open for the user, having secured the affected parties' agreement, to present this proposal to Ofcom, who will then consider the application and vary the licence accordingly. Such arrangements can be entered into in various ways with different degrees of Ofcom involvement.

- spectrum trading in accordance with the trading regulations;
- arrangements in which the affected parties agree not to object to proposals to vary the initiator's licence;
- coordination procedures, which may be specified in licences.

1.26 The parties to such arrangements would be free to agree on commercial terms to compensate the affected parties for any diminution in their spectrum assignment or

spectrum quality resulting from the change. This approach is inherent in spectrum trading, but is also possible under the other two mechanisms.

1.27 If licence restrictions were changed to the form of SURs, then this ability to negotiate would remain. In particular, Ofcom would expect licences in the form of SURs to be tradable. However, we believe that stating licence restrictions in terms of SURs would make negotiation simpler because one licence holder could explicitly agree to a change in the interference they would experience by a simple change to relevant SUR parameters.

## Implementation and other issues

1.28 This consultation document is concerned only with the appropriate form of SURs. It does not discuss any issues associated with their implementation, either generically across all spectrum licences or in particular licence classes. Once we have concluded on the best form of SURs, we will bring forward proposals for implementation, where appropriate.

1.29 There are a number of other subsidiary issues on which this document is silent, or on which it provides only initial thoughts. These include the following.

- The way in which the SUR parameters for specific licences will be calculated. Licence holders themselves might have a role in determining these parameters themselves but we have further work to do.
- The timing of any introduction of licences in SUR form.
- The process and legal form we will follow for varying licences if a change to SURs occurs. At present, trading and licence variation both involve Ofcom in reissuing licences but there may be mechanisms that could be permitted under the trading regulations and that would enable a simpler procedure.
- The application of SUR principles to different classes of licence and occupied or unoccupied spectrum. We suggest here that determining the SUR parameters might be more difficult for licences covering small areas, such as single transmitter locations, while the benefits of changing to SURs for such licences will be smaller. Hence, we are minded to applying SURs initially to national or regional licences and not to more local assignments. Further, it would be simpler for licences in SUR form to be introduced in the first instance for new awards as this avoids the need to convert existing licences.
- How administrative incentive pricing might be applied to licences in SUR form.

## Summary

1.30 In summary, we are consulting on a new method for stating necessary restrictions in spectrum licences. We designate this ‘spectrum usage rights’ (SURs). Licences in SUR form would restrict the permissible emissions into frequency bands and geographic locations of neighbouring users. This would both maximise flexibility while protecting neighbouring users from excessive interference. Licences in SUR form would be more flexible than existing licences and holders would be able to take advantage of the existing mechanisms, including spectrum trading, to negotiate changes with neighbours.

1.31 We are setting these ideas out at this stage for consultation on the concept of SURs. Depending on the comments received, we would then intend to consult further, as appropriate, on more detailed issues and on the scope for applying SURs to specific licence classes. The timing of this is dependent on the responses to this consultation.

## Section 2

# Current licence restrictions

## Introduction

2.1 Users require authorisation in order to transmit radio signals. In granting this authorisation it is necessary to place some restrictions on their rights to transmit. Without such restrictions there would be a high risk that significant levels of interference might be caused to others. For example, if users had no restriction on the signal levels they were allowed to transmit outside of their designated bands, they might transmit high levels, to the detriment of neighbouring users.

2.2 In general there is a trade-off between flexibility and the probability of causing interference. Highly restrictive licence conditions will give limited opportunities for any change of use, and hence for any change in the interference environment. The opposite is true for unrestrictive licences.

2.3 There are two key mechanisms whereby interference could change. The first is the deployment of a different technology, with different in-band and out-of-band (OOB) emission characteristics. The second is an increasingly dense deployment of the same technology at the same power levels which will increase the number of locations where a neighbouring user will be close to a transmitter and hence may suffer interference.

2.4 The risk of interference can be reduced through the provision of guard bands between users. These allow the emissions from transmitters to fall to a lower level than at the edge of the band and so reduce their effect. The larger the guard band the greater the reduction in interference, but the more spectrum that will not be usable. Guard bands have typically been used between spectrum users who have dissimilar licence conditions, or where an uplink and a downlink are in proximity.

2.5 Current licences have their restrictions specified in a range of different manners. These include:

- Through a particular technology.
- Through a particular use.
- Through a particular set of emission characteristics known as a mask.

2.6 Each of these is discussed below.

## Technology restrictions.

2.7 Some licences have a restriction on the technology that can be used. This may be a single technology or a family of technologies. Under such an approach the technology must conform to a published standard. This standard will list parameters such as maximum transmit levels and signals emitted in neighbouring bands. Hence, effectively, the standard sets the emissions mask for the technology.

2.8 The restriction on technology might also effectively exert some control on deployment. For example, if the technology is only capable of working over a short range, deployments using high powered transmitters on high masts would make little commercial sense. If the technology were one suited to private business radio (PBR)

use, but not cellular, then given the relatively low number of PBR users compared to cellular users, it might be expected that a relatively small number of cells would be deployed. However, this level of control is weak, for example in the US, Nextel took a PBR-type technology and made it suitable for cellular use. As a result, the economics of provision changed and they dramatically increased the density of the network deployed (which subsequently led to interference problems with neighbours).

2.9 Technical specifications are often designed with the assumption that neighbouring users will adopt the same technology. The standards body will set OOB emission levels sufficiently low such that the emissions into neighbouring bands can be tolerated by the technology but equally sufficiently high so that the equipment is less costly to build. This optimisation can lead to good technical efficiency. By setting licence restrictions to the same technology across a band then good coexistence coupled with good technical efficiency is possible. However, there can still be problems. Within 3G technology for example, there is a problem known as "deadzones" where if a mobile is at the edge of its coverage and so receiving a weak signal, while simultaneously near a base station in a neighbouring band, so receiving a strong signal from this base station, albeit in a neighbouring band, the effect of the strong signal is sufficient to cause the mobile to drop the call.

2.10 One of the key disadvantages of technical restrictions is their inflexibility. If an inappropriate technology is specified then the band may remain unused, as happened with bands such as ERMES, or the economic efficiency of using the band may be lower than would be possible under a different technology. Economic efficiency requires spectrum to be used in the way that delivers highest value to the society and economy at large. This use may not be the same as the use which has been planned in detail by the regulator, who knows less about the uses that could be made of the spectrum than the market. Even if the optimal technology was initially selected, it may become sub-optimal over time as new technologies emerge. Moreover, change from one use, decided and planned by the regulator, to another use, decided and planned in the same way, is a time-consuming process that can be beset by regulatory uncertainty. These problems, of inflexibility, and poor economic efficiency in spectrum use, have been made more pressing by the pace of innovation in wireless technology, which means that more and more technologies and applications are now vying for access to spectrum.

2.11 A further disadvantage is that users have some risk that if a neighbour in frequency or geography significantly increases their density of deployment then the interference they experience will rise.

2.12 In summary, technical restrictions can be efficient if the technology selected is optimal. However, they are inflexible and only provide a limited degree of certainty as to the interference neighbours can expect.

## Usage restrictions

2.13 Usage restrictions specify a type of use such as "fixed". There may be a further definition of what this type of use means, for example "fixed" may be defined as "providing services to a premises or dwelling".

2.14 Usage restrictions are generally less restrictive than technology restrictions. This is because most technologies are currently connected to a particular usage – for example GSM to mobile, and DAB to sound broadcasting. By restricting usage, the licence holder can select from a number of different technologies, or indeed, invent a

new technology. This allows for an improved economic efficiency, enabling the possibility of employing new and better technologies over time as they emerge.

2.15 The increased flexibility comes at a price. If neighbouring users select different technologies they may not be able to work with the emissions each other causes without the provision of guard bands. Also, because a user can change to a different technology, with different emission characteristics, the interference experienced can change. Finally, the same problem of an increased deployment density causing increased emissions to neighbours remains. The risk of this occurring may be higher than for technical restrictions if the increased flexibility allows the licence holder to adopt a different business model which in turn required a more dense deployment.

2.16 In summary, usage restrictions are more flexible than technology restrictions, although they still lack complete flexibility. However, they increase the risk that emissions into neighbouring bands and areas will change and may have a lower technical efficiency.

## Transmitter emission restrictions

2.17 The licence restrictions can be stated in terms of the maximum power that can be transmitted from each transmitter. This is normally shown as a plot of allowed transmitted power against frequency. Typically, within the band covered by the licence a flat power level across the band is allowed. Outside this band the power level is required to reduce, or “fall off”, becoming smaller as the distance from the band edge increases. Such a restriction is often known as a “transmitter mask” because the actual emissions from the transmitter, when measured must fit within the restrictions.

2.18 Since such a mask is typically specified in a technology standard then emission restrictions have many similar characteristics to technology restrictions. However, critically, they allow licence holders to deploy a different technology if it can fit within the same mask, and so are more flexible. It is also possible not to specify usage, although this brings some risks as described below.

2.19 Because the emission characteristics of the equipment are set then neighbouring users do not have to be concerned that a change in technology will result in increased interference. However, like all the approaches described in this section, a change in deployment density would result in increased interference. If there are no further restrictions on usage then, for example, a licence holder might decide to convert a network previously used for fixed services to one for mobile usage, perhaps through using a different technology. This might result in a very different density of base stations or base station heights which might significantly change the interference experienced by neighbours.

## Summary

2.20 While licences specified in the terms set out above have allowed widespread use of the radio spectrum over many years, they all make varying degrees of trade-off between the flexibility of the licence holder to change their use and the risk of increased interference under such changes to neighbouring users. This is shown in the figure below, although this is illustrative only as there may be some situations where the relative positions of the bubbles on this chart change places.

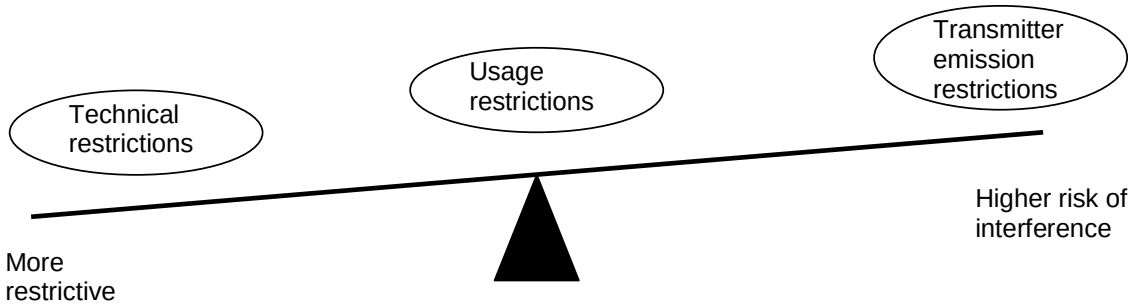


**Figure 1: Current licence restrictions**

2.21 Importantly, none of these licence restrictions directly control the deployment density of networks. Hence, with any of them, neighbouring licence holders have some uncertainty as to the levels of interference that they may experience in the future. Technical and usage restrictions may exert some control over deployment density by limiting what is economically viable, but this is a weak form of control and guard bands can be used to increase the protection, although this may be wasteful of spectrum. In an ideal world we would like a method of defining restrictions that had the flexibility of emissions restrictions but with a lower risk of interference changing than for technical restrictions.

## Section 3

# Liberalisation

## Ofcom's approach to managing the spectrum

3.1 Ofcom has set out its approach to managing the spectrum previously in the Spectrum Framework Review (SFR)[1]. Ofcom's key spectrum vision put forward there is:

- spectrum should be free of technology and usage constraints as far as possible. Policy constraints should only be used where they can be justified;
- it should be simple and transparent for licence holders to change the holding and use of spectrum; and
- rights of spectrum users should be clearly defined and users should feel comfortable that they will not be changed without good cause.

3.2 As discussed in the SFR, Ofcom believes that market forces are often more suited than central control in achieving the optimal use of a limited resource such as spectrum. A key change proposed in the SFR is to allow market based mechanisms to prevail wherever this is judged to be in the best interests of citizens and consumers. Such market mechanisms include:

- trading of spectrum between users so that they can buy, sell, aggregate or unbundle spectrum holdings; and
- liberalisation of spectrum use, so that users can change technologies, or the type of use, applied to their spectrum.

3.3 Ofcom's proposals for trading are now well advanced. Trading in some licence classes was implemented at the end of 2004, and it is planned to extend it progressively to almost all suitable licence classes.

3.4 Spectrum liberalisation is a more complex issue than trading. Spectrum users have been packed in tightly by spectrum managers over the years in several frequency bands, with many users sharing spectrum. Inappropriate liberalisation could cause undue interference or inefficient use of the spectrum unless suitable restrictions are imposed on the use of spectrum in those bands.

3.5 Recognising that in the past the selection of licence restrictions might have erred on the side of caution, Ofcom has embarked on a process of liberalisation. This seeks to reduce or remove licence restrictions while not enabling users to increase significantly the interference that they can cause to others. As discussed in the Liberalisation Statement and the Spectrum Framework Review, this process has three phases.

3.6 In Phase One, which has been implemented, users are able to request that Ofcom make changes to their licence, for example to remove the restriction to a particular technology. Ofcom will consider each request on its merit. For example, Ofcom might agree to remove licence restrictions that specify a particular technology. Any request for variation to a licence will be considered carefully against Ofcom's statutory duties, including considering whether the variation would cause undue interference to others.

[1] "Spectrum Framework Review", Statement, Ofcom, 28 June 2005

3.7 In Phase Two, for which proposals will be consulted on shortly, Ofcom is examining classes of licence, such as some PBR licences, and considering whether restrictions can be lifted across a complete class. As in Phase One, Ofcom needs to be satisfied that this relaxation in restrictions is unlikely to lead to increased interference, and hence there are limits on the level of relaxation that can be allowed.

3.8 Phase Three, is the phase that is discussed in this document. We are consulting on this in parallel with our work on Phase 2 proposals because we expect Phase 3 to take substantially longer to implement than Phase 2.

3.9 In all three phases, there may be wider policy reasons, in addition to interference considerations, that may temporarily make it appropriate in particular cases for Ofcom to restrict liberalisation, for example on account of the effects of potential decisions on the promotion of competition, the protection of consumers or the availability of services such as electronic communications, television and radio across the UK.

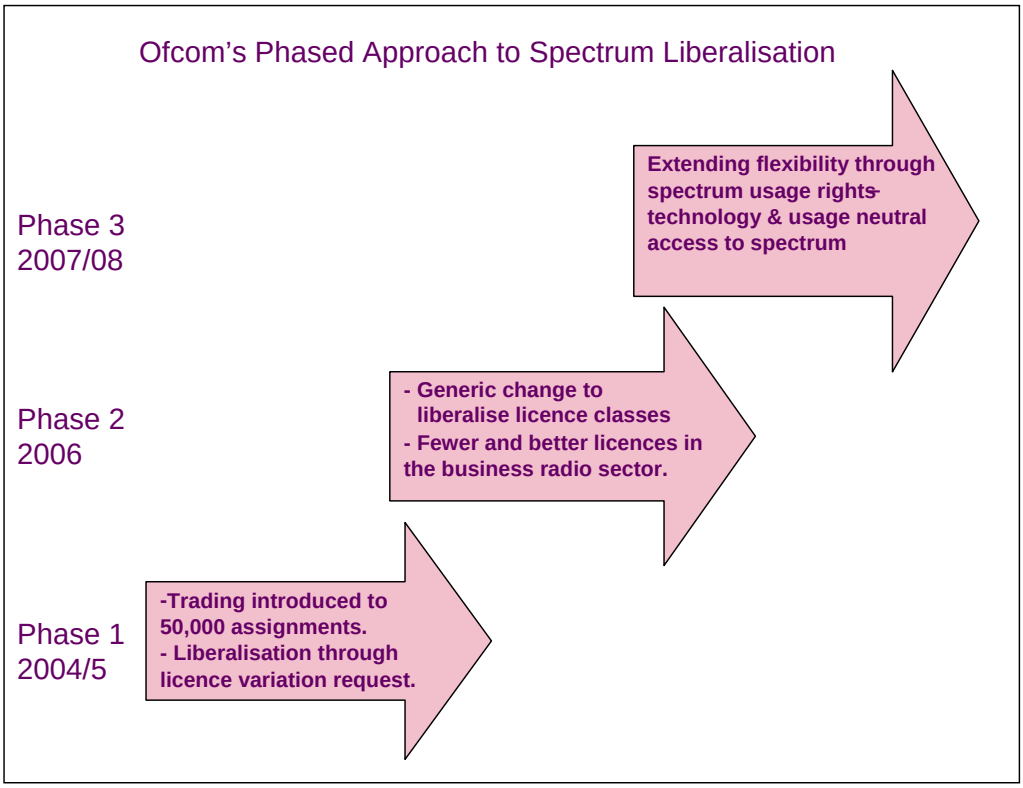


**Figure 2: Liberalisation Phasing**

3.10 This document also discusses a longer term scenario to which these three phases could lead, in which licence holders are able to change their own licences without recourse to Ofcom. This raises complex issues and would require changes to the law. It is raised here for discussion only and Ofcom would welcome any initial views that stakeholders might have.

## Previous consultations and statements related to liberalisation

3.11 Ofcom has already published two consultations which have addressed liberalisation: the liberalisation consultation and the SFR.

3.12 The first, in September 2004, was a consultation on spectrum liberalisation[2]. This set out the phased approach described above and addressed phase 1 in some detail. Ofcom subsequently issued a statement on liberalisation in January 2005 confirming these proposals[3] and is intending shortly to consult on further extending liberalisation in the Business Radio sector by rationalising and simplifying the range of licence classes.

3.13 Following this, the SFR set out Ofcom's long term strategy for managing the radio spectrum. As part of that goal it addressed the concept of SURs. The SFR outlined at a high level a mechanism by which SURs could be implemented to achieve technology and application neutral access to the spectrum.

3.14 The SFR proposed that the idea of SURs could be developed further once additional study had been undertaken to:

- add detail to proposals;
- examine whether any changes to the legal framework would be needed to enable the proposals; and
- test the proposals using a software model.

3.15 This work has now been carried out. Further work addressing these issues has been undertaken by external consultants, the detail of which can be found in their final report[4]. Findings and recommendations from this work have been taken into account in this discussion of SURs. A comparison between the proposals suggested here and the work reported on by the consultants is given in Annex 1.

## Principles of liberalisation

3.16 Liberalisation promises to bring much more efficient and flexible usage of the radio spectrum to the benefit of citizens and consumers. However, changes in spectrum use by a licence holder can change the interference experienced by neighbours in both geography and frequency terms. Ofcom has outlined the principles underlying its approach to liberalisation as follows.

- A spectrum user should not suffer an excessive increase in interference as a result of the actions of a neighbour unless:
  - they agree; or
  - the neighbour had not in the past taken up all their existing rights but was now seeking to do so. In this case the affected user would have been experiencing lower interference than could reasonably have been expected based on the terms of the original licence and the interference levels will now be rising towards that level.
- The market is often better able to determine optimal outcomes for variables such as boundary conditions than the regulator because of its greater access to relevant information.
- The mechanism adopted should not place a disproportionate burden on the parties. It should be as flexible and dynamic as possible consistent with avoiding harmful interference, complying with international obligations or directions from the

[2] "Spectrum Liberalisation", Consultation document, Ofcom, 17 September 2004
[3] "Statement on Spectrum Liberalisation", Ofcom, 26 January 2005
[4] "Spectrum Usage Rights - Final Report", Aegis Ltd, 10 February 2006

Secretary of State, securing any relevant wider public policy objectives and avoiding distortions of competition.

These principles have been followed in defining licence conditions for SURs as discussed in the following section.

## Section 4

# Spectrum Usage Rights

## Introduction

4.1 The existing approaches to specifying technical restrictions on spectrum use protect neighbouring users against harmful interference indirectly. They involve specifying or assuming a certain application or technology, and imposing technical limitations, based on the emissions that the technology or application is likely to cause to neighbouring applications or technologies, which are likewise specified or assumed. If both the interfering and victim characteristics are known, it is simpler to predict the interference that will result, though more difficult to deal with change.

4.2 SURs would employ an alternative method of directly specifying the emissions that a licence holder may radiate in neighbouring locations and frequency bands. This could bring two key advantages.

- Licensees would have greater flexibility since their licences would not restrict the technology or application.
- Neighbouring licence holders would have more clarity over the interference they can expect, and more confidence that increased flexibility will not cause them to suffer interference above this level.

4.3 This section outlines some options for defining licence terms for SURs. There are three main types of interference that must be specified:

- Interference across a geographical boundary to a licence holder using the same frequency in a different area. We term this “geographical interference”.
- Interference caused by OOB emissions from a licence holder, to licence holders using adjacent or near-adjacent frequencies. These may be both in the same geographical area and neighbouring areas, although in practice the effect in neighbouring areas is normally negligible.
- Interference caused by in-band emissions from a licence holder, to licence holders using adjacent or near-adjacent frequencies. This can be due to the inability of the receivers of neighbouring licence holders to fully remove the signal transmitted within the band of the licence holder.

4.4 For each of these types of interference there are a number of ways that the emissions could be specified. We discuss these in detail below.

4.5 This section firstly outlines the interference problem. We then describe the philosophy that we have used as the basis for selecting the licence conditions from the various options, before discussing each option and the preference that results.

## The Interference Problem

4.6 In a liberalised regime ideally the only constraint on spectrum use should be the controls necessary to avoid harmful interference. Therefore the focus in determining the parameters that would be used for new rights is on determining a set of controls that offer flexibility in spectrum use while not increasing the level of harmful interference.

4.7 It is well known that the propagation of radio signals cannot be contained within the assigned frequencies and geographic areas and receivers do not perfectly screen out emissions in adjacent bands. In a simplified form the resulting interference environment can be represented by Figure 3 below. Apart from the OOB emissions resulting from the modulation process, there are also spurious emissions that can be generated beyond the immediately adjacent bandwidth.

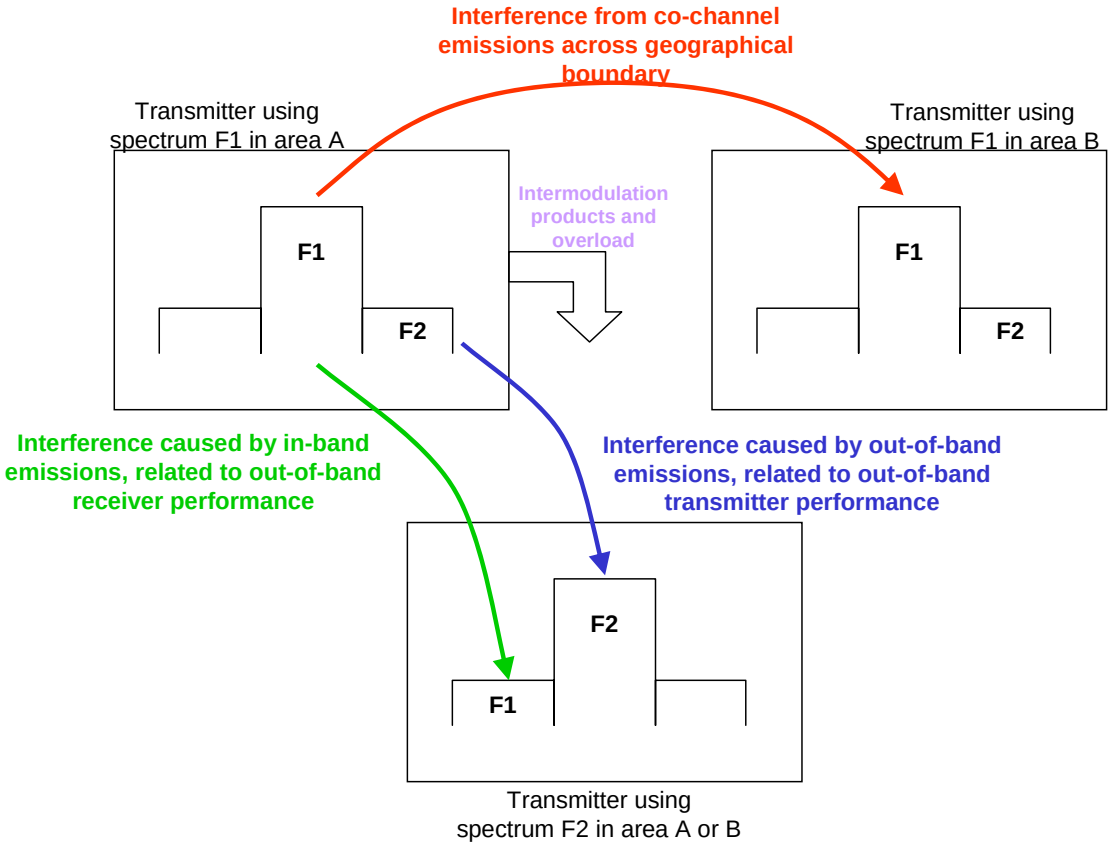


**Figure 3: Types of interference**

4.8 These proposals consider only the impact of radiation from a transmitter on a victim receiver, rather than secondary considerations such as the impact of unintentional emissions from a receiver on other receivers.

4.9 Figure 3 shows four key types of interference:

- interference caused by co-channel transmissions across geographic boundaries (shown in red), termed here geographical interference.
- interference caused by OOB emissions falling across frequency boundaries (shown in blue);
- interference caused by in-band emissions, (shown in green), determined by the in-band power of the transmitter and the OOB performance of the victim receiver.
- The intermodulation products and overload (shown in purple) are to some extent controlled by the OOB limits applying to the transmitter. There are, however, situations where intermodulation products arise unexpectedly in a receiver or passively due to non-linear conductivity in metal. Other spurious emissions (e.g. harmonics / frequency conversion products) exist, both for transmitters and receivers.

4.10 These four types of interference (or interference entries) must be considered when deciding the degree of control that should be exercised under a liberalised regime.

## Options for Controlling Interference in a Usage Neutral Regime

4.11 Ofcom and others have already proposed that transmission rights could be defined in terms of:

- time;
- geographic boundaries;
- frequency boundaries;
- in-band power limits;
- OOB power limits; and
- interference mitigation factors.

4.12 Additionally, an indication of what constitutes undue interference is required. This, at a high level, outlines the licence conditions which are required in a usage neutral licence.

4.13 The options for controlling each type of interference are discussed in the following sub-sections. Ofcom also engaged consultants to test options against case scenarios. The detail of this can be found in the consultants' report, but findings and issues from the case studies relating to each option are discussed here where relevant.

## Selection of Interference Measure Controls

4.14 Selecting a mechanism to control interference requires a trade-off between increasing the risk of interference versus the flexibility offered to rights holders within the terms of the licence.

4.15 As described in our principles for liberalisation in section 3, we believe a licence holder should not suffer an undue increase in interference as a result of the actions of their neighbour. For this reason the preference in selecting licence emission control parameters is toward ensuring levels of interference are not exceeded.

4.16 Although this might be the regulator's preference, licence holders might well have different preferences in relation to interference. Therefore, if licence terms were restated in the manner described here, neighbouring licence holders should subsequently be free to change to any other approach they agree between themselves should they wish.

## Geographical interference

4.17 In this instance we wish to protect a victim receiver separated geographically from the licence holder wishing to change their use.

4.18 The options for controlling co-channel interference across a geographic boundary need to ensure that the interference at a victim receiver is bounded. This could be achieved in a number of ways, the most important factor being a control on distance, whether this is achieved by specifying an actual distance or implicitly by specifying a power flux density (PFD) limit derived from an assumed distance.

4.19 Three options were considered:

- **Specification of EIRP:** In this approach the licence allows deployment of transmitters anywhere within a geographic area as long as the transmitter effective isotropic radiated power (EIRP) is no more than a specified level.
- **Specification of Aggregate PFD:** In this approach the licence allows deployment of transmitters such that an aggregate PFD at and beyond a geographical boundary is no more than a certain level. Since the PFD limit at a boundary is designed to protect receivers on the other side of the boundary, and there is no assumed knowledge of deployment density, it is appropriate that the boundary limit should be specified as an aggregate limit.
- **Technical coordination:** In this approach the licence holder must agree every change with its neighbours. An agreed modelling tool would be required for each geographical and spectrum neighbour, and each neighbour would approve the change on this basis.

4.20 These options were modelled against two case studies to test the approaches:

- in-band sharing between public user of spectrum (radar) and a mobile operator; and
- in-band sharing between two operators providing mobile services.

4.21 The options and issues raised from case study modelling of the different approaches are discussed below. Further detail on the case studies undertaken and the conclusions can be found in the consultants' final reports[5,6].

### 4.22 EIRP

4.22.1 The EIRP approach (as does the PFD approach) requires a geographical separation between the transmitters of one licence holder and neighbouring receivers. In the case of specification of maximum EIRP within an area, receivers of a spectrum user in an adjacent area will be unusable within a certain distance of the boundary associated with the maximum EIRP, unless mitigating techniques are employed.

4.22.2 The use of EIRP within a deployment area introduces some uncertainty of interference levels due to the difficulty in predicting aggregation effects. This uncertainty could be resolved by parties mutually agreeing to technical coordination.

4.22.3 It is important to note that in the case of specification of EIRP, the interference levels received in a geographically neighbouring area will be a function of the deployment density of the transmitters. If a licence holder significantly increased the density of transmitters, for example by deploying a higher density of base stations, a neighbouring area would expect increased interference levels. Thus there is a risk of increased interference if in the future base station deployment densities and powers are expected to vary greatly.

### 4.23 PFD

[5] "Spectrum Usage Rights - Final Report", Aegis Ltd, 10 February 2006
[6] "Spectrum Usage Rights - Final Report – Case Studies", Aegis Ltd, 10 February 2006

4.23.1 In the case of specification of PFD on a geographical boundary, the level at which the limit is set directly affects where the unusable area lies. This is shown in Figure 4.

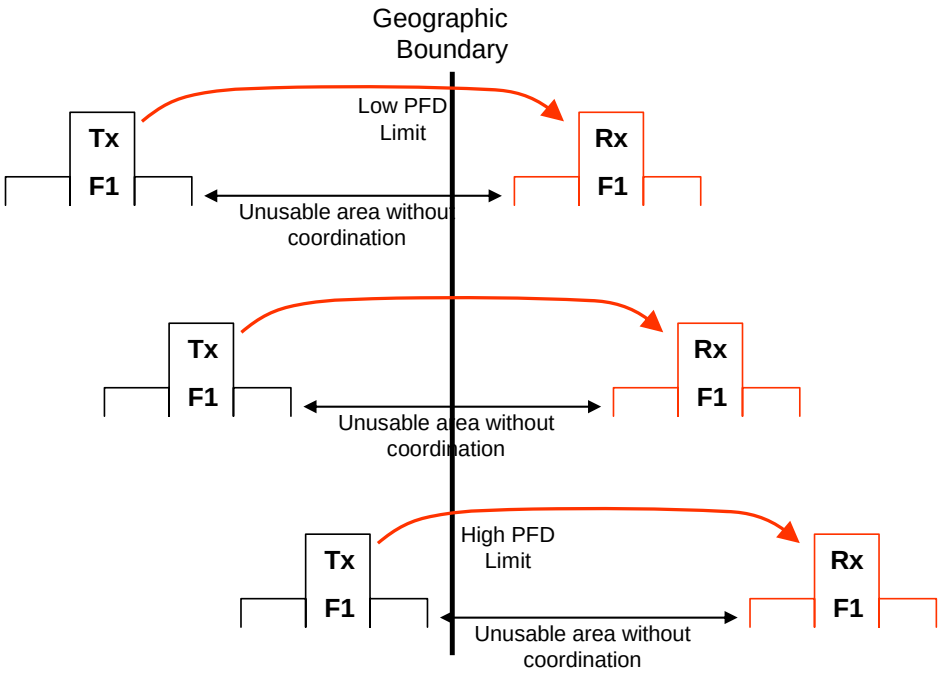


**Figure 4: Setting the PFD limit**

4.23.2 The aggregate PFD level selected determines how close it is possible to transmit or receive to the geographical boundary; by choosing a high aggregate PFD level, the licence holder can employ transmissions near the geographical boundary. A low aggregate PFD level instead allows neighbouring receivers to operate near the geographical boundary. It should be noted that use of a high PFD level introduces uncertainty about interference levels as it is not possible to predict how the aggregate PFD level will attenuate beyond the boundary with any accuracy without significant additional information about the system including deployment of transmitters, use of power control etc.

4.23.3 On the basis of work undertaken by our consultants the following format for specifying the PFD to control geographic interference is proposed:

> The aggregate PFD at or beyond [definition of boundary] should not exceed X dBW/m$^2$/[reference bandwidth] at any height up to H m above local terrain for more than P% of the time;

4.23.4 Since the aggregate PFD level at a point can vary in height, a maximum height term is included in the licence constraint to bound this. The time term included in the above formulation accounts for variations due to propagation and traffic levels.

4.23.5 It is suggested that a technically robust method to define aggregate PFD level and associated percentages of time would be to derive them from the characteristics of typical or expected receivers in the neighbouring area. Aggregate PFD levels beyond the boundary can be assumed to be constant.

## 4.24 Technical Coordination

4.24.1 An approach of technical coordination offers the potential of high technical spectrum efficiency at the expense of requiring close cooperation between parties. There would need to be an agreed tool for all neighbouring parties adopting this approach. Thus for example a mobile network operator (MNO) wishing to change deployment of their network of base stations would require a tool and methodology to be agreed for each of its geographical and spectrum neighbours.

4.24.2 Use of technical coordination can lead to high technical spectrum efficiency but requires close cooperation between parties.

4.24.3 Technical coordination introduces issues relating to resolution of congestion at spectrum hot-spots. One solution is use of the principle of first come first served although this can bring its own problems.

4.24.4 A technical coordination approach could be beneficial where the excluded area is large and hence the cost of not cooperating high (e.g. where directional antennas are used such as with fixed services) or where the deployment of transmitters by the geographically adjacent operator can assessed on a case by case basis.

## 4.25 The Suggested Approach for Licence Conditions to Control Geographic Interference

4.25.1 Three options were considered for managing in-band emissions across geographical boundaries:

- EIRP mask;
- aggregate PFD on geographical boundary; and
- technical coordination of transmitters.

4.25.2 There is a possibility that a change of use could involve a significant change in density and hence a potential increase in aggregate emissions. For this reason we conclude that it would be better for in band emission limits to be set as aggregate limits for a licensee, and therefore propose specification of a PFD level at and beyond a geographical boundary:

the aggregate PFD at or beyond [definition of boundary] should not exceed X dBW/m$^2$/[reference bandwidth] at any height up to H m above local terrain for more than P% of the time.

4.25.3 Specification of a low level PFD on boundary is suggested. This ensures that neighbouring users can deploy their receivers within their defined area close to the boundaries of adjacent licence holders. Also, use of a high PFD level introduces uncertainty about emission levels in neighbouring areas, as it is not possible to predict how the aggregate PFD level will attenuate beyond the boundary with any accuracy without significant additional information about the system including deployment of transmitters, use of power control etc.

*Question 1: What is the best way to control in-band interference across geographical boundaries?*

## Interference caused by out-of-band emissions

4.26 In this instance the aim is to protect a victim receiver possibly in the same geographical area from OOB emissions from another licence holder operating in a neighbouring frequency band. Interference received in-band from OOB emissions can only be controlled by specifying OOB emission limits in one way or another.

4.27 It can be noted that setting limits at a frequency boundary is analogous to the geographic boundary in the case above. Depending on the level of allowable OOB emissions set at the frequency boundary and the performance of the equipment there will likely be unusable spectrum (i.e. a guard band) that falls within the spectrum associated with the transmitter. Knowledge of the level of OOB emissions may also require the receiver associated with the spectrum on the other side of the frequency boundary to provide a guard band.

4.28 It should be noted that even when OOB emission limits are defined it is often possible to arrive at a situation where the close proximity of the transmitter of one system interferes with the receiver of another system. This is exacerbated when any of the systems are mobile. In effect when deployment is uncontrolled it is not realistically possible to prevent interference completely. It either has to be accepted that interference will occur when systems operate within a certain distance of each other or a control on physical deployment has to be put in place. This is clearly difficult and potentially costly, particularly in the case of mobile or nomadic systems.

4.29 Furthermore, when deployment is uncontrolled, or where liberalisation means that system deployment might be changed radically such that emitter density increases, there is always the possibility that the risk of interference and / or the level of interference increases.

4.30 Four technical approaches to manage interference caused by OOB emissions have been considered:

- Approach 1: Use of EIRP Mask. An operator can deploy a transmitter at any location within their licensed area as long as the levels of OOB emissions into adjacent bands are within the emission mask level defined in the licence. A number of sub-approaches were considered including low or high OOB EIRP levels.
- Approach 2: OOB PFD Mask. An operator can deploy a transmitter at any location within their licensed area as long as the aggregate PFD received in adjacent bands does not exceed specified levels for defined percentages of locations and times. Further detail on this concept and an example derivation can be found in the consultants' report[7].
- Approach 3: Technical Coordination. An operator can deploy a base station at any location within their licensed area as long as interference analysis indicates it would not exceed interference thresholds of adjacent operators.
- Approach 4: Technical Standard. An operator can deploy a base station at any location within their licensed area as long it meets an agreed defined standard.

4.31 Management of interference caused by OOB emissions is harder to manage than that caused by in-band emissions. Our studies showed that there was a trade-off between technical efficiency and risk of interference. Each of the approaches above occupies a different position in this trade-off.

[7] "Spectrum Usage Rights - Final Report – Case Studies", Aegis Ltd, 10 February 2006, Annex D.2

4.32 The four options and the significant issues from case study modelling are summarised in the sub-sections below. Further detail on this matter is contained in the consultants' report[8].

### 4.33 Use of an EIRP Mask

4.33.1 Use of an EIRP mask defined at the edge of the licensed frequency band is a technologically neutral and simple method to define transmit rights. However, as in the case above, controlling EIRP can introduce the risk of interference into receivers as there are no controls on densities of transmitter deployment. This risk is dependent upon the level of the specified mask:

4.33.2 Use of high EIRP masks derived from typical transmitter masks has an increased risk of interference into adjacent bands, but a reduced risk of lower spectrum efficiency.

4.33.3 Use of a low level EIRP mask derived from typical characteristics of victim receivers in adjacent bands reduces the risk of interference into adjacent bands but also introduces the risk of lower spectrum efficiency.

4.33.4 A number of approaches to balance the risks related to EIRP masks can be considered – such as adjusting the distance at which interference could occur or for OOB levels to vary between rural and urban areas. Several different approaches were considered within the case study modelling. However neither of these removed both of the two risks identified above.

### 4.34 Use of an Out-of-Band PFD Mask

4.34.1 A technological neutral measure of interference caused by OOB emissions that does include information about deployment densities is the OOB PFD mask. This would measure the emission levels caused by OOB emissions at a percentage of locations and for a percentage of time:

the OOB PFD at any point up to a height H m above ground level should not exceed XdBW/m$^2$/MHz for more than Y% of the time at more than Z% of locations in any area A km$^2$.

4.34.2 This approach introduces a new measure of interference whereby a PFD level would be set to manage co-located but OOB emissions in an area A. A single point measurement is not appropriate as near a transmitter any PFD level which would be reasonable for efficient use of spectrum can be expected to be exceeded. Therefore it would be necessary to define PFD as a distribution across a range of locations, as shown in Figure 5.

[8] "Spectrum Usage Rights - Final Report – Case Studies", Aegis Ltd, 10 February 2006

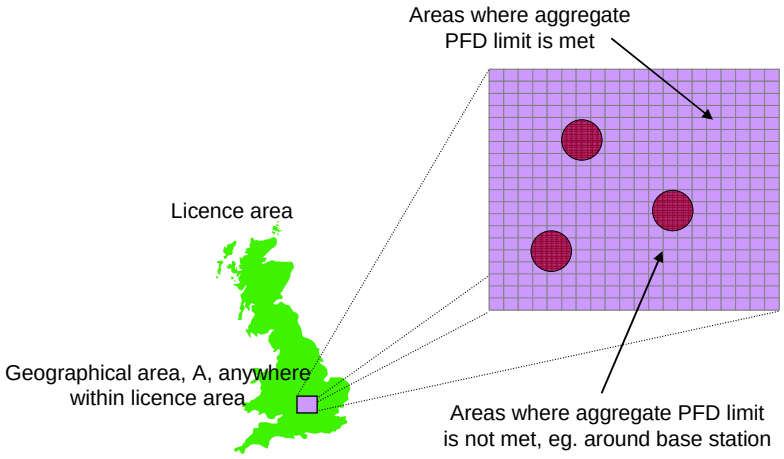


**Figure 5: Out-of-band PFD emissions**

4.34.3 Such a measure has a number of benefits:

- it gives a good idea of the level of interference that operators in adjacent bands could experience;
- it allows flexible deployment without needing coordination;
- it would not be possible to dramatically increase density of transmitters without reducing the EIRP (without entering negotiation), as that would result in linear increase in percentage of locations interfered; and
- it would not be possible to make a significant change to system operation, such as switching off automatic power control without reducing EIRPs (or without entering negotiation).

4.34.4 Conversely, because interference levels are specified as probabilities, it gives no information about specifically where interference could be expected, therefore allowing locally high levels of interference.

## 4.35 Technical Coordination

4.35.1 Technical coordination can result in low risks of interference combined with the potential for high spectrum efficiency. However, it places a substantial administrative burden on all parties involved.

4.35.2 Technical coordination has been proposed for use in other countries (e.g. New Zealand and Australia) and would remain an option to be agreed during negotiations between licence holders. Its use would in most cases require a database of individual transmitters.

## 4.36 Use of System Specific Standards

4.36.1 Use of system specific standards is a low risk method of managing interference caused by OOB emissions, albeit one that does not provide any flexibility. Ofcom has previously concluded that the gains from flexibility are likely to be much greater than any benefit from reduced risk of interference.

## 4.37 The Suggested Approach for Licence Conditions to control Interference Caused by Out-of-band Emissions

4.37.1 Four approaches to managing interference caused by OOB emissions were considered:

- use of EIRP Mask;
- OOB PFD mask;
- technical coordination; and
- technical standard.

4.37.2 No single approach was seen to be ideal in all circumstances. All approaches have advantages and disadvantages in terms of risk of interference, allowed flexibility of usage, spectral efficiency and administrative burden/cost.

4.37.3 As in the in-band case above, controlling EIRP can introduce the risk of interference into receivers as there are no controls on densities of transmitter deployment. Through using low level EIRP the risk of interference can be reduced, however there is then a reduction in the likely spectral efficiency of this approach. We do not think this approach aligns with our philosophy of ensuring levels of interference are not exceeded whilst achieving efficient use of the spectrum.

4.37.4 Technical coordination would likely achieve high spectrum efficiency. However the administrative burden is high.

4.37.5 Use of technical standards would not provide true application neutrality without negotiation, which itself would then need to be based on interference issues.

4.37.6 The preferred approach to manage interference caused by OOB emissions is the use of aggregate OOB PFD defined in section 4.34.

4.37.7 It is noted that this approach would allow locally high levels of interference and gives no information about where this could be expected, only probabilities. Whilst this is not ideal, we believe that for a wide area approach this is a well balanced approach between over-specification of detail and interference management.

4.37.8 It is also noted that OOB PFD masks are potentially complex to define and to measure. In practice there will be a set of masks defined for several frequencies from the centre frequency.

4.37.9 Measurement would be undertaken by making a statistically significant set of measurements across a set of points over any area, A, within their geographical limits. The area, A, over which measurements should be made would be a parameter defined for each licence. Measurement is discussed further in section 6 below.

*Question 2: What is the best way to control interference caused by out-of-band emissions?*

## Interference caused by in-band emissions

4.38 In this instance we wish to protect a victim receiver from interference received out of its band of operation, caused by in-band emissions from another licence holder.

4.39 This situation is similar to that immediately above, and the approaches for interference control discussed above are equally valid here.

**4.40 The Suggested Approach for Licence Conditions to Control interference Caused by In-band Emissions**

4.40.1 The same options for controlling interference received in-band from OOB emissions discussed above are appropriate here.

4.40.2 However in this instance a victim of increased interference has the potential for improving the receiver selectivity of their system in order to maintain quality of service.

4.40.3 The approach could be taken of choosing not to control this interference mechanism, leaving it instead to spectrum users to ensure they have adequate receiver protection to interference from OOB emissions. However, this would not align with our philosophy of ensuring levels of interference are not exceeded whilst achieving efficient use of the spectrum.

4.40.4 Therefore it is suggested that the same interference control measure as in the above case are used, and therefore suggest use of PFD masks. Note that in this instance they would have different values to the OOB case.

*Question 3: What is the best way to control interference caused by in-band emissions?*

## Intermodulation, overload and other spurious emissions

4.41 These aspects of interference generally only become an issue with relatively high power transmitters and/or transmission/reception equipment in relatively close proximity.

4.42 Intermodulation products (IPs) are generated from multiple signals by non-linearities in the transmit chain, the receiver, or corroded / unclean metal junctions. While IP emissions from a transmitter will largely be controlled by an OOB / spurious emission mask, the case is not so clear cut with regard to the other two situations, although it is possible to define receiver performance to some degree. Furthermore, responsibility for generating IPs in these cases is not always obvious. For example, a receiver that has been operating satisfactorily for sometime may suddenly be affected by IPs with the installation of a new transmitter nearby interacting with an existing transmitter.

4.43 Overload occurs when a strong OOB signal, which might otherwise be satisfactorily filtered out by the rest of the receive chain, saturates the low noise amplifier at the front end and drives it non-linear. The degree of degradation due to overload depends on the performance of the receiver front end and the possible implementation of input filtering although this is generally undesirable from noise considerations.

4.44 Whereas OOB emissions discussed earlier occur immediately outside the necessary bandwidth of the transmission and result from the modulation process, spurious emissions occur over a much wider range outside the necessary bandwidth. Spurious emissions include harmonics, parasitic emissions, IPs and frequency conversion products. Receivers also generate spurious emissions.

## Control of Spurious Emissions

4.45 Intermodulation products and overload are to some extent controlled by the OOB emission limits applying to the transmitter discussed above.

4.46 The options for control of this interference are;

- No additional regulation. This is an issue which does not arise often. This approach would not rely on a regulatory structure, but on negotiation and cooperation between licence holders to establish a solution.
- Registration of transmitters to enable a first in time prioritisation rule to be applied in cases where a recently introduced transmitter caused problems to existing systems. In this case, if intermodulation interference were discovered as a result of the interaction between two (or more) transmitters, it would be the responsibility of the most recently introduced transmitter to rectify it.

*Question 4: Which would be your preferred option for control of spurious emissions? If not one of the above options, what would you propose?*

## Indicative Interference Level

4.47 It can be argued that the rights of a spectrum user can be defined solely in terms of transmit rights or in terms of receive rights, whichever of these being specified implying the other. It is suggested that rights are defined solely in transmit terms.

4.48 It is suggested that transmit rights are sufficient to determine the interference environment in which receivers operate. Users can work out what interference levels they can expect to receive based on the combination of the transmit rights of all of their neighbours and other noise sources such as EMC-related emissions. Since these transmit rights will initially be based on the status quo then the total expected interference levels should be similar to those currently experienced.

4.49 Interference levels calculated on the basis of neighbouring transmit rights can only be indicative because of the probabilistic nature of propagation, but will be useful in planning and triggering investigations. These are termed Indicative Interference Levels (IIL).

4.50 If licence holders wished to make use of IILs it would be their responsibility to determine them, ensure they were correct and update them when a change to any associated licence parameters occurs.

4.51 Ofcom currently provides guidance for licensees about the levels of interference that it expects are likely to be encountered from other licensed services using spectrum quality benchmarks (SQBs). These are typically the parameters we use when determining whether to make an assignment and are generally related to “small area” licences such as individual PBR assignments or fixed links. Because we are not proposing to introduce SURs to such assignments we would continue to use SQBs in these cases. If there were any assignments where SQBs are currently used and SURs are implemented then the IIL would supersede the SQB. However, we would expect them to be set at equivalent levels such that the licence holder does not suffer any significant change.

*Question 5: Do you agree to the proposed approach described here for Indicative Interference Levels?*

## Summary: Possible licence terms for SURs

4.52 For controlling emissions into neighbouring geographical areas the following could be used:

- the aggregate PFD at or beyond [definition of boundary] should not exceed $X_1$ dBW/m$^2$/[reference bandwidth] at any height up to H m above local terrain for more than P% of the time.

4.53 For controlling emissions outside of the licence holder's frequency band (that appear as in-band interference for a neighbour) the following could be used:

- the OOB PFD at any point up to a height H m above ground level should not exceed $X_2$dBW/m$^2$/MHz for more than Y% of the time at more than Z% of locations in any area A km$^2$.

4.54 For controlling emissions inside the licence holder's frequency band (that may cause interference to neighbouring users in frequency due to imperfect receiver filters) the same measure could be used:

- the in-band PFD at any point up to a height H m above ground level should not exceed $X_3$dBW/m$^2$/MHz for more than Y% of the time at more than Z% of locations in any area A km$^2$.

4.55 At present we do not see a need for any licence conditions specifically aimed at restricting intermodulation.

4.56 Computer modelling of a number of case studies has been undertaken. The results of this modelling have shown no inconsistency with the licence terms described here.

4.57 Proposals for setting the appropriate parameter numbers in an SUR licence and for measurement of emissions from neighbours are given in section 6.

4.58 The implications of changing licence restrictions to SURs of the form suggested above are:

- Licence holders would have increased flexibility to change technology and usage compared to many current licences.
- Licence holders would have increased certainty in the levels of interference they might suffer compared to currently.
- However, under some circumstances licence holders might have less ability to significantly increase deployment density than they do at present.

## Section 5

# Negotiation and trading

## Introduction

5.1 Under current licence terms, if neighbouring users wish to make a change in their licence terms which all affected parties agree to then they are able to present this proposal to Ofcom which will consider changing licences appropriately or, in some cases, might negotiate a coordination agreement. Alternatively, the parties might be able to effect the change by spectrum trading. The change to SURs would not change spectrum trading proposals in any way. Licences where the restrictions were stated in terms of SURs could potentially be traded just like any other licence.

5.2 If licence restrictions were changed to SURs then the ability of neighbouring licensees to negotiate would remain. However, we believe that stating licence restrictions in terms of SURs would make any negotiation simpler because one licence holder could explicitly agree to a change in the interference they would experience by a simple change to relevant SUR parameters.

5.3 Negotiation might be an important element of SURs in allowing licence holders to effectively make changes to their licences, subject to Ofcom approval, where the terms of the licence are insufficiently flexible. For example, in the case where a user wanted to significantly increase deployment density, if this was of no concern to their neighbour then they could negotiate this change with them. If it was of concern, then the fact that they were now restricted from making this change would benefit the neighbour.

5.4 This section outlines suggestions for a structured process to facilitate negotiating a change of use between SUR licence holders and discusses the associated issues.

## Frequency boundary neighbours

5.5 The trigger for negotiation occurs when a proposed change of use requires modification to any of the parameter values contained in the licence.

5.6 With respect to frequency there are effectively three domains; the in-band domain, the OOB domain and the spurious domain. The OOB domain is generally taken to end at a point separated from the centre frequency of the transmitted channel by more than 250% of the channel bandwidth. (In the case of multiple channels within a licence bandwidth, the channel concerned is the one closest to the band edge.) This is effectively the same as saying two channels beyond the edge of the necessary bandwidth. This could form a useful basis for determining which neighbours should be involved in any change of use negotiations. However we note that high power transmitters might need to negotiate with a much wider community of spectrum users in the frequency domain depending on their OOB emission mask.

5.7 It is suggested that frequency neighbours are defined at least by those within the OOB domain, within 250% of the transmission bandwidth of the signal carrier frequency. It would be the responsibility of the party wishing to change use and enter negotiations to determine if further frequency neighbours would be affected and therefore would also be required to be included in negotiation.

## Geographic boundary neighbours

5.8 It would be convenient to be able to say that only immediate neighbours, whose spectrum space abuts that of the spectrum user wishing to make a change, need be consulted. However, it is easy to envisage instances, particularly if adjacent areas are relatively small, where areas beyond the immediately adjacent ones might be affected.

5.9 As in the frequency case above, we propose it is the responsibility of the party wishing to change use and enter negotiations to determine if further geographical neighbours than the nearest neighbours will be affected and will therefore will also be required to be included in negotiation.

*Question 6: How should a licence holder determine which frequency and geographical neighbours should be involved in a change of use negotiation?*

## Summary of the Change of Use Process

5.10 A high level summary of the suggestions for a change of use process for an SUR licence holder is given in Figure 6.

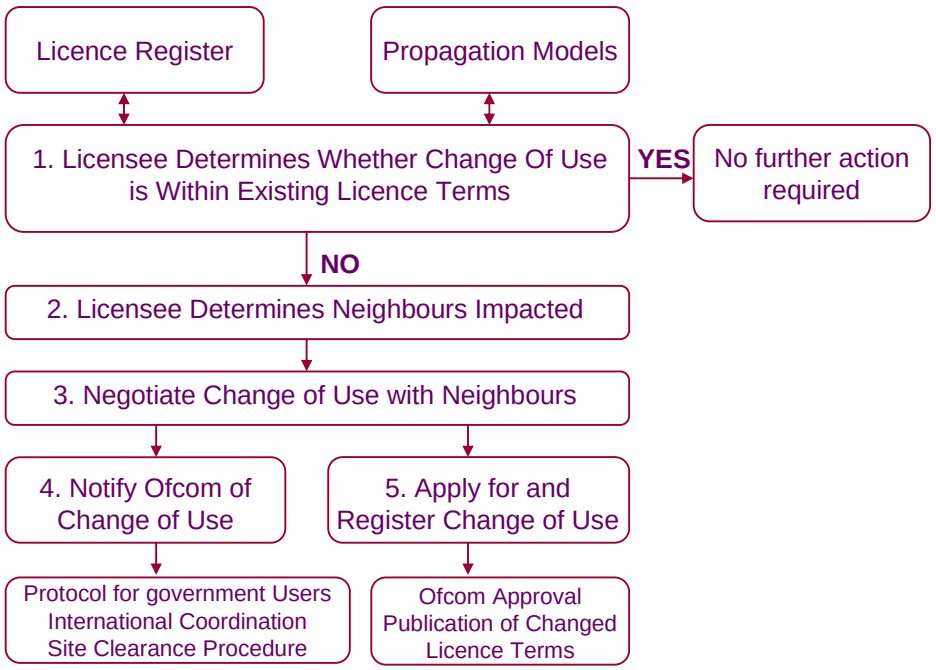


**Figure 6: Elements of the Change of Use Process**

5.11 Firstly the licence holder wishing to change their usage would determine whether it can be accommodated within their existing SUR parameters. If it cannot they need to determine who might be affected by the change of use and enter into negotiations to agree the change of use, possibly through compensation for any degradation likely to be suffered as a result.

5.12 The next stage in the process, which could be conducted prior to negotiation if appropriate, is notifying Ofcom of the change of use on a confidential basis, the licensee providing Ofcom with information on the change in licence parameters it is seeking. This stage would trigger government process and release of information, for

example provision of information on international co-ordination constraints, starting engagement with government users who may be affected, or generating a request for site clearance according to the procedures overseen by the Cabinet Office Working Group on Radio Site Clearance (WGRSC).

5.13 Finally the application for the change of use is made; required changes to the SUR are made and registered on the Register of Licences[9].

5.14 Stages 2 – 5 of this process are discussed in further detail in the sections below since all have impact on the negotiation of change of use.

## Determining the impact of the change of use on other users

5.15 Parties should determine between them the impact of the change of use, and therefore the degree of any compensation for modified licence terms necessary.

5.16 It is suggested that the interference assessment for a change of use would be made using relevant ITU/CEPT models where they exist. However, we recognise that different licensees may wish to use models other than those recommended, for example proprietary planning models. Therefore should parties in negotiation wish to use models other than those recommended by Ofcom, they should be able to do so; licensees would have the option to use other models agreed with neighbours or models derived under an industry code of practice.

5.17 Ofcom has developed a tool for modelling the interference impact of a change of use by a spectrum user. This tool has been used in modelling some of the case studies described. It is possible that this tool could be made publicly available to be used on an "at risk" basis to assist parties wishing to undertake a change of use. Ofcom would be interested to receive views on this matter.

*Question 7: Would it be useful for Ofcom to make its change of use modelling tool publicly available?*

## Negotiating Change of Licence Terms

5.18 Once the party wishing to make a change of use has determined which neighbours will be affected then it will need to negotiate terms with them for making changes to licence terms (including financial compensation if appropriate).

5.19 There are particular issues here with specific stakeholder cases– for example government users such as the MoD, and licence exempt users. We discuss these circumstances in the sub-sections below.

5.20 It is possible for a situation of hold-out by a commercial licensee to arise in negotiation, in which a licensee either refuses to accept payment in return for allowing the proposed change of use, or prolongs negotiations excessively, for example over many months or years. Whilst we note that this may be an issue, it is not addressed in this document. If appropriate, it will be discussed as we move to consider the implementation issues associated with SURs.

**5.21 Receive only users**

[9] As described in "Statement on Spectrum Trading", Statement, para. 7.45, Ofcom, 6 August 2004

5.22 At the moment, Ofcom gives these users a degree of informal recognition through its assignment policy and enforcement activities but there is no formal entitlement to recognition.

5.23 Where RSA is introduced, these users could obtain a formal right to recognition which would be registered on the Register of Licences, referred to in paragraph 5.13.

**5.24 Licence exempt users**

5.25 Licence exempt applications are protected from interference from neighbouring bands, though there is no protection from other users within the band (assuming they are operating legally).

5.26 However, since there is no single holder of the right to protection for licence exempt applications operating in a band and there are likely to be many unidentifiable users who in effect jointly possess the right to interference protection it will not be possible to negotiate changes to this protection. It is suggested that protection given to licence exempt application bands will be a hard constraint, non negotiable with neighbouring licence holders.

**5.27 Vacant spectrum and guard bands**

5.28 Ofcom believes in general that it can best secure optimal use of the radio spectrum by awarding any vacant spectrum in its possession as soon as practicable. However in the short to medium term issues could arise through neighbouring national licence holders wishing to undertake a change of use which would modify the interference levels in these spectrum bands.

5.29 If a licence holder wishes to make a change of use that could increase the amount of interference experienced in vacant parts of the spectrum that Ofcom administers there are two options that may be considered:

1. An approach of non-negotiable interference constraints is adopted at borders in bands where Ofcom is the band manager
2. Ofcom varies the licence and adjusts the licence fee accordingly.

5.30 The first option would limit the extent of change of use and represents a constraint on full liberalisation.

5.31 The second option could require that Ofcom in effect assigns geographical area/spectrum to the user making the change. This might in some cases run counter to Ofcom's obligation under the EU framework to provide transparent, non-discriminatory spectrum access or have implications for competition or impact Ofcom's future plans to award the spectrum.

5.32 Ofcom's policy of spectrum awards should reduce the extent to which this issue arises in practice. However, were it to arise, we would consider each case on its merits in the light of all relevant considerations.

**5.33 Government users**

5.34 At present Ofcom manages the interface between government and commercial users, for example by negotiating increased sharing of government spectrum and protection of commercial users' interests in the context of changes in government spectrum use (and vice versa). This process can be time-consuming.

5.35 There are two issues which will make it more difficult for a licensee to determine whether a change of use has an impact on these users. Firstly rights to spectrum use are not in general defined at present, and secondly information on spectrum use is not held/known by Ofcom.

5.36 This may be a particular issue in relation to certain spectrum bands managed by government users such as the Ministry of Defence. Enhancement of sharing with commercial users is a key theme of the audit of major spectrum holdings by Professor Martin Cave[10], which made a number of recommendations in this area. The response[11] to the audit commits the Government and Ofcom to work together to implement the audit's recommendations. This includes proposals to formalise public sector spectrum holdings and make more information about them available. These measures will facilitate band-sharing generally and negotiation of changes to licences to accommodate new services.

### 5.37 International Users

5.38 In principle, licence holders could be free to negotiate with other spectrum users across international boundaries. Ofcom would be prepared to consider the possibility of international negotiations. However, this is only likely if and when other administrations choose to adopt similar approaches to liberalisation.

*Question 8: Are the proposals for negotiating a change of use with non-commercial and other similar users appropriate?*

## Registration of Change of Use

5.39 If negotiations conclude satisfactorily, then the licensee wishing to change use and all other affected licensees would need to apply for licence variations. It is at this stage that Ofcom would formally approve or reject the proposed change of use. If the changes were accepted they would be written into the Register of Licences, mentioned in paragraph 5.13, and licence variations would be issued. Ofcom could consider providing facilities such as email alerts for registered parties to notify them if a change of license in their band has taken place.

5.40 To reduce regulatory uncertainty, Ofcom's decision to approve a licence variation should be made with reference to clearly defined criteria. Our initial thinking is that in this scenario the only reasons for refusing a licence variation should be the same as those for refusing a trade under the draft trading regulations:

- Interests of national security
- Compliance with Community obligations and international agreements
- Compliance with a direction from the Secretary of State under sections 5 or 156 of the Communications Act 2003.

5.41 Ofcom would not have a role in approving the technical aspects of the licence variations, as this would not put sufficient responsibility on the parties concerned to address potential interference problems in negotiations. It may also conflict with its responsibilities in enforcing licences and more generally regulating the sector.

## Enforcement and Dispute Resolution

[10] "Independent Audit of Spectrum Holdings", Final Report, Professor Martin Cave, December 2005
[11] "Government Response to the Independent Audit of Spectrum Holdings", March 2006

5.42 Historically the UK has operated radio spectrum under a command and control regime in which the regulatory body has had responsibility for management of the radio spectrum. The aim of the regulator was efficient use of the radio spectrum whilst minimising interference between neighbouring users, and for enforcement of unlicensed interference or users who operate outside of their licence terms.

5.43 There is potential when changing to a new licence conditions for interference levels experienced by users to be increased against their wishes. There are a number of reasons which we believe mitigate this risk:

- We believe it is in the interests of all users of the radio spectrum to ensure interference levels are minimised.
- In these proposals our approach has leaned toward a licensing approach which does not result in increased levels of interference experienced by spectrum users, by limiting the flexibility allowed within licence conditions.

5.44 By moving to licence conditions focused on interference control rather than usage, it would arguably be *less* likely that interference levels experienced by users will be increased against their wishes than is the case today. For example under the current regime an operator could potentially massively increase their base station density without adjusting their base station EIRP, resulting in a significant increase in interference to neighbours.

5.45 Ofcom's approach to interference resolution has been set out in our consultation on liberalisation[12]. Three cases were outlined there which are summarised below.

5.45.1 *If a licensee is in breach of licence conditions*, Ofcom will take appropriate action. This will depend on what is proportionate and necessary in the circumstances. For example, a transmitter fault resulting in spurious emissions, possibly unknown to the user, could be solved by negotiation and agreement on a voluntary basis if the user cooperates. If the breach was not due to transmitter fault and was deliberate, on the other hand, Ofcom would probably consider issuing a Conformity Notice in accordance with sections 172 to 174 of the Communications Act 2003. This process gives time for remedial action or representations to be made before a criminal prosecution was brought. An immediate interim close-down would be possible, especially if there was a threat to public safety or serious operational or economic problems were caused to other users. The sanction of varying or revoking a licence is separate to the legal enforcement process and in practice would be triggered by the need for strong enforcement action following prosecution or repeated breaches of licence conditions.

5.45.2 *If the fault lies in the victim installation*, Ofcom will not generally take any action as remedial action is the user's own responsibility in such a case but may, for a fee charged at commercial rates, advise the operator on remedial action.

5.45.3 *If the originator of the interference is operating within the licence terms* and conditions and acted in good faith but interference nonetheless results from a discrepancy between the predicted and actual effects of the transmission, Ofcom will consider the facts of the case, representations by the parties and any other relevant considerations and decide what, if any, action to take. If the victim had previously agreed to the change that caused the interference,

[12] "Spectrum Liberalisation", paragraphs 6.20 – 6.30, Consultation document, Ofcom, 17 September 2004

Ofcom will generally expect the parties to resolve the situation themselves in line with the terms of their agreement. If they cannot, or if the victim was not party to such an agreement, Ofcom will consider appropriate intervention action and will generally intervene if the victim's spectrum quality is reduced below its benchmark level. In those circumstances, Ofcom may, for example, decide that it is appropriate to enforce a solution by requiring the interferer to take remedial action and to achieve this by giving formal notice of a proposal to vary the interferer's licence.

5.46 We suggest that this approach would also be appropriate for liberalisation through the use of SURs.

*Question 9: What is the best approach towards enforcement and dispute resolution?*

## Section 6

# Implementation and other issues

## Introduction

6.1 This consultation document is concerned only with the appropriate form of SURs. It does not discuss any issues associated with their implementation, either generically across all spectrum licences or in particular licence classes. After considering responses to this consultation, we will bring forward proposals for implementation, where appropriate.

6.2 There are a number of other subsidiary issues on which this document is silent, or on which it provides only initial thoughts. These include the following.

- The way in which the SUR parameters for specific licences will be calculated. Licence holders themselves might have a role in determining these parameters themselves but we have further work to do. Initial proposals for this are made below for consultation.
- The means by which measurements can be undertaken to determine whether there is undue interference from a neighbouring licensee. Initial proposals for this are made below for consultation.
- The timing of any introduction of licences in SUR form.
- The process and legal form we will follow for varying licences if a change to SURs occurs. At present, trading and licence variation both involve Ofcom in reissuing licences but there may be mechanisms within trading regulations that provide a simpler procedure. This is discussed further below.
- The application of SUR principles to different classes of licence and occupied or unoccupied spectrum. We suggest here that determining the SUR parameters might be more difficult for licences covering small areas, such as single transmitter locations, while the benefits of changing to SURs for such licences will be smaller. Hence, we are minded to apply SURs initially to national or regional licences and not to more local assignments. Further, it would be simpler for licences in SUR form to be introduced in the first instance for new awards as this avoids the need to convert existing licences. This is discussed further below.
- How administrative incentive pricing might be applied to licences in SUR form.

6.3 We provide some initial discussion of some of these points below.

6.4 Ofcom will carefully review the outcome of this consultation, other initiatives such as at a European level and the progress of on-going key spectrum activities in order to determine whether and when to publish a statement on SURs.

## Setting the initial parameter values in a SUR licence

6.5 The appropriate initial parameter values will vary depending on the frequency and the current usage of the licence. For example, operators providing a service requiring only 90% availability would require different parameter levels from those requiring 99.99% availability.

6.6 For existing licences, we suggest that existing licence holders should be asked to specify their view on the relevant parameter values for their licence. For example Ofcom would request all the MNOs to provide their view on the correct values for their SURs. There would be a strong incentive on licence holders to set realistic levels, as, for example, if they selected high levels of allowed interference into neighbouring bands and their parameters were also applied to their neighbours then they in turn might suffer high levels of interference.

6.7 Once licence holders had provided their views Ofcom would:

carefully examine each for appropriateness;

compare those of neighbouring users and understand the reasons for any differences;

conduct modelling, as appropriate, to resolve any issues; and

publish a proposed set of parameters and consult upon these if needed with the affected stakeholders.

6.8 For new licences Ofcom would follow a similar process to the present one of determining the most likely use, setting parameters based on this and then consulting upon these.

6.9 It is likely that in many cases parameters will be unchanged across multiple classes of licences. The table below is provided as a first estimate of how these might be set in most cases.

| | |
|---|---|
| Aggregate In-band PFD at or beyond geographical boundary should not exceed $X_1$ dBW/m^2/[reference bandwidth] at any height up to H m above local terrain for more than P % of the time | $X_1$ = (based on sensitivity of services in neighbouring areas and any international agreements)<br>H = 30m AGL<br>P = 10% |
| Out-of-band PFD at any point up to a height H m above ground level should not exceed $X_2$dBW/$m^2$/MHz for more than Y% of the time at more than Z% of locations in any area A$km^2$. | H = 30m AGL<br>$X_2$ = (based on service and standard “mask” for most likely technology also may be multiple values for different separations from band edge)<br>Y = 10%<br>Z = 50%<br>A = 3 $km^2$ |
| In-band PFD at any point up to a height H m above ground level should not exceed $X_3$dBW/$m^2$/MHz for more than Y% of the time at more than Z% of locations in any area A$km^2$. | H = 30m AGL<br>$X_3$ = (based on service and maximum transmit power of most likely technology)<br>Y = 10%<br>Z = 50%<br>A = 3 $km^2$ |

6.10 By way of guidance only for example, consider a particular new licence where we decided that the most likely use, at least for part of the band, was 3G cellular. In this case we would set:

$X_1$ somewhat lower than the receiver sensitivity for a typical cellular user such that any interference received would reduce network capacity by less than, say, 1%.

$X_2$ might be set by taking the standard 3GPP mask, assuming a deployment density similar to current 2G and 3G networks and using modelling to determine the resulting values.

$X_3$ would then simply be set at a level above $X_2$ corresponding to the difference between the in-band and OOB power limits in the 3GPP mask.

6.11 Of course, once set, neighbours would be able to change any of these parameters through negotiation if they so wished.

*Question 10: What is the right approach to setting initial licence parameters for an SUR?*

## Measurement of Interference Emissions from Neighbours

6.12 In order to determine whether there is undue interference from a neighbouring licensee a process of measurement is required. The method we propose for this is described below.

6.13 For measuring emissions from neighbouring geographical areas we propose that measurements should be made at a range of positions along the specified geographic boundary at 1.5m above ground level. These measurements would need to be made for a statistically significant time period. We would suggest a minimum of 300s would be suitable in most cases. If a measurement at any position exceeded the specified PFD for greater than the specified percentage of time, the neighbour would be deemed to be in breech of their licence conditions.

6.14 For measuring interference that appears as in-band interference to the victim, arising from OOB emissions from a neighbouring licence holder we propose:

- Measurements are made at a uniform grid of points across the area, A, within the victim licensee's geographical operating area.
- All measurements should be made outdoors.
- The number of grid position points should be statistically significant, depending upon the parameter value Z. A high value for Z would require more positional measurements to be made for statistical confidence. We would suggest a minimum of 25 measurement locations across the area, A, but increasing as required for statistical confidence.
- Measurements that cannot be made on a grid point due to obstruction, for example by a building, should be made at the nearest location to the grid point where measurement is possible.
- Measurements should be made at 1.5m above ground level.
- Values of $X_1$, $X_2$ and $X_3$ are specified to be at the input to an omni-directional antenna of the measuring system.

*Question 11: What is the best approach to the measurement of interference?*

## Process of Licence Variation

6.15 Changes of use within the SUR licence terms could go ahead with no involvement from Ofcom. However, under the current legislation, licence holders who enter into negotiation are not able to make any subsequent changes to their licence themselves, but must request that Ofcom make these change or approve the transfer of rights and obligations under the trading regime.

6.16 If there were agreement from all affected neighbours to the proposed modification of SUR parameters, and assuming there were no issues associated with Ofcom's duties and obligations, then Ofcom's approval would be likely be rapid.

6.17 Ofcom would strive to make the process of approval as simple, cheap and rapid as is possible to facilitate changes of use. Where possible, automated processes would be employed to facilitate this.

6.18 Whilst at present, trading and licence variation both involve Ofcom in reissuing licences, there may be mechanisms that could be permitted under the trading regulations that would enable a simpler procedure. In the longer term, we will give consideration as to whether changes in primary legislation that would simplify this process further would be desirable. There would be full and detailed consultation before such options were progressed and timing would in any case depend on decisions by the Government on the legislative programme and availability of Parliamentary time.

## Application of SUR principles to different classes of licence and occupied or unoccupied spectrum

6.19 Spectrum is licensed across a range of different geographical scales, from a national basis down to site specific licences. It is possible to allow change of use at all geographical levels; however, the degree of complexity increases as the licence area reduces, while the benefits of any change are likely to be lower for small coverage areas. Hence, for small licensees the benefits may be insufficient to compensate for the costs imposed by the complexity. For these reasons, it is suggested that SURs are implemented initially at the wide area or national level. This is likely to bring the maximum benefit balanced against the regulatory overhead and complexity involved.

6.20 The reason why the complexity rises as the licence area reduces is due to the "aggregation problem". This is explained in detail in the box, below, but in essence if a spectrum user receives interference from multiple geographically neighbouring users then the interference each is allowed to produce must be apportioned between them. This apportionment turns out to be both technically challenging and difficult from a policy or "fairness" viewpoint. For national licences the interference will only be received at geographical borders. Typically if there is any interference this will only be due to one emitter. For a licence holder in a city with a single site licence there may be many sources of interference. Hence, technology neutral national licences would be simpler to define and work with than local ones.

6.21 The aggregation problem does not arise if licences are specified in a technology-specific manner. This is because the calculation of interference and any apportionment can be performed at the point that the assignment is made, typically using a planning tool. This is the method currently used, for example, by Ofcom when assigning PBR licences.

6.22 The reasons why the benefits are likely to be lower is related simply to the number of end users. With national coverage there are likely to be many more end users than with local coverage. Assuming the benefit to be proportional to the number of users who gain that benefit, then larger area licences would benefit more.

**The Aggregation Problem**

A receiver is affected by the totality of all the interference it receives. This could come predominantly from a single source, typically the case where there is an interferer close by, or could be made up from a number of sources, such as a few base stations in the vicinity. Our approach to setting interference levels is to start with the interference that a receiver could tolerate and then to set this as the maximum PFD that a transmitter can cause. However, where there is more than one transmitter contributing significantly to the interference then this interference level needs to be distributed among the various transmitters such that the aggregate interference is acceptable. Distributing the interference turns out to be highly problematic, and is what we refer to as the aggregation problem. This is illustrated below with an example.

Imagine a PBR band where there are multiple licences for individual base stations distributed across London. We might consider one particular base station - call it BS1 - and consider how to divide the allowed interference into its coverage area across the surrounding base stations - let's assume there are six. We could simply partition it out equally, but this would likely be inefficient as at any point on the boundary of BS1 there might only be between one and three base stations causing significant interference. We could go to the other extreme and for each unit area along the boundary - say a 50m stretch, we could use a propagation tool to determine the likely relative contribution from each base station and scale accordingly. We could then give each base station a licence that specified the maximum PFD for each 50m of their boundary. However, this would result in a very complex PFD limit for each base station and would be time consuming to produce. It might also be judged to be unfair since someone with a taller transmitter mast might be granted a greater degree of the interference allowance. Or we could just ignore the problem and hope that aggregation was rarely significant, but this clearly risks increasing interference.

Given the vagaries of radio propagation, the accuracy of any such approach will be limited and as a result, significant margins for error will likely need to be built in. If any base station wishes to change their limits, they will need to negotiate with a number of other base stations and will need to understand how to re-attribute the interference in an appropriate manner. This problem is not intractable, but it is very resource intensive, likely to be technically inefficient due to the margins needed and could make change of use cumbersome.

With a nationally managed band, such as PBR or fixed links, these problems are passed to the band manager (in most cases this will be Ofcom). They may simplify the problem by using a single central planning tool and providing simple licences, much as is done today. Or he may take a different approach depending on his views as to what might be optimal. In the first case, the end result would be no different from the current situation. But in the second case, significant enhancements to value might be possible.

6.23 This leads to the conclusion that a system of usage rights might work most effectively if it operates differently at a national compared to a local level. At a national level, fully flexible rights can be defined. At a local level it might be more effective to define less flexible licences with recourse to a “band manager” who could ascertain whether

any request for a change of use should be allowed. Hence, we suggest here that we would only change national and wide-area licences to SURs, at least initially. Through the use of existing rights under spectrum trading, such SUR holders would be able, if they wished, to establish subsidiary users. They could choose whether to cascade technology neutral terms to such subsidiary users or whether to limit the rights passed through trading by private contractual agreements, for example limiting the power a transmitter may operate at or the use for which it may be used.

*Question 12: Should SURs be initially introduced at national and wide-area level?*

### 6.24 Receive only systems

6.25 There would be benefit in ensuring that the need of receive only systems for spectrum of a defined quality is recognised. We are currently developing the concept of Recognised Spectrum Access (RSA). RSA is a means for Ofcom to take into account, within national spectrum planning, uses of frequencies that do not require to be licensed under the Wireless Telegraphy Act 1949. An example of such a service is radio astronomy. The proposed structure is designed to accommodate RSA where we decide, following consultation, to apply it.

## Section 7

# Comparison with Spectrum Framework Review

## introduction

7.1 Previously we set out in high level outline form a system of SURs in the Spectrum Framework Review[13]. We stated at that time we would undertake further work to refine the high level proposals and test these through software modelling. In this section the proposals presented here are compared with the high level proposals outlined in the SFR.

## Broad comparison of the proposals

7.2 In the SFR we stated that we believe the best mechanism for implementing change of use would be through technology-neutral SURs, allowing users to understand their ability to change their technology or usage without needing prior approval from Ofcom or expensive interference studies. It was proposed that Ofcom would allow users to modify their rights provided they have agreement with all the affected (neighbouring) third parties.

7.3 In outline, the areas we have suggested that remain unchanged are:

- Licences would be specified in technology-neutral terms.
- Licence variations would be possible through negotiation with neighbours.
- Geographical limits would be specified in terms of power density on a boundary.

7.4 The areas of change are:

- The idea of restrictive rights would be removed (effectively restrictive rights have been reduced to “zero” rights).
- The way that in-band and OOB emissions are measured has been changed from the power measured at 100m from a base station to a distribution function of received power.

7.5 These changes are discussed in more detail below.

## Restrictive Rights

7.6 In the SFR it was proposed that a single set of SURs would not provide the flexibility sought. A system of “specific” and “restrictive” usage rights was proposed; a user wishing to change use would have to abide by the restrictive rights and negotiate new specific usage rights with neighbours.

7.7 However, further study has suggested that the restrictive rights would be so restrictive that they would be unlikely to be of any use. Hence, no licensee would choose to change their use beyond the SUR terms without negotiation with their neighbours. In this case, the restrictive rights do not add any value to the SUR proposal and so have been removed in order to simplify the proposal.

## Interference Control Measures

7.8 A second difference to the proposals made in the SFR is in the way we suggest that the licences will control interference to neighbours.

7.9 The SFR proposed to regulate interference through specifying the maximum in-band power and the maximum OOB power that a transmitter could emit. This would be measured 100m from a transmitter or base station, allowing neighbouring users to simply assess whether the level of interference they are receiving is excessive. An implication of this measure is that interference caused to neighbours is dependent on the density of deployment of base stations. This could potentially cause problems if a network operator decided to deploy a significantly higher density of base stations, since neighbouring users would then experience increased interference levels.

7.10 Since then work has considered a number of further possible options for control of emissions. We have evaluated these options in line with the principles to liberalisation outlined in section 3: that we believe a licence holder should not be adversely impacted by the actions of their neighbour. For this reason the preference in selecting from options for licence interference control parameters is toward ensuring levels of interference are not exceeded.

7.11 It is suggested that the following interference measures would be used in SURs:

- Geographical Interference: To control in-band interference across a geographical boundary the SUR specifies aggregate PFD at and beyond a geographical boundary is no more than a certain level.
- Interference caused by OOB emissions: To control interference caused by OOB emissions the SUR specifies that the aggregate PFD received in adjacent bands does not exceed specified levels for defined percentages of locations and times.

7.12 This approach more tightly constrains the risk of interference through controlling aggregate interference levels. It would give a good idea of the level of interference that operators in adjacent areas and bands could experience. It would also give operators considerable flexibility in deploying their network whilst safeguarding against increased levels of interference to neighbours.

7.13 It would not be possible to dramatically increase density of transmitters without reducing the power with which they transmit as that would result in linear increase in percentage of locations interfered. Similarly it would not be possible to switch off power control without either reducing transmitter power or entering into negotiations.

## Summary

7.14 In summary our more detailed proposals are consistent with those of the SFR in broad terms. However as a result of further work we suggest stating interference conditions for SURs in a way which could further reduce the risk of interference to neighbours.

## Annex 1

# Comparison with work undertaken by consultants

A1.1 Consultants were engaged to provide further detail to the existing work regarding technology neutral SURs initially presented in the SFR.

A1.2 The consultants' final report[14] gives:

- A mix of recommendations as to their preferred approach and an evaluation and comparison of a range of licence parameters.
- Testing of the proposals against a set of case studies.

A1.3 Ofcom directed the consultants to make technical considerations and proposals in the absence of any legal constraints to existing legislation. Thus their work should lead to the best approach from a technical standpoint, but might require significant changes to existing legislation for it to be implemented completely. This was indeed the case; the technical solution envisaged in the consultants final report would require legal changes to be implemented.

A1.4 It was recognised that much of the consultants'' proposals could be implemented within the existing legal and regulatory framework. In this discussion document we therefore have presented a modified set of proposals based upon the consultants'' work, which can be implemented within the existing legal and regulatory framework.

A1.5 Ofcom also conducted a critical evaluation of the ideas put forwards by the consultants, and while it was in agreement with many, there were some areas where we felt the consultants had not selected the optimal solution.

A1.6 This annex compares the proposals suggested in this document with those contained in the consultants report.

### Technology Neutral Interference Conditions

A1.7 In this area the consultants provided a number of options that could be used for control of in-band and OOB emissions. These were considered and tested against a number of case studies.

A1.8 In forming our suggestions we have selected what we consider to be the best of the options put forwards by the consultants. These are described in section 4.

### Spectrum Management and Spectrum Usage Rights

A1.9 The consultants work proposes a two tier system of rights, termed Spectrum Management Rights and Spectrum Usage Rights:

- Spectrum Management Rights (SMRs) – At the wide area, or national level, SMRs confer on the holder the right to exploit the use of that piece of spectrum and the duty to manage the use of the band including interference within the SMR terms. The SMR also confers on the holder the ability to use the spectrum. These would

[14] "Spectrum Usage Rights - Final Report", Aegis Ltd, 10 February 2006

be held by either private companies such as the MNOs or public bodies such as Ofcom, CAA and MoD;

- Spectrum Usage Rights (SURs) – At the subsidiary level SURs confer on the holder the ability to use the spectrum and transmit under the SUR terms, as defined by the SMR holder. Each SUR would be associated with its parent SMR. SURs could be owned by the same organisation as the holder of the parent SMR or a different one. For example an MNO would own both an SMR and associated SURs. We note that the term SUR is defined differently here in the context of the two level approach of SMR/SUR proposed by the consultants to the more general meaning of SUR used throughout this document.

A1.10 The consultants proposed that the SMR holder may issue SURs as they see fit and with conditions as they judge appropriate so long as the conditions of the Spectrum Management Rights are met.

A1.11 It is acknowledged that under the current legislative framework, a holder of an SMR would not be able to issue an SUR as this would amount to the issuing of a licence. Wireless telegraphy licences are granted under section 1 of the WTA which makes it an offence to establish or use any station for wireless telegraphy or to install or use any apparatus for wireless telegraphy except under the authority of a licence granted by Ofcom.

A1.12 At present Ofcom can delegate some of its functions to other parties. This is achieved under the Deregulation and Contracting Out Act 1994 (the "DCO Act"), which allows a Minister or office holder (including Ofcom) to authorise a person to exercise a function normally carried out by the Minister or office holder. The authorisation is created by a statutory instrument. While in theory it would be possible for Ofcom to create statutory instruments that would allow SMR holders to issue licences on its behalf, the granting of SURs as proposed goes further than the simple grant of licences for a specific purpose on behalf of Ofcom. Giving an SMR holder the ability to grant an SUR as proposed would, in effect, delegate almost all of Ofcom's regulatory functions in relation to spectrum management including its obligations to act in accordance with the WTA, Communications Act and European Communications Directives as specified below. As a principle of public law, Ofcom would not have the ability to delegate all such functions.

A1.13 All rights would be need to be subject to Ofcom's over-riding obligation to carry out its duties and functions under the WTA, the Communications Act 2003 ("Communications Act") and the European Communications Directives including:

(i) its general duties under section 3 of the Communications Act;

(ii) its specific obligation under section 4 of the Communications Act with regard to carrying out its functions in accordance with Article 8 of the Framework Directive;

(iii) its powers to modify rights or take back spectrum where this is required for reasons of national security, to comply with European or international regulations and for spectrum management reasons.

A1.14 In this document we have suggested proposals which allow a tiered licensing system to emerge within the existing trading regulations and legislation. Existing national licences would be restated in technology neutral terms as SURs, which would be tradable under the existing Spectrum Trading Regulations. A subsidiary SUR could be created through a concurrent trade of a parent SUR licence. This would need

Ofcom's approval, although we expect this to be granted in almost all situations. This would allow functionality similar to that proposed of the SMR; a parent SUR holder could then create technology and usage neutral subsidiary SURs, bound by the SUR emission conditions and any further emission criteria that the parent SUR holder sees fit for efficient use of the spectrum.

A1.15 Subsidiary SURs would be issued with the same terms as the parent SUR. Thus there would likely be increased reliance on private contractual agreements under this approach as more accurate specification of conditions becomes necessary for licences over smaller areas.

## Registration of Rights

A1.16 The consultants work proposes a central, public register for SMRs and SURs. This would not be required if SURs were to be implemented under the Spectrum Trading regulations since the existing Register of Licences would be utilised.

## Negotiation of Change of Use and Enforcement

A1.17 The proposals suggested in this document for negotiation of a change of are broadly the same as those put forwards by the consultants. These were that changes of use within the SUR conditions would require no approval from Ofcom. A change of use which was outside the licence terms would require negotiation between neighbours as described in section 5 and Ofcom approval as is required in the current liberalisation regulatory framework. Ofcom approval would be limited to the legal rules which limit its discretion in authorisation of Wireless Telegraphy licences as suggested by the consultants, for example matters of international law and ensuring licences are granted in accordance with obligations under the European Authorisation Directive.

A1.18 To safeguard against technically poorly constructed agreements the consultants proposed that certification be required by a suitably qualified engineer. This would underline the importance of correct calculations and modelling underpinning the proposed change of use. Whilst we agree that this may have some benefit we recognise that there would already be significant incentives to construct technically sound proposals for changing licence parameter values, including the possibility of having to undo a change of use that caused undue interference to neighbours.

A1.19 The consultants proposed a process of arbitration as a means of resolving disputes. Whilst we recognise the benefit of such an approach, under the existing legislation Ofcom has no power to mandate such a process. Therefore we suggest that the approach taken is determined by the parties involved in the dispute.

## Annex 2

# Impact Assessment

## Policy Objective

A2.1 This impact assessment (IA) estimates the costs and benefits of the proposed introduction of SURs. Overall, the proposed changes will reduce the amount of regulation since licence holders will have increased freedom to change the use of their spectrum with less need to apply to Ofcom.

A2.2 Ofcom's objectives in liberalising the spectrum are to maximise the value created by use of the radio spectrum while at the same time protecting existing users. Value will be maximised by encouraging innovation, by removing barriers to entry for new companies or technologies and by minimising the time that spectrum sits unused.

## Options

A2.3 Ofcom has identified that the three main approaches to liberalisation are:

- Not to allow liberalised use of spectrum.
- To require all change of use requests to be notified to Ofcom for it to decide whether they should be allowed (the current liberalisation approach).
- SURs, as set out in this document.

A2.4 Ofcom could choose to use any of these in any part of the spectrum. In outline, we propose to move to SURs for national and wide-area licences but to retain the second approach requiring notification to Ofcom for local licences.

## Risks

A2.5 The risk of doing nothing is substantial. In a study for the EC published in May 2004, Analysys estimated that the benefits to Europe of introducing trading and liberalisation are in the region of €9bn per year. Of this €9bn, some €8bn came from liberalisation and €1bn from trading. This study assumes liberalisation broadly in line with our proposals. Some of these benefits will be realised from the existing approach to liberalisation but the full realisation will require SURs as proposed here.

A2.6 However, the approach proposed is not risk-free. With such wide-ranging and high level proposals there are many potential risks. Here we address the key ones.

| Area of risk | Possible effects | Mitigation |
|---|---|---|
| SURs incorrectly specified | 1) Increased interference to licence holders. | Careful introduction of liberalisation to allow the interference risk to be assessed. Use of modelling. |
| | 2) Flexibility not as great as might be achieved. | Cases where change of use could not be achieved studied to understand whether a change to SUR format is possible. |
| SURs contradict each other | Neighbouring licence holders transmit within their rights but suffer interference. | Careful introduction of SURs in conjunction with licence holders and modelling where appropriate. |
| Market failures | Abuse of market power (eg hold-outs) | Use competition powers |
| | Transaction costs | Consider making tools available to allow easy assessment of the impact of changes |
| Disruption to customers | As use is changed some services may be withdrawn with subsequent disruption. | Limited action from Ofcom – this is part of a standard market and would not normally require intervention. |

## Costs and benefits

A2.7 This is a difficult area to determine costs and benefits. We are providing increased flexibility but it is up to licence holders to determine how this flexibility is used. The decisions that they make, which we cannot predict, will have a major impact on the costs and benefits. In the Spectrum Framework Review (SFR) Statement we set out an approach to determining the costs and benefits based on the Analysys study. The responses were mixed. Some acknowledged that estimating benefits in this area was extraordinarily difficult and that we had likely done as much as was possible and sensible. Others felt that a more detailed estimate of the benefits was needed but did not provide any views on how this might be achieved. Our assessment is that given the difficulties in estimating the benefits, but the fact that the benefits are highly likely to massively outweigh the costs, it is not appropriate to expend substantial time and effort attempting more detailed quantification. Hence, what follow is largely the same material as presented in the SFR.

A2.8 With the introduction of SURs, the only costs imposed on licence holders are voluntary. Any licence holder can choose not to change use and hence to continue their use of spectrum unchanged. If licence holders wish to change their use then there may be costs associated with this, but it is likely that licence holders would not incur these costs unless they expected the benefits to be greater.

A2.9 The benefits are difficult to quantify since they will depend on the uses to which the spectrum is put and subsequent technical developments. Based on the Analysys report and assuming that the benefits to the UK equate to approximately 1/6th of the benefits to all of Europe, we estimate that the benefits across all of the economy including licence holders, consumers, etc, from the introduction of liberalisation might be in the region of £0.9bn per year. This estimate is highly speculative.

A2.10 As discussed in this report, SURs are an extension of an on-going liberalisation initiative. Some of this £0.9bn will result from the existing initiatives and some will only be realised with the introduction of SURs. Estimating the split is highly problematic. However, insofar as the introduction of licences incorporating SURS facilitate liberalisation, they can be expected materially to enhance the gains from liberalisation and trading. We would welcome evidence from respondents on the extent to which SURs would make it more likely that they would embark on a process of introducing new services outside the scope of their present licences.

A2.11 The potential costs of making a change of use without SURs in place include:

- costs to business of going through the Ofcom process;
- costs incurred by Ofcom in considering each request;
- lost opportunities (or much lower probability) of negotiation between neighbours if they do not have SURs since without these the two parties would have to negotiate a conditional agreement and then both submit change of use requests to Ofcom.

A2.12 Quantifying these is difficult, but we believe that they are real and will be significant in some cases.

A2.13 Given that the key value is likely to come from major changes of use, which will likely involve negotiation with neighbours, we conclude that a proportion, which is potentially significant, of this £0.9bn per year benefit will not be achieved until SURs are introduced.

## Summary and recommendations

A2.14 In summary we propose the introduction of SURs in order to fully liberalise the use of spectrum. There are risks involved in such an approach but in most cases there are mechanisms whereby the impact can be reviewed and our approach modified if problems appear to be emerging.

A2.15 Because most of our proposals reduce regulation, there is little cost for users. Benefits are difficult to quantify and necessarily speculative, but could be of the order of hundreds of millions of £s per year.

## Annex 3

# Responding to this consultation document

### How to respond

Ofcom invites written views and comments on the issues raised in this document, to be made by **5pm on 21 June 2006.**

Ofcom strongly prefers to receive responses as e-mail attachments, in Microsoft Word format, 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 5), among other things to indicate whether or not there are confidentiality issues. The cover sheet can be downloaded from the 'Consultations' section of our website.

Please can you send your response to joe.butler@ofcom.org.uk.

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

Joe Butler
2nd Floor
Riverside House
2A Southwark Bridge Road
London SE1 9HA
Tel: 020 7981 3536
Fax: 020 7981 3406

Note that we do not need a hard copy in addition to an electronic version. Also note that Ofcom will not routinely acknowledge receipt of responses.

### Further information

If you have any want to discuss the issues and questions raised in this consultation, or need advice on the appropriate form of response, please contact Joe Butler on 020 7981 3536.

### Confidentiality

Ofcom thinks 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 (when respondents confirm on their response cover sheer that this is acceptable).

All comments will be treated as non-confidential unless respondents specify that part or all of the response is confidential and should not be disclosed. Please place any confidential parts of a response in a separate annex, so that non-confidential parts may be published along with the respondent's identity.

Ofcom reserves its power to disclose any information it receives where this is required to carry out its legal requirements. Ofcom will exercise due regard to the confidentiality of information supplied.

Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use, to meet its legal requirements. Ofcom's approach

on intellectual property rights is explained further on its website, at www.ofcom.org.uk/about_ofcom/gov_accountability/disclaimer.

## Next steps

Following the end of the consultation period, Ofcom intends to publish a statement around the end of August.

Please note that you can register to get automatic notifications of when Ofcom documents are published, at http://www.ofcom.org.uk/static/subscribe/select_list.htm.

## Ofcom's consultation processes

Ofcom is keen to make responding to consultations easy, and has published some consultation principles (see Annex 4) which it seeks to follow, including on the length of consultations.

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, whose views are less likely to be obtained in a formal consultation.

If you would like to discuss these issues, or Ofcom's consultation processes more generally, you can alternatively contact Vicki Nash, Director for Scotland, who is Ofcom's Consultation Champion:

Vicki Nash
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA
Tel: 0141 229 7401
Fax: 0141 229 7433
E-mail: vicki.nash@ofcom.org.uk

## Annex 4

# Ofcom's consultation principles

A4.1 Ofcom has published the following seven principles that it will follow for each public written consultation:

### Before the consultation

A4.2 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

A4.3 We will be clear about who we are consulting, why, on what questions and for how long.

A4.4 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.

A4.5 We will normally allow ten weeks for responses to consultations on issues of general interest.

A4.6 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 organisations 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.

A4.7 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

A4.8 We will look at each response carefully and with an open mind. We will give reasons for our decisions and will give an account of how the views of those concerned helped shape those decisions.

## Annex 5

# Consultation response cover sheet

A5.1 In the interests of transparency, we will publish all discussion responses in full on our website, www.ofcom.org.uk, unless a respondent specifies that all or part of their response is confidential. We will also refer to the contents of a response when explaining our decision, without disclosing the specific information that you wish to remain confidential.

A5.2 We have produced a cover sheet for responses (see below) and would be very grateful if you could send one with your response. This will speed up our processing of responses, and help to maintain confidentiality by allowing you to state very clearly what you don't want to be published. We will keep your completed cover sheets confidential.

A5.3 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 cover sheet in a way that allows Ofcom to publish their responses upon receipt, rather than waiting until the consultation period has ended.

A5.4 We strongly prefer to receive responses in the form of a Microsoft Word attachment to an email. Our website therefore includes an electronic copy of this cover sheet, which you can download from the 'Consultations' section of our website.

A5.5 Please put any confidential parts of your response in a separate annex to your response, so that they are clearly identified. 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

Title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

### CONFIDENTIALITY

What do you want Ofcom to keep confidential?

| | | | |
|---|---|---|---|
| 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 to be confidential, 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. It can be published in full on Ofcom's website, unless otherwise specified on this cover sheet, and I authorise Ofcom to make use of the information in this response to meet its legal requirements. 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 6

# Consultation questions

*Question 1: What is the best way to control in-band interference across geographical boundaries?*

*Question 2: What is the best way to control interference caused by out-of-band emissions?*

*Question 3: What is the best way to control interference caused by in-band emissions?*

*Question 4: Which would be your preferred option for control of spurious emissions? If not one of the above options, what would you propose?*

*Question 5: Do you agree to the proposed approach described here for Indicative Interference Levels?*

*Question 6: How should a licence holder determine which frequency and geographical neighbours should be involved in a change of use negotiation?*

*Question 7: Would it be useful for Ofcom to make its change of use modelling tool publicly available?*

*Question 8: Are the proposals for negotiating a change of use with non-commercial and other similar users appropriate?*

*Question 9: What is the best approach towards enforcement and dispute resolution?*

*Question 10: What is the right approach to setting licence parameters for an SUR?*

*Question 11: What is the best approach to the measurement of interference?*

*Question 12: Should SURs be initially introduced at national and wide-area level?*