Annex 8: Ofcom has failed to consider additional sources of evidence in addition to and as an aid to proper interpretation of the international and UK benchmarks

Introduction and summary

Ofcom has derived a view of the value of 900MHz not directly, but indirectly from auction data, using the UK auction to supply an anchor point of 800MHz market value as well as international data to obtain a value for 900MHz, using both absolute and relative auction data. From these observations Ofcom has emerged with a view that the value of 800MHz is £30m per MHz, and the value of 900MHz is £25m. This means that there is an implicit value discount between the two of 17%. However Ofcom has undertaken no analysis as to whether this relative position might be correct. All that Ofcom has observed is that 900MHz is "unlikely" to have a higher value than 800MHz.

This is totally inadequate as a way of deriving a value of un-auctioned spectrum in circumstances where an annual outflow of cash from the mobile industry in excess of £300m is the outcome of Ofcom's provisional conclusions. Ofcom has failed in the consultation to consider four distinct points:

A. That there are very good reasons to believe that the value of 900MHz must in general be less than 800MHz. Indeed Ofcom observes that in those countries where simultaneous auctions of both bands were held, the range of value discount seen is 20-40%. By adopting a value discount of less than this, Ofcom is creating a contradiction with its own benchmarking observations. Ofcom is implicitly assuming that conditions exist in the UK such that a smaller relative discount is appropriate. However Ofcom makes no attempt to discover what the reasons for such an eventuality might be.

   In reality Ofcom's own work on mobile spectrum totally contradicts this implicit assumption. There are sound reasons to support the conclusion that generally a substantial value discount must exist between 800MHz and 900MHz in any simultaneous auction or other valuation of the bands.

B. However the international benchmarking datapoints of a 20-40% value discount are merely observational data, unsupported with any logical justification. Based on Ofcom's own work on spectrum, there are strong reasons to expect that the particular circumstances and conditions that exist in the UK would indicate that had 900MHz and 800MHz been auctioned simultaneously, a higher value discount than Ofcom has generally observed overseas would have resulted.

C. Furthermore Ofcom needs to examine, but has failed to do so, whether matters have changed since the date of the auctions which it is using to indirectly estimate the value of 900MHz and 1800MHz spectrum in 2014. The problem for Ofcom is in the first place to set a forward looking value of this un-auctioned spectrum as at spring 2014. To do so Ofcom is making use of the UK Auction in February 2013 and applying international benchmark data from 2012 and 2011. We can show that the position for UK mobile operators in 2014 is different from those faced in prior years, and that generally the value of spectrum is falling. This also leads to the conclusion that to the extent that the observed range of international value of 900MHz being between 60% and 80% of the value of 800MHz is to be used for the 2014 UK 900MHz spectrum

valuation calculation, then at the very most a value at the bottom of this range should be applied.

D. Finally Ofcom is not just attempting to set a rate appropriate for 2014 – rather for investment certainty it is setting a rate that it intends to use for an extended period. Given that the evidence shows that the general trend of spectrum value is downward, Ofcom has an obligation to consider not only whether the rate that it is expecting operators to pay in 2014 is reflective of 2014 market value, but also there should have been a further test by Ofcom to ensure the rate that it sets now and applies to the future stream of payments will still be reflective of market value in 2015 and successive years. It is insufficient to state that if the proposed fee were to be found to be out of line in the future Ofcom would change it – given the long life cycles of network investment the prospect of future fee revision is in itself a source of present investment uncertainty and a deterrent to the provision of high speed mobile data services that Ofcom is so keen to foster.

   Given that the value of spectrum is falling, it follows therefore that in order to maximise the length of time for which it might reasonably be seen to be in line with market value, any fee set in 2014 should be at the very bottom of any range of plausible 2014 value.

For these reasons we consider that Ofcom's present proposals are untenable – at the very most a value that represents 60% of the revised 800MHz historic auctioned spectrum value should be adopted. This suggests that at the maximum an annual fee derived from a lump sum value of the 900MHz spectrum of £12m should be used.

We consider in section 1 below Ofcom's failure to take an evidence-based view on the relative valuation of 800MHz and 900MHz spectrum. We review the evidence that was available to Ofcom that it should have used, and would have led it to conclude that there are sound general reasons as to why the value of 900MHz should be viewed as being significantly lower than 800MHz. In particular we look at Ofcom's own research and own view on the inability of 900MHz to be used for LTE in both the immediate future and in the medium term.

We discuss in section 2 below the reasons for expecting that a larger discount would be more appropriate between the now historic UK auctioned 800MHz market value and any 900MHz forward looking market value than that which is observable internationally from past simultaneous auctions. These reasons relate to both UK specific conditions (point B above) and changes that have occurred since the historic datapoints (point C). We conclude that at the very least this means that the low end of any range of value discount provided by international benchmarking, which we see as £12m must be adopted in calculating any 900MHz value for spectrum fee setting purposes.

In section 3 of this annex we look at a further set of factors that suggest that even though Ofcom has widely established elsewhere, for example in its mobile data strategy document in November 2013, in the spectrum management strategy consultation in October 2013, in the 2013/14 annual plan, and in the draft 2014/15 annual plan that it is a major priority for Ofcom to facilitate the continued long term growth in consumer and citizen benefits from increasing the use of mobile services, it is clear that high spectrum prices will act as a deterrent to this by frustrating mobile operators' ability to profitably provide a high level of capacity. The importance of this

priority strategy for Ofcom is conspicuously absent as a concern from the present consultation. However consideration of it should have led Ofcom to the conclusion that to avoid the risk of the long term growth of consumer and citizen benefits not being achieved, Ofcom should set annual spectrum fees conservatively.

Finally in section 4 we address the point of future investment uncertainty in the face of the falling future spectrum value established in the previous sections, and its implication in terms of the need to set a spectrum fee that is “in line” with the underlying valuation of spectrum for as long a period as possible.

1. Ofcom provides no direct UK evidence for the relative values it is proposing between 800 MHz and 900 MHz

The failure of Ofcom's analysis

Ofcom has derived its view of the value of 900MHz not directly, but indirectly from auction data, using the UK auction to supply a starting point of 800MHz market value and international data to obtain a value for 900MHz, using absolute and relative auction data. From these observations Ofcom has emerged with a view that the value of 800MHz is £30m per MHz, and the value of 900MHz is £25m. This means that there is an implicit value discount between the two of 17%. However Ofcom has undertaken no analysis as to whether this relative position might be correct – the entirety of Ofcom's reasoning on this issue is contained in a single sentence:

> "*we consider on balance that 900 MHz is* ***unlikely to have a higher value***[1] *than 800 MHz spectrum in the UK, i.e. the value of the 800 MHz spectrum in the UK is likely to set an upper limit on the value of 900 MHz in the UK*[2]".

This is totally inadequate as a way of deriving a value of un-auctioned spectrum and is an extraordinarily weak conclusion in circumstances where an annual outflow of cash from the mobile industry in excess of £300m is the outcome of such loose reasoning.

Ofcom has failed to derive, develop, or consider in this consultation any logical reasons why the level of value discount between 800MHz and 900MHz of 17% that it has obtained from this method might or might not be the correct percentage to adopt in the UK. We note that in the July 2012 statement Ofcom did suggest that it would conduct such an exercise of reviewing the relative values of 800MHz and 900MHz. We consider the failure to embark on such an analysis in the present consultation to be an abdication of responsibility on Ofcom's part, particularly significant given the enormous sums that will be transferred out of the industry as a result of the proposed levels of spectrum fees.

The only evaluation on the relative value of 800MHz and 900MHz in the present consultation is limited to paragraphs 4.41 and 4.42. The entirety of Ofcom's general research on the UK use of mobile spectrum and the detailed underpinning of relative spectrum value in the UK, apart from passing references in Annex 6 to work done in other contexts, is unaccountably dismissed in a single sentence of 4.42:

> *"As discussed in Annex 6, the technical evidence is not sufficiently clear-cut or robust to derive a reliable inference about the relative value of 900 MHz and 800 MHz."*

This represents a step back from the previous discussions by Ofcom on mobile spectrum fees in auction consultations. In the July 2012 auction statement, Ofcom's assessment was considerably more measured:

> *"A12.49 We have not assessed the relative values of 900 MHz and 800 MHz spectrum in detail, and do not have a firm view on this. There are countervailing*

[1] Vodafone emphasis
[2] Consultation at paragraph 4.42

arguments, as set out in the different responses. ***We will assess the points raised fully***[3] *when we consult on ALF after the Auction.*

A12.50 We do not agree that it is critically important for Ofcom explicitly to address this issue now. This is because:

12.50.1 We would anyway be unable to give a definitive view at this time. This is because ***we would have to take account of the further information*** *that is likely to become available before ALF is set for 900 MHz spectrum, and responses to our planned ALF consultation. To take a definitive position now would be likely unlawfully to fetter our discretion.*

12.50.2 There is likely to be materially better information on which to make this assessment by the time we consider setting ALF for 900 MHz spectrum in 2013. In particular, there may be more information about the following which may be relevant to setting ALF for 900 MHz spectrum:

a) Additional European Auction results involving both 800 MHz and 900 MHz spectrum being Auctioned together;

b) ***The timescales for using 900 MHz spectrum for LTE, including the availability of LTE900 user devices and any development on standards***[4]*; and*

c) The value of initial deployments of LTE and how this compared to HSPA.

There may also be additional information on the relative value that stems from responses to our specific ALF consultation."

It is clear to Vodafone therefore that the present consultation manifestly fails to fulfil these commitments. We discuss this point further in Annex 1. We find no trace in the present consultation of Ofcom examining further information, beyond that which existed in July 2012 (with the one exception of more international auctions) or undertaking a proper consideration of the timescales for using 900MHz spectrum for LTE etc., or an explanation of why such matters are no longer worth consideration.

It is readily apparent from the international auction data, that where 900MHz and 800MHz spectrum are auctioned simultaneously, the observed value of 900MHz spectrum is considerably less than that of 800MHz. A value discount of 20-40% between the two bands has been observed by Ofcom, not the 17% implied for the UK by the present Ofcom consultation. Such a level of discount is not an accidental product of the international auction data – rather there are reasons why in general such a discount would be expected and why, in the UK, the lower end of international observations of discount, i.e. 40% should be adopted.

In fact, if one were to ignore the £3m provision per MHz that Ofcom has included in the £30m of 800MHz value that relates to UK 800MHz interference/ co-existence costs, before comparing 800MHz with 900MHz relative values for the purposes of international benchmarking comparison, then the extent of the value discount between 800MHz and 900MHz allowed by Ofcom would be only 7%. This is clearly very considerably less than the 20-40% observed internationally.

[3] Vodafone emphasis
[4] Vodafone emphasis

Instead of properly engaging with these issues Ofcom simply throws its hands up in the air and concludes:

> *"arguments can be made on both sides as to whether 900 MHz [sic] has a higher or lower value than 900MHz. In addition, future releases of HSPA+900 and LTE800 (including LTE Advanced) may change the balance of relative technical performance between the bands, and the alleged commercial first-mover advantages of 900 MHz are equally difficult to estimate with certainty."*
>
> *In our view the qualitative and quantitative technical modelling submitted is not sufficiently clear-cut or robust to derive a reliable inference about the relative value of 900 MHz and 800MHz."*[5]

But Ofcom as we discuss in Annex 9 has conducted **no** qualitative or quantitative technical modelling aimed directly at answering the question before it; namely the appropriate relative values between 800MHz and 900MHz (and between 1800MHz and 2.6GHz). The work done to date by Ofcom **can** inform and act as a starting point to further investigation of this important issue but to conclude that because that was work done for other purposes cannot be simply recycled to answer the question in front of Ofcom today and, upon that basis, decide it is not worth further investigation is a clear abdication of Ofcom's responsibility to actively seek and consider available evidence.

Ofcom has unaccountably ignored its own very substantial recent body of work on relative spectrum use and value. In the present context, one particular strand of this work relates to establishing the fact that 900MHz is currently not capable of deploying LTE services in the UK. It follows that the position is not that as Ofcom suggests it is unlikely for 900MHz to be greater than 800MHz. Rather it is very evident that 900MHz must not have the same value as 800MHz spectrum – had Ofcom in the current consultation considered its own work it would have inevitably have arrived at this conclusion. We briefly discuss Ofcom's spectrum work on this matter and the effect Ofcom's conclusion on it had on the overall design of the auction in the section below.

The 900 MHz band has no practical usability for LTE for some years to come

There is a broad consensus that 900MHz in the UK cannot and will not be used for LTE for some time to come. This view can be seen in a large series of Ofcom documents. In fact this was a key element of the decisions in the Ofcom auction Statement in July 2012 affecting the design of the auction – the view that O2 and Vodafone needed new spectrum to be able to continue to be effective competitors to EE, in that their existing 900MHz spectrum was not capable of being used for LTE for some period. The inevitable consequence of this point is that 900MHz **must** have a lower forward looking value than 800MHz, which is both immediately free and immediately capable of being used for LTE.

There were two elements to Ofcom's reasoning in the 2012 auction statement on 900MHz: 900MHz is not suitable for 4G as yet from an ecosystem viewpoint, and 900MHz is also occupied by legacy technologies (which use the spectrum less efficiently) but which cannot be cleared until after LTE can be established and adopted in alternative frequencies, particularly 800MHz and 2600MHz.

[5] Consultation at A6.33 and 6.34

When 900MHz is cleared it will add to the stock of 4G spectrum by another 72MHz – but the timing of the progressive clearance that needs to be undertaken is very uncertain. As we discuss in section 2 below, given the timings of the provision of additional mobile spectrum from the Ofcom mobile data strategy document, not only the 700MHz spectrum but also a considerable volume of other spectrum will become available for LTE use **before** 900MHz becomes fully available for LTE use.

As a result of the work of Ofcom, the current inability of UK operators to use their holdings of 900MHz for LTE is not a controversial or an unknown point. We provide a few examples of Ofcom's conclusions on this matter below:

In the liberalisation of EE's 1800MHz spectrum consultation

Ofcom in their consultation on the liberalisation of EE's 1800MHz spectrum to allow LTE commented:

> *"4.28 Based on these considerations, our view is that it is unlikely that the 900 MHz band will be used for LTE until after the 800 MHz and 2.6 GHz bands become available for use. Our understanding is also that the 2.1 GHz band is likely to be used for 3G services for some time yet, and that LTE equipment is unlikely to be available for that band for at least a few years.*
>
> *4.29 By contrast, we expect LTE to be deployed in the 800 MHz and 2.6 GHz bands soon after they become available; winners of rights to use these frequencies are likely to have sufficient time between the conclusion of the award process in 2013 and the availability of the 800 MHz and 2.6 GHz spectrum across the majority of the UK to prepare an LTE launch by the end of 2013, should they wish to do so."*[6]

In the Ofcom July 2012 statement

For the July 2012 auction statement Ofcom commissioned a study by Real Wireless on the availability of mobile equipment by band by technology[7]. This study was extensive and its conclusions on the time lag before 900MHz would be usable for LTE quite clear. Ofcom concluded:

> *"A2.62 Both the updated Real Wireless study and responses supported our view that the 800 MHz, 1800 MHz and 2.6 GHz bands will all be used for LTE soon after the Auction (if not before in the case of 1800 MHz) and that there will be a reasonable selection of user devices, including smartphones and tablets, within a couple of years. Real Wireless's research suggests two tiers of LTE frequencies in device procurement terms. The 'first tier' will consist of 3-4 bands per region which will be nearly universally supported, with the second tier being outside this. Real Wireless conclude that the 800 MHz, 1800 MHz and 2.6 GHz bands will all be first tier bands for LTE in Europe. There is already at least one high quality smartphone commercially available that can use LTE with all three frequencies (the Samsung Galaxy SII LTE).*

[6] Ofcom Notice of proposed variation of Everything Everywhere's 1800 MHz spectrum licences to allow use of LTE and WiMAX technologies, March 2012

[7] Real Wireless report into comparative device availability at different frequencies, May 2012

> *A2.67 Based on Real Wireless's findings,* ***we remain of the view that the use of 900 MHz spectrum for LTE is likely to be somewhat later than 800 MHz, 1800 MHz and 2.6 GHz***[8]*."*

In the liberalisation of the 900/1800MHz spectrum

Ofcom comment in technical liberalisation of 900/1800/2100MHz consultation, February 2013 as follows:

"*3.20 In any event, in terms of timing it is also worth noting that the operators will not necessarily deploy 4G services in these bands in the immediate future. Telefónica and Vodafone's existing 900 MHz and 1800 MHz spectrum is currently used for 2G and 3G traffic and would require refarming before it could be used for 4G services.* ***Moreover, if these companies win licences at 800MHz and 2.6 GHz in the Combined Award then these new bands are likely to provide the focus for their immediate 4G deployment strategies***[9]*."*

In the DotEcon report that is part of the July 2012 statement

Further evidence developed by Ofcom is contained in the Dotecon report that forms part of the July 2012 auction statement. This report states in paragraph 32:

> *"In addition, whilst other frequency bands may appear to be suitable comparators for deriving estimates of 800MHz and 2.6GHz value (for example 900MHz for 800MHz or higher frequency spectrum in the 2.1GHz and 2.3GHz bands for 2.6GHz), one needs to be careful to take full account of similarities and differences.* ***Although in terms of propagation characteristics, 800MHz and 900MHz for example are similar, they are different in terms of available technologies/equipment in the short term****, with 800MHz having become available only recently and designated for LTE, whilst in 900MHz there is legacy GSM use and use in the near term may be focused on 3G/UMTS rather than LTE given current equipment availability."*

Conclusion

There is thus very clear and widespread acknowledgment from Ofcom in several spectrum related consultations that 900MHz is not in the current time frame for 4G use as the auctioned spectrum or 1800MHz. We therefore find the absence of any such consideration in the present consultation document a significant and surprising omission, particularly since this was a matter that in July 2012, as we pointed out above, Ofcom suggested it would need to specifically address in the spectrum fees consultation. Had Ofcom considered the matter in this consultation, it is clear that the only possible conclusion from the evidence available to it would have been that 900MHz is worth considerably less to an operator than 800MHz, since it cannot realistically be used for LTE for some time.

[8] Vodafone emphasis
[9] Vodafone emphasis

2. *There are good reasons for considering a larger discount between 800MHz market value and 900MHz market value than that generally obtained from historic, international auctions would be more appropriate*

Summary

As we have noted, the international benchmarking datapoints of a 20-40% value discount that Ofcom has developed are merely observational data, unsupported with any logical justification. Based on Ofcom's own work on spectrum, there are strong reasons to expect that the particular circumstances and conditions in the UK would indicate that had 900MHz and 800MHz been auctioned simultaneously, a higher value discount than Ofcom has generally observed overseas would have resulted.

Furthermore Ofcom needs to examine, but has failed to do so, whether matters have changed since the time of the auctions which it is using to indirectly estimate the value of 900MHz and 1800MHz spectrum in 2014. The problem for Ofcom is to set a forward looking value of the UK un-auctioned spectrum as at spring 2014. To do so Ofcom is making use of the UK Auction in February 2013 and applying international benchmarking data from 2012 and 2011. We can show that the position for UK mobile operators in 2014 is different from those faced in prior years, and that generally the value of spectrum is falling. This also leads to the conclusion that to the extent that the observed range of international value of 900MHz being between 60% and 80% of the value of 800MHz is to be adopted, then at the very most a value at the bottom of this range should be employed.

Since the drivers of UK specific differentiation and of post-auction change (both in the UK and generally) are in detail somewhat intertwined, we consider such factors as are relevant to the evaluation of 2014 UK spectrum value jointly in this section. They are:

- The post auction valuation necessitated by both the Direction and by Ofcom's general duties will lead to a lower level of un-auctioned 900MHz spectrum value than would occur if 900MHz and 800MHz had been auctioned simultaneously, as is the case in the international benchmarking examples that supply the relative values that Ofcom is applying

- Additional spectrum brought into use for LTE will be for providing additional capacity rather than coverage and will thus be of a lower value to operators

- New and more developed information has emerged since the time of the international auctions used for benchmarking on general future additional spectrum availability for mobile use. As the likelihood of future spectrum availability has increased, then the value of existing spectrum, and in particular when it is used in an incremental LTE manner, will have fallen.

- Furthermore Ofcom's own increasing and more certain prioritisation of spectrum release in the UK, encapsulated in the mobile data strategy consultation released in November 2013 further increases UK operator confidence about the availability and timing of alternative bands. This will serve to push spectrum values down further, magnifying the necessary value discount from the historic UK auction data.

- When used for capacity provision, differences between bands and thus differences in value to the operator, are not substantial. In other words 1800MHz is nearly as good as 900MHz at providing capacity, and that this difference is more relative than absolute, in that Ofcom's own data suggests that 1.15 units of 1-2GHz spectrum can provide as much capacity as 1 unit of sub1GHz spectrum. Spectrum is thus very substitutable, particularly since all operators already have some sub1GHz spectrum in their possession.

- Ofcom's licencing approach has in the UK created at least two different types of spectrum, lowering the relative utility and value of 900MHz spectrum

We discuss these factors in more detail below. The conclusion that inevitably arises is that at the very most the present value of 900MHz spectrum in the UK is no more than 60% of the past auctioned market value of 800MHz spectrum, and may very well lie below this level.

In the UK there is a need for sequential, not simultaneous valuation of 900MHz

In the international auctions which Ofcom examines where both 800 MHz and 900 MHz were auctioned, this process took place simultaneously. By observing Ofcom's methodology applied in the 900MHz valuation, we can concluded that in its present consultation, Ofcom is, in effect, assuming that the value of non-auctioned 900MHz spectrum can be best derived from pretending that it had been auctioned, and that such a hypothetical auction occurred simultaneously with the 800MHz/2600MHz auction, without in any way changing the value of the spectrum that was in fact made available to mobile operators in the auction. However there is no explicit recognition or discussion in the present consultation that Ofcom has made either of these assumptions. It is clear to Vodafone that had Ofcom examined these assumptions it would have concluded that neither of them can be correct. We consider this below.

To derive a proper view of the value of 900MHz in the UK for the purpose of setting forward looking spectrum fees, it must be considered that any valuation of 800MHz from the auction and 900MHz are not and should not considered to be simultaneous events.

Ofcom is in fact required by the Direction to revise the spectrum fees for 900MHz and 1800MHz **after** completion of the Auction:

> "*6.—(1) After[10] completion of the Auction OFCOM must revise the sums prescribed by regulations under section 12 of the WTA for 900MHz and 1800MHz licences so that they reflect the full market value of the frequencies in those bands.*
>
> *(2) In revising the sums prescribed OFCOM must have particular regard to the sums bid for licences in the Auction*."

This means that the market value of these bands must be derived not simultaneously with the auction, but as a subsequent act. In any event, Ofcom's general obligations suggest that the valuation of the bands must be a forward looking one. Given that the statement that will accomplish this task will at the best be published in spring 2014, at least a year after the auction, it is very clear that the post-auction landscape is the relevant context. For Ofcom to use only data or information from a fixed point in time, namely the conclusion of the auction in February 2013, would mean that Ofcom had

[10] Vodafone emphasis

quite deliberately deprived itself of the opportunity to make enquiries of and take into account all relevant facts and circumstances when undertaking its regulatory function. That approach would mean that Ofcom's analytical framework itself was deficient and incapable of adapting to changing facts and circumstances. It is difficult to see how this is consistent, in administrative law terms, in the first place with the principles to which any public body must adhere in performing its role. That is no doubt why Parliament, in the context of the sector specific regulatory framework, requires through the Communications Act that Ofcom must operate in accordance with principles of best regulatory practice. A decision by a regulator engaged in a review of a matter with very considerable consequences for industry stakeholders and consumers to rule out consideration of new developments raises material concerns about the legality of its procedural and substantive approach.

In effect therefore, 900MHz spectrum can in the UK be only valued after the fact of the UK auction. Thus must mean that it will be made in the context of the post-auction holdings of the operators[11]. It would be wrong in the UK to value 900MHz from the pre-auction spectrum holdings alone. Quite clearly the spectrum holdings of the mobile operators have changed very significantly as a result of the auction. Before the auction, excluding the quarantined divestment spectrum and the unpaired 2100MHz spectrum, operators held in total 2*151.4MHz of usable spectrum. Of that total, only 2*10MHz was available and capable of LTE use, and that was in the hands of one operator only. After the auction, again ignoring the unpaired spectrum[12], operators held in total 2*266.4MHz of spectrum, of which 2*135MHz was ready for LTE use – all operators held some LTE capable spectrum, and further all operators held some sub1GHz LTE capable spectrum. All operators had sufficient spectrum to launch LTE services, and all did so by the end of 2013, i.e. before the relevant date for evaluation of 900MHz market value.

Unlike markets where 800MHz and 900MHz spectrum was auctioned simultaneously, the market values of 900MHz and 1800MHz spectrum are likely to be lower when valued sequentially because operators will know post-auction what other frequencies they (and their rivals) hold and will be able to value any increment of spectrum in the context of the use they will make of the spectrum they now hold - a knowledge which they did not previously have. As we discuss elsewhere in this Annex, it is wrong to attempt to value any one spectrum band in isolation.

In reality any forward looking valuation of a particular band must be made in the context of the multi-band portfolios of all mobile operators resulting from the auction. Therefore, the effect of the auction, by satisfying the immediate demand for spectrum with which to launch the competitive 4G services that will rapidly become the major component of mobile activity in the UK (and thanks to the particular Auction outcome which means that all major mobile operators now have some low-frequency spectrum in the form of 800MHz) this must mean that the forward-looking value of the non-auctioned spectrum will inevitably be lower than prior to the auction.

Ofcom in its preparatory work for the auction, for example in designing the auction rules, made clear that no particular spectrum band can be valued in isolation. The process it undertook to consider the minimum quantity and band of spectrum that each operator needed to acquire in the auction was made in the context of their pre-auction spectrum portfolio, evaluated in the round. A similar conclusion on the shift in the spectrum landscape arising from the auction can also be drawn from reference to the

[11] Or more strictly in the light of the spectrum holdings in spring 2014
[12] But including the divestment spectrum

DotEcon/Aetha work that was carried out in July 2012 to assist Ofcom in the setting of reserve prices for the auction. One of the methods used was a large technical model developed by Aetha. The basis of the Aetha technical modelling was to value the prospectively to be auctioned spectrum on a forward looking basis in relation to the need of each operator to acquire spectrum in the auction to deploy LTE services, **given their pre-auction holdings**. It did this by scenario comparison – for example between the positions where an operator obtained no spectrum from the auction i.e. merely continued with its pre-existing portfolio and attempted to launch LTE (or at least high speed data services) from its existing spectrum resources, with various other scenarios where differing quantities of spectrum were acquired in the auction.

But the situation is now different: the auction is over, and Ofcom is attempting to value non-auctioned spectrum after the fact of and thus in the light of the auction. Any scenarios that Aetha has used to derive values of auctioned spectrum have very obviously been superseded by the actual auction outcome. The logic of the Aetha approach if it were to be applied in the current context would be to recognise that the post-auction spectrum landscape[13] is considerably different from the pre-auction one. If Aetha's modelling methodology were to be applied to the post-auction position, it would use as its starting point the current, post-auction holdings of LTE spectrum, and then by varying the supply of other incremental LTE spectrum attempt to consider differential LTE strategies and costs from this baseline in order to derive a valuation of the non-auctioned spectrum. It is quite obvious that were such a modelling approach to be attempted, a very different, lower outcome than the 2012 outputs of the Aetha model would be the result for the non-auctioned spectrum.

The Aetha model is not in itself capable of making such an analysis as the model would require too much modification to properly reflect the post-auction position and to consider the impact on the commercial and technical value of incremental spectrum, but the point stands – before the auction operators held only 2*10MHz of spectrum that was free and available to be used for 4G, whereas after the auction some 2*135MHz of LTE capable spectrum was in the hands of the operators. The value of the non-auctioned spectrum to operators has very clearly been lowered by the auction, so any forward looking valuation of the non-auctioned spectrum that takes place in 2014 should take account of this fact by selecting a value towards the lower end of the discount range provided by international benchmarking.

Additional spectrum brought into service for LTE will be used for providing capacity rather than basic coverage and thus will be of a lower value to operators

What is more, given that the cost for this 800 MHz spectrum is now sunk, it has indefinite title and total cost certainty over the next 20 years, it can form part of the 'core' low frequency holding for all four major UK operators. All mobile operators launched LTE services by the end of 2013 and are planning to establish extensive coverage networks with their existing LTE capable spectrum (for three out of the four operators this is being done using the spectrum acquired in the auction and/or by the divestment spectrum). This will lead to wide area coverage in the UK of LTE being established. As we discuss in Annex 9, in order to achieve 98% indoor coverage, UK network operators are building 18,000 plus sites[14]. These sites, and the density with

[13] Including the 1800MHz divestment, the outcome of which was not known at the point of the DotEcon appraisal

[14] Ofcom report on the availability of communications services in the UK, May 2013 at paragraph 5.53

which they occur in urban areas, will give a very considerable initial capacity to LTE networks. In addition, the future rise in spectral efficiency will further increase the carrying capacity of macrosites with the currently capable LTE spectrum.

Once such coverage has been established, the need for future network expansion primarily relates to increasing capacity demands, where the demanded traffic density exceeds the current supply provided by the installed equipment using the existing LTE capable spectrum at the current levels of spectral efficiency. But as seen above 900MHz spectrum is not currently LTE capable. Any additional spectrum such as 900MHz that is in the future brought into use on top of the basic LTE coverage layer which has been deployed will therefore be used principally for capacity, rather than coverage.

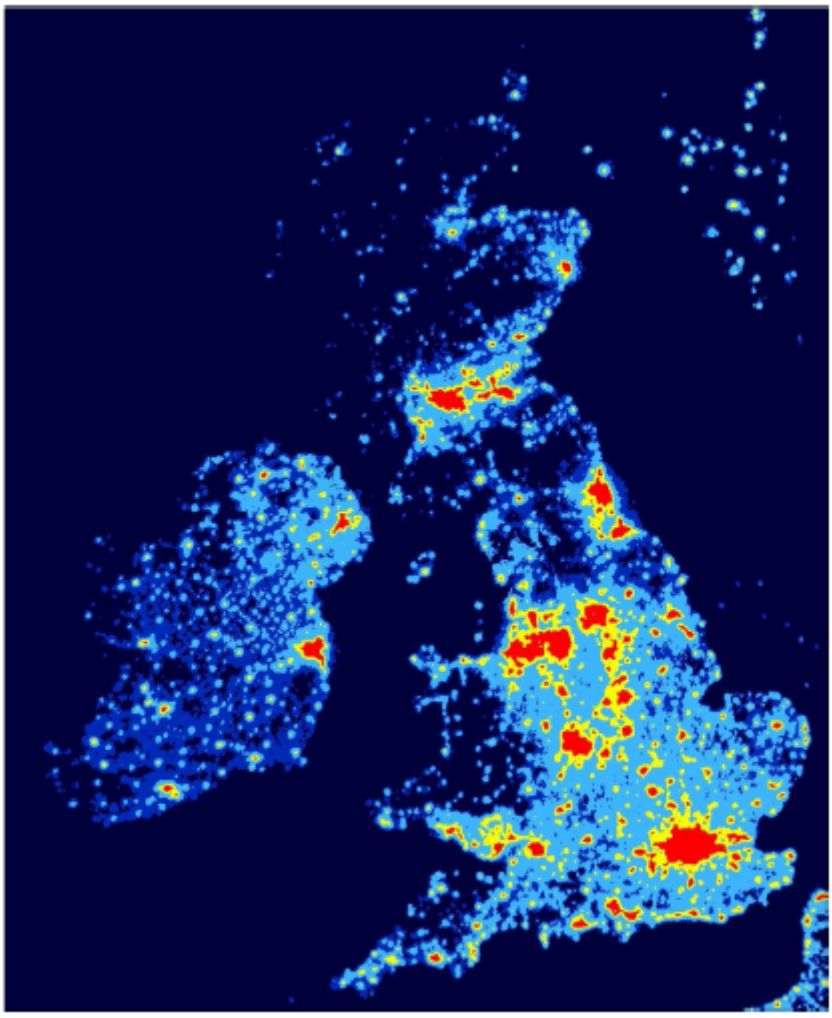
Traffic demand however is clearly irregularly distributed across the UK so that as overall traffic grows some areas will need additional spectrum earlier than others, and some areas may not need additional spectrum at all. As a consequence the need for incremental spectrum will vary across both space and time. Under these circumstances each successive incremental unit has a lower value to the operator than previous increments.

When 900MHz does become usable for LTE in the UK, it will be available to be used in an established ecosystem of 18,000+ sites. The function of 900MHz spectrum will therefore be to increase capacity where required, in traffic intensive sites, but only in those sites.

An interesting pictorial illustration of the variability of demand across the UK is provided by the light pollution map below[15] supplied in a recent Ofcom document.

[15] Ofcom: the availability of communications services in the UK, May 2013

Figure 1. Light pollution in the UK



Source: Campaign to Protect Rural England.

This is obviously not totally representative of the distribution of mobile demand, given the variation between where people may be when they use a mobile service vs. where people live, but it is a useful graphical proxy.

So the incremental spectrum will not be needed at all sites and in all time periods.

- Given the asymmetric spatial distribution of traffic, each additional increment of spectrum is needed in a progressively smaller area, and thus the value of each increment in terms of the incremental traffic that it needs to carry falls. This effect is exacerbated when revenue does not increase linearly with traffic volume[16].

- This is obviously a single year analysis; if we assume that in the following year the demand curve moves upwards but preserves the same spatial distribution, then an increasing number of sites over time will be avoided by a particular spectrum band increase. But each subsequent increment of spectrum will be required later and across a smaller area than the previous increment.

[16] We consider this in section 3 below

From a present value point of view therefore, the first spectrum band will avoid a larger total cash outflow over an extended period (in terms of cell site provision) than any subsequent bands. Therefore subsequent spectrum additions will have a lower incremental value than the initial spectrum coverage bands currently being deployed, that are needed at a larger number of sites. In other words, since 900MHz spectrum will only be used in the UK for LTE to provide incremental capacity on top of the already provided coverage layer, it is inevitable that its value will be substantially discounted from the 800MHz auction value.

New general information on future additional mobile spectrum availability has emerged since the international auctions

Some of the improved, more certain data on the likelihood and timing of the provision of additional mobile spectrum to provide high speed mobile data services has emerged generally – but some of the increased confidence on future availability is specific to the UK

New information generally

Ofcom appears to have done nothing to update the outputs of its benchmark auctions, notwithstanding that some of these are now up to 4 years old. For its benchmarking work on 900MHz, three of Ofcom's observations are for auctions in 2010, eight observations in 2011 and four in 2012. Of that, its 'more important evidence' comes from Greece and Spain in 2011 and Ireland and Portugal in 2012.

However there have been a number of developments since some of these auctions which have generally indicated that more spectrum will be available than previously considered and in generally shorter timeframes:

a) WRC-12, February 2012: Allocation of 694-790MHz to Mobile in region 1 and identification of this spectrum for IMT.

b) WRC-12, February 2012: Decision for agenda item for WRC-15 on future spectrum for mobile broadband, and the subsequent work in ITU and by Ofcom

c) Radio Spectrum Policy Programme; published on 14th March 2012: Article 3b) states that "every effort should be made to identify … at least 1200MHz of suitable spectrum [for wireless broadband] by 2015. It is important to note that the figure of 1200MHz does not appear in the Commission proposal for the RSPP of 2010, which only states "make sufficient appropriate spectrum available in a timely manner to support Union policy objectives". Therefore this represented a significant recognition by European policy-makers of the need to identify and release further suitable spectrum.

d) 2.3-2.4GHz: RSPG Opinion on Licensed Shared Access, November 2013 and the establishment of CEPT Group FM52, which first met in October 2012: "WGFM decided at its 64th meeting in April 2012 to establish a Project Team (PT) during its 65th meeting, with the aim to develop harmonisation measures in the band 2300-2400 MHz." A number of initiatives have been launched in 2013 targeted at enabling access to this spectrum widely across Europe, through the use of licensed shared access.)

e) 3.4-3.6GHz: Revision of ECC Decision (11)06; Consultation on draft closed in November 13 and now expected to be finally approved by ECC in March 14.

f) Finally, we understand momentum is building for an agenda item for the WRC after WRC-15, to consider further spectrum for mobile broadband at higher frequencies. Ofcom is supporting this as a CEPT proposal, having consulted the UK Government Spectrum Strategy Committee.

Given the central role Ofcom plays in a number of these fora identifying, harmonising and releasing spectrum it needs to take these developments into consideration when seeking to interpret historic data from its international benchmarks as a guide to current market values.

Specific UK information and initiatives with respect to additional mobile spectrum release

The realistic (and timetabled) prospect of additional spectrum being made available for mobile use in the future has significantly increased as a particular element in the UK since the auction, as a result of Ofcom's ongoing efforts to provide sufficient mobile capacity to meet anticipated future demand for mobile data traffic. Ofcom's mobile data strategy document in November 2013 has effectively created a road map for future spectrum release. As we lay out below, this suggests that a further 1,250MHz or more of new mobile spectrum could be added by 2030 to the existing stock of 270MHz of LTE capable spectrum. But in terms of the measure critical to traffic capacity, the quantity of downlink spectrum usable for LTE, this under Ofcom's roadmap could rise from the 135MHz currently available to 1,043MHz, an increase of 670% (including the eventual transfer of spectrum occupied by legacy technologies to LTE). This also represents an increase of 60% on what was being assumed in 2012 by Analysys Mason as being available to mobile use by 2030.

It is becoming increasingly clear that in the UK a considerable proportion of this additional spectrum will become available to mobile operators before it is possible to fully refarm the existing 900MHz spectrum for LTE. This will mean that rather than 900MHz spectrum being the next increment of spectrum after the existing LTE spectrum obtained in the auction, it will be some increments further down. This factor will further reduce the relative value of 900MHz spectrum against 800MHz.

The mobile data strategy consultation is focussed on increasing the supply of mobile capacity to the benefit of the UK as a whole:

> *"1.1 The objective of our mobile data strategy is to identify and prioritise actions which Ofcom could undertake* ***to facilitate the continued long term growth in consumer and citizen benefits from increasing use of mobile data services***[17]*. In doing so we recognise that increases in the efficiency of delivering mobile data services, particularly through technology and network improvements, will be important for minimising the impact of this growth on other services.*
>
> *1.2 This document considers the challenges that rapidly growing demand for these services could raise and what this may imply for Ofcom's work over the coming years. In particular, we identify a number of spectrum bands where we think further*

[17] Vodafone emphasis

work should be carried out to consider their potential future availability for mobile data use, whilst recognising the many other competing demands for spectrum."

1.3 Mobile data services, and the applications they support, already deliver substantial benefits to UK citizens and consumers. These services include provision of mobile broadband to consumer devices such as smart phones and laptops as well as emerging machine-to-machine (M2M) communications, for example to cars. At the same time, the demand for mobile data is growing rapidly and there are reasons to believe that it could continue to grow materially in the future.

1.4 ***Meeting this growing demand could substantially increase the benefits of mobile data services to consumers, and the UK economy more generally***[18]*. Sustaining mobile data growth, in particular the delivery of high-capacity services to rural areas, could also make a significant contribution to citizen benefits, contributing to digital inclusion and facilitating social participation.*

There is now a concerted effort (in which Ofcom is playing a major part) to release more spectrum, in a manner that is significantly more definitive, planned and organised than was the case at the time of the UK combined spectrum auction.

Quantification of current and potential future spectrum

The mobile data strategy document provides a detailed list of candidate bands, together with likely timings of release and potential volumes. Ofcom in any analysis of forward looking non-auctioned 900/1800MHz spectrum value needs to consider the impact of this additional spectrum on overall spectrum value but has not done so. Other things being equal, the more spectrum that is available, the fewer the additional site builds that are required. Indeed avoiding this expenditure in the future is an explicit purpose of making mobile spectrum available to mobile operators. The effect therefore of adding additional spectrum will be to lower the marginal value of spectrum increments.

The post auction position with respect to paired spectrum holdings and their use, as of July 2013 (accounting for the EE launch of 2*20MHz of 1800MHz for 4G in that month) was:

- 2G: 2*24.8MHz of 900MHz plus 2*36.6MHz of 1800MHz = 122.8MHz, and falling as EE releases further 1800MHz spectrum from 2G to 4G;
- 3G: 2*10MHz of 900MHz plus 2*60MHz of 2100MHz = 140MHz;
- 4G: 2*35MHz of 1800MHz (and rising), 2*30MHz of 800MHz, and 2*70MHz of 2600MHz = 270MHz;

This is a total of 532.8MHz of spectrum (it excludes the 65MHz of unpaired spectrum at 2100MHz and 2600MHz). At least 51% of the total is available to be used by 4G, 23% is occupied by 2G, and 26% is occupied by 3G.

Given that the demands of data on radio spectrum are asymmetric, with more data downloaded than uploaded, the critical dimensioning element impacting traffic carrying

[18] Vodafone emphasis

capacity is the quantity of spectrum in the download link, of which the current 4G capable supply is half the total of 270MHz, or 135MHz.

A previous very provisional estimate from Real Wireless work for Ofcom in relation to DTT[19] in 2012 shows an estimated increase to 650MHz of downlink spectrum to 2030. (This chart is of spectrum used by both 3G and 4G rather than just 4G, so the opening position is higher than a purely 4G only view would be.)

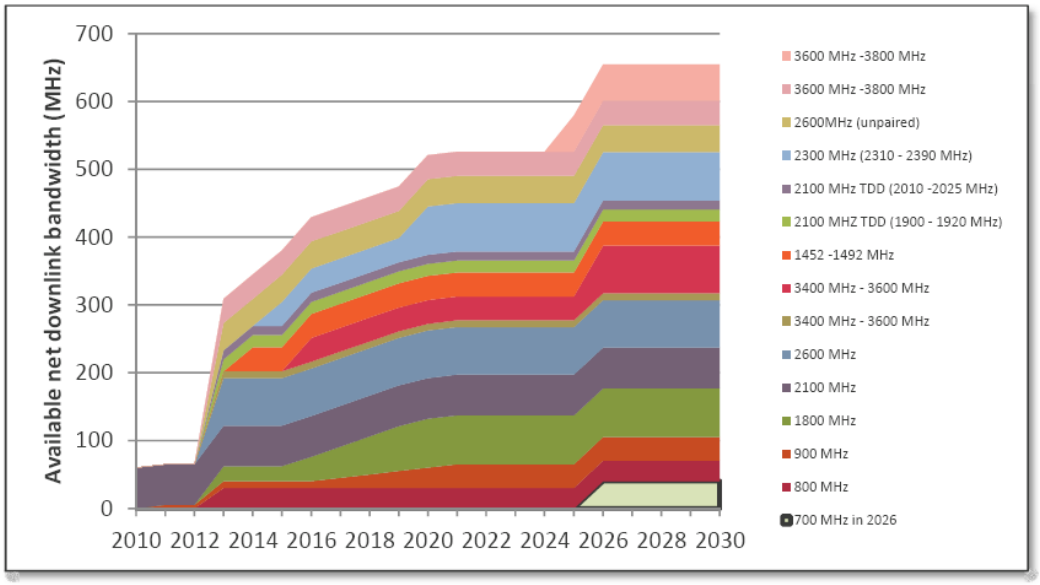


Figure 1-11: Illustrative spectrum scenario, representing the available harmonised standardised spectrum for downlink traffic over the study period. Mid scenario, with 700 MHz available from 2026

But in fact this is now somewhat out of date – for example it is very likely that as a result of Ofcom's subsequent analysis that in the UK 700MHz spectrum will become available for mobile use significantly earlier than the year of 2026 being assumed above: Ofcom is now suggesting 2020. Furthermore Ofcom has more recently in the mobile data strategy document identified further opportunities of additional spectrum bands. It is also worth considering that these timings made in 2012 were not Ofcom's view, rather those of an analyst working for Ofcom.

In the mobile data strategy document of November 2013 Ofcom identifies potential target spectrum bands and quantities, and sets a prioritisation of each one as follows:

[19] Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030, A report for Ofcom, March 2012

Table 1: Proposed prioritisation of bands for potential future release

Relative priority for potential release	Bands for consideration
Current priorities	• 700 MHz • 2.3, 3.4 GHz • UHF white space
High	• 1452-1492 MHz • 1980-2010 / 2170-2200 MHz (2 GHz MSS) • 3.6-3.8 GHz • 5350-5470 MHz, 5725-5925 MHz
Medium-High	• 2.7-2.9 GHz • 3.8-4.2 GHz
Medium	• 450-470 MHz[4] • 470-694 MHz • 1350-1518 MHz

Ofcom's view from table 17 of annex 7 of the mobile data strategy document estimates that by 2030, including all of the four categories above, the available downlink spectrum could be as much as 1,043MHz. This represents a very substantial increase of 670% on the 135MHz currently available for LTE downlink. But more importantly, it is an increase of 60% on the volume contemplated by the Real Wireless work for Ofcom in 2012 – this is a very significant increase since the Auction.

In terms of timing, Ofcom[20] suggests that the current and high priority spectrum releases could be available for mobile use by 2020, the medium-high spectrum from 2020 to 2025, and the medium priority bands around 2030. This is shown in Ofcom's table 7 below.

[20] Noting that this is Ofcom, not Analysys Mason making these assessments of both timing and quantity of spectrum release

Table 7: Potential timing if bands are made available for mobile data

Relative priority	Bands	Potential timing of availability *if* made available
Existing bands (re-farm)	900 MHz, 1800 MHz	These bands are already being partially re-farmed; by 2020 we expect them to be almost completely re-farmed for mobile data use.[41]
Current priorities	2.3 GHz, 3.4 GHz, 700 MHz	The 2.3 GHz and 3.4 GHz bands are planned for release in 2015 – 2016. Timing of 700 MHz release is still uncertain; however if released it might be available around 2020.
High	1452-1492 MHz	Currently going through CEPT process, devices may be available from 2015.
	1980-2010/2170-2200 MHz	Currently subject to enforcement process coordinated at EU level and therefore difficult to assess timing at this stage.
	3.6-3.8 GHz (adjacent to release of MOD spectrum at 3.4 GHz)	Currently subject to harmonisation activity in EU. Might be available for use on shared basis by 2017-2020
	5 GHz Wi-Fi extension	Potentially supported in devices from 2016-2018
Medium-High	2.7-2.9 GHz	Potentially by 2020 - 2025 depending on how much and how spectrum is released.
	3.8-4.2 GHz	Potentially 2020 onwards – depending on extent of relocation of existing earth stations (if any)
Medium	450-470 MHz, 470-694 MHz and 1350-1518 MHz	These are more likely to be longer term prospects and the timing is highly uncertain at present. Potentially around 2030.

With respect to the timing of the refarming of the 900MHz and 1800MHz spectrum in the top row of Ofcom's table 7 above it is clear that under discussion is the transfer from 2G to **either** 3G or 4G in that Ofcom is considering both 3G and 4G as providing mobile data use. Footnote 41 to table 7 states: "*A small amount of spectrum may continue to be used to provide 2G services. For the purposes of our capacity illustrations we assume that 2 x 5 MHz is used for 2G services out to 2030*". However as we made clear in our response to the EE 1800MHz liberalisation consultation, we do not see 3G even under HSPA+ to be anything like the equivalent of 4G.

Ofcom is thus not stating in the table above that it is assuming that 900MHz will be completely re-farmed to 4G by 2020. Therefore it is reasonable to conclude that Ofcom's own timings suggest that its "current priority" spectrum of 700MHz, 2.3GHz and 3.4GHz (which according to Ofcom in table 17 of the mobile data strategy document will provide some 191MHz of download spectrum) will become available to operators for 4G use before the 35MHz of download 900MHz spectrum can be so used. This new development very much suggests that 900MHz has moved "down the queue" in the expectation of future incremental LTE use. Such a move can only mean that the relative forward looking value of 900MHz vs. 800MHz in the UK has fallen further since the auction than that observed in the historic international auctions.

Implications of the increasing confidence in future spectrum availability

Very clearly it is not only the non-auctioned 900MHz spectrum that can be considered as being capable of providing any necessary incremental LTE spectrum on top of the basic LTE coverage deployment – all of the additional spectrum release contemplated in the activities above can and will be used for incremental LTE capacity.

Increasing confidence in the availability of additional spectrum changes the valuation of spectrum. The 2012 Aetha model described above used in its modelling of value only the pre-auction and auction spectrum. The 2013 Analysys Mason model added 700MHz spectrum as well. It is quite clear that any valuation model constructed in 2014 would need to include considerable further spectrum when modelling a network operator through to 2034.

The availability of additional mobile spectrum dilutes, and continues to dilute the need for 900MHz to perform such a role – it follows therefore that this will have lowered the value of 900MHz in 2014 against the fixed relative values of past historic auctions. Past auction value discount percentages between 800MHz and 900MHz thus understate the appropriate percentage to use in translating the UK 2013 800MHz market value to a 2014 900MHz market value.

The greater the number of alternatives for meeting the same underlying demand, the lower the incremental value of any one of those alternatives, and the greater the substitutability between bands. This factor will also tend to increase over time the value differential between the basic 800MHz coverage spectrum value from the auction and the forward looking value of additional incremental capacity spectrum such as 900MHz.

Ofcom's initiatives to provide more spectrum are thus likely in themselves to drive down the value of incremental spectrum. Ofcom to a very considerable extent thus "owns" at least one of the levers of long run market value, supply (and can also affect demand provision by modifying the price of spectrum).

But there are two further factors that need to be considered on the relative valuation of particular bands – the difference in utility between the different bands in providing additional capacity, and whether the licencing regime may itself impact prioritisation of use. These are considered below.

When used for capacity provision, differences between bands and thus differences in value to the operator, are not substantial

The traditional view of the value of spectrum is that low frequency spectrum is very much more valuable than high frequency spectrum to the mobile operator. But with LTE this is not as true as it used to be. It may be correct to say that coverage may be better achieved by lower frequency spectrum. Other things being equal, a lower frequency spectrum band requires fewer sites to achieve a particular percentage of population coverage than a higher frequency band. Furthermore a lower frequency band is arguably preferable for indoor coverage – but Ofcom's own data on this particular point that it developed for the Auction is somewhat equivocal.

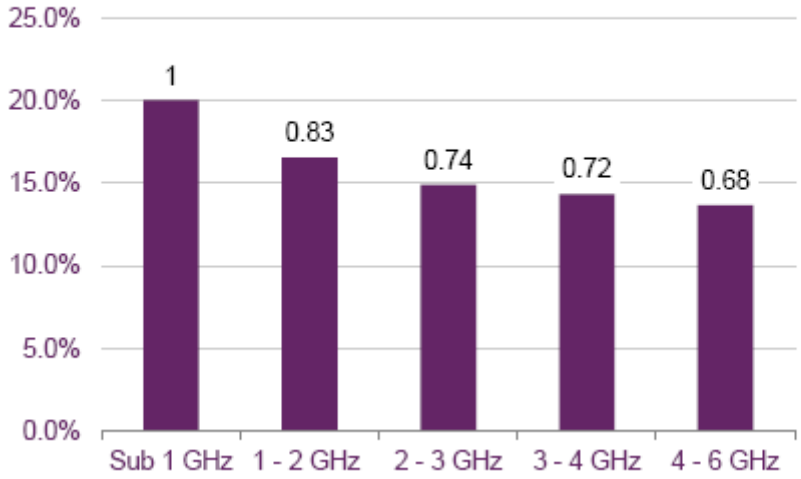
But these considerations apply much less in relation to capacity increases on top of an already existing coverage band, especially where 18,000 plus coverage sites will have already been provided in the UK. To overlay additional capacity on top of this dense network, the frequency of the spectrum band with which that capacity is added is potentially less critical than the quantity of spectrum that is available. As a consequence the long run value of different bands for future LTE use is narrowing.

This is exactly the conclusion of Ofcom's mobile data strategy document. Having identified all the bands of potential mobile spectrum listed out in the section above, the mobile data strategy document in section 7 attempted to quantify the effective capacity that could be added by all the additional bands collectively, taking into account the expected increase in spectral efficiency. In order to be able to derive this result, Ofcom needed to build up a view of the relative ability of each band to provide an effective capacity increase in the UK. This work is in Annex 7 of the mobile data strategy document, and builds on the extensive work previously done by Ofcom in the pre-auction documents, particularly in the July 2012 statement.

Ofcom developed an analysis using four simulation areas to represent different population densities of the UK, with the reasonable assumption that 18,000 sites had already been established for coverage across the UK. As we understand it, in each of these simulation areas, with a given density of already established sites, Ofcom evaluated for each spectrum band, how much additional effective capacity could be provided by that particular band. These results were then extrapolated from the simulation areas to the UK as a whole.

The output of this calculation is in figure 18 below.

Figure 18: Increase in capacity in 2020 relative to 2012 as a result of a 50 MHz increase in spectrum availability at different frequencies



Ofcom's own analysis shows therefore that across the UK the weighted average difference between the bands in their ability to provide additional capacity is relatively small, in that 1800MHz might provide per Hz of spectrum only 17% less capacity than 800MHz, and 2600MHz only 26% less capacity than 800MHz and 11% less than 1800MHz. These results are not that surprising. Demand is highest and has most need for capacity expansion in the most densely populated areas. But it is in these locations where site areas are smallest and thus any area coverage disadvantage of

higher frequency is heavily damped down, especially as these areas are also those most likely to be able to economically take advantage of small cell traffic offload of traffic hotspots.

What this basically means is that the addition of new sub1GHz spectrum to current operator LTE deployments is not absolutely essential. Rather it means that to provide additional capacity to existing networks 1.15 units of 1-2GHz spectrum are as good as 1 unit of sub1GHz spectrum. This further enhances the likelihood discussed above that as additional spectrum is made available to mobile operators, the need to prioritise the deployment of 900MHz for LTE declines – thus 900MHz can move down in the queue, and its value reduces as it becomes used later in time and across a smaller area.

Load balancing

An additional factor that may further reduce the difference between additional bands for an operator that already operates a multi-band portfolio is described by Ofcom in the mobile data strategy document as "load balancing"[21].

> "*5.35 Load balancing refers to traffic management at the network level aimed at optimally distributing traffic across different network layers and different frequencies. Load balancing can for instance reduce congestion by appropriately managing traffic between different type of base station (e.g. between macros cells and small cells). It can also allow better utilisation of different frequencies by for instance reserving lower frequencies for users in harder to serve locations.*
>
> *5.36 Load balancing increases the effective spectral efficiency of the network thus mitigating the overall demand for spectrum. It may also help to reduce overall demand for additional low frequency spectrum as this can be more efficiently targeted on users in harder to serve locations."*

It is obvious that through this means any disadvantage of a higher frequency band can be further minimised by an operator that holds a mixed portfolio of higher and lower frequency bands, as is the case for all operators in the UK. This leads to the conclusion that spectrum values will not only fall but also converge between relative bandwidth values when the spectrum is used for providing additional capacity, subject to network infrastructure and device availability, existing use of spectrum, and other constraints.

Converging values of spectrum

The same point on the likelihood of a future convergence of values of spectrum for capacity was made by Analysys Mason in a 2012 paper[22]:

- *"Operators should re-evaluate the difference between high- and low-frequency spectrum as capacity becomes more important than coverage. Current wisdom*

[21] We believe from the way that Ofcom has derived figure 18 above that it has not been able to take account of load balancing in its calculations – if it were to do so, then the relative differentiation between frequency bands for a mobile operator with a multi-band portfolio could be further reduced.

[22] Analysys Mason March 2012 – Spectrum valuation – critical strategic, technical and commercial factors for operators and regulators

on spectrum valuation may be overturned as capacity, rather than coverage, becomes the driving force behind the need for more spectrum. The difference in value between high- and low-frequency spectrum may be overstated, and appears to be diminishing over time. A renewed focus on capacity, greater availability of spectrum in low-frequency bands and the development of a high-frequency LTE device ecosystem (brought about by the early availability of high-frequency LTE bands) will all contribute to this trend.

- *Regulators should expect the premium for low-frequency spectrum to diminish as LTE900 devices become available and 700MHz spectrum is allocated. Operators are prepared to pay a premium for spectrum in the 700MHz and 800MHz bands because:*
    - *LTE devices are available for use in those bands – unlike the 900MHz band, for which only UMTS, not LTE, devices are available*
        - *spectrum in the 700MHz and 800MHz bands is better suited to deployment of LTE services than that in the 900MHz band, which tends to be assigned in smaller blocks for GSM in many countries.*
        - *Allocation of 700MHz spectrum in some countries, and the eventual availability of LTE900 devices, will relieve the scarcity of sub-1GHz spectrum. This, together with capacity planning for future mobile services, will tend to even out the price differential between high- and low-frequency spectrum."*

This is not an unexceptional conclusion. Ofcom is very aware that the value of spectrum can change over time. Ofcom, in a recent consultation on 28GHz licence variation requests[23] reports a significant change in auctioned spectrum prices. In 2000, "*the prices paid in 2000 for each 15-year licence were £38,160,000 for 16 regional packages[24]".* However the prices paid in 2008 for a larger set of packages was £320k, i.e. 100 times less than the total received from the previous auction, but for rather more spectrum.

In relation to 3G mobile spectrum, the Competition Commission observed that[25]:

"2.5.43. We consider that the evidence clearly points to a very significant difference between the expectations that prevailed at the time of the auction and the market reality as at March 2007. That does, in our view, render the auction fees from 2000 a problematic guide to the forward-looking value of 3G spectrum. If they are to be used as a proxy at all, the expectations prevailing at the time of the auction need to be properly understood so that errors are not made when it comes to any scenario analysis."

"*2.3.45. We do not consider that the statutory section and Article relied upon undermine Ofcom's decision to focus on forward-looking costs and efficient price signals. Whilst Ofcom was undoubtedly under an obligation to have*

[23] Variation of 28 GHz Broadband Fixed Wireless Access Licences, Consulting on licence variation requests by Urban Wimax and Cable & Wireless Consultation, December 2012
[24] At paragraph 5.3
[25] Competition Commission - Mobile phone wholesale voice termination charges Determination 16 January 2009

> *regard to the extent of the investments made in 3G spectrum, in the light of the other objectives that the legal framework includes, such as promoting efficiency, competition and the interests of end-users, that obligation cannot have extended to a requirement to use a historic valuation rather than a current one, or to focus on cost recovery rather than providing efficient price signals."*

In this instance the CC is clearly observing that a historic auction cannot be used as a reliable forward looking guide from 2007 even for the same spectrum that was auctioned. The principal reason for this is that the position on the use of the 3G spectrum bands has changed over time. The point must obviously be even more relevant in the present circumstances, when it is a different spectrum band from the one auctioned that is under consideration.

In this present case we have already made the point in this annex that the value of 900MHz cannot be construed as being similar to the historic auction market value of 800MHz, and must be considerably discounted from any such auction derived value. Our point here is that the elapsed time since the auctions not only the UK Auction but also the previous international auctions has also brought changes that are relevant to the forward looking value of Ofcom's anchor point of 800MHz – in particular the increasing certainty of the availability of new mobile spectrum, marked by publication since the current consultation of the mobile data strategy document and the considered view from that document that the difference between the spectrum bands with respect to the ability to provide coverage is rather less than generally supposed.

The relevance of this to the relative valuation of 800MHz vs. 900MHz spectrum is straightforward. Given that 900MHz will be used for LTE for adding capacity, the fact that such a band is only 17% better at providing such capacity enhancement than say 1800MHz and 26% better than 2100MHz or 2600MHz suggests that it is by no means axiomatic that 900MHz will be considered to be the automatic first choice capacity increment. For all the other reasons discussed elsewhere in this section, it is quite likely that 900MHz will be by no means the first such increment. Given the rising substitutability of spectrum bands and the increasing availability of alternatives, it can be expected that in the future, in the UK 900MHz will very much be a less important source of additional capacity. This strongly suggests the need for a substantial value discount between 800MHz and 900MHz.

Ofcom's licencing approach has created in the UK at least two different types of spectrum, lowering the relative utility and value of 900MHz spectrum

The availability of an increasing number of bands suitable for mobile spectrum makes possible a certain degree of substitutability between them, particularly as was established in the previous section, there may very well be little effective difference between them in the provision of incremental capacity. Given the existence of such a choice, it then follows that other things being equal operators are likely to prioritise the bands they use based on both a total future cost of ownership basis and on a sunk cost versus future cost basis. Ofcom's existing licencing policies have clearly created at least two different types of spectrum when evaluating a choice between the use of alternate spectrum bands on this basis.

In the first category there is auctioned spectrum for which no further payment is needed, during the initial 20 year period of the licence. We can presume based on past

practice and present indications that any additional spectrum will be made available to operators in this way.

In the second category there is what might be termed “pay as you go” spectrum, on which some form of annual licence fee is levied. In this category will fall both the 900/1800MHz spectrum that is the subject of the existing consultation, and any spectrum that passes beyond the first 20 years of its licence, such as 2100MHz after 2020[26].

Other things being equal, the logical best deployment strategy of these two spectrum classes that minimises forward looking costs is to maximise the intensity of use of first the “sunk cost” auction spectrum to provide coverage and the first layers of capacity, and then use only as a last increment the 900/1800MHz or 2100MHz spectrum on which annual fees are being paid. In these circumstances the marginal “ALF-able” spectrum will be used as the last increment, and hence will be the least used or needed, and thus the least valuable to the operator.

At the very least this would suggest that 700MHz spectrum will rank above 900MHz in terms of LTE use and value, particularly if as seems likely 700MHz becomes usable for LTE before 900MHz. Furthermore the charging of a high annual fee for the 900MHz spectrum strongly risks that it will not be efficiently or effectively used.

[26] It is obviously not clear at the moment on what basis future 2100MHz spectrum fees will be set – if in 2020 the fees are set at a level that reflects the then current (lower) value this may well be inconsistent with the 2020 level of the 900MHz fee. This would distort the choice between 900MHz and 2100MHz in subsequent LTE deployment. This is a further argument to set the 900MHz fee conservatively.

3. Rising data demand does not translate into increased spectrum value

Summary

Ofcom has established that it is one of its priorities to facilitate the continued long term growth in consumer and citizen benefits from increasing the use of mobile services. However operators can only to provide the capacity that will allow such growth to occur when they can do so profitably.

- The total costs of supply of incremental capacity are those defined by cost modelling, i.e. a mixture of, or choice between additional cell site build and the provision of additional spectrum together with the associated network expenditure to allow that spectrum to be used.

- The total incremental revenue that is likely to be earned from the provision of such incremental capacity is likely to be limited

Therefore it is clear that high spectrum prices can act as a deterrent to the provision of additional capacity and may thus frustrate Ofcom's intentions of fostering mobile data growth, to the detriment of the UK as a whole. This also suggests that Ofcom should set annual spectrum fees conservatively to avoid this risk.

Falling incremental revenues compared with the incremental cost of supply put at risk the provision of additional capacity

The need for additional spectrum to be deployed in the future for LTE arises from predictions of rising demand for mobile data services. It is forecast that despite the rising spectral efficiency and the ability to offload traffic on mobile devices to wi-fi and integrated small cells, the level of rising data demand cannot be satisfied by existing spectrum in its existing use. However whilst the demand for mobile data may be rising the willingness to pay of customers for data is nowhere near linear to volume.

The previous sections have established that:

- Ofcom is planning to make available for mobile use considerable volumes of mobile spectrum;
- Spectral efficiency increases will increase the data throughput of each unit of spectrum;
- Spectrum beyond the coverage layer will tend to be used for providing capacity rather than coverage;
- Due to the non-homogeneity of traffic demand, each additional unit of spectrum will be required either or both later and in a smaller area than its predecessors;
- Differences in provision of capacity between bands in practical terms are likely to be small.

All of these suggest that from the mobile operators' point of view, the long run value of spectrum bands used for providing additional capacity is likely to converge, towards a low value that reflects the capacity provision opportunity of each band.

This issue however is magnified by considerations of revenue opportunity for the mobile operators. The Ofcom technical modelling approach used in the mobile data strategy consultation to develop the capacity provision ability of each band of spectrum pays no attention to the profitability of provision of such capacity by a mobile operator – it is implicitly assuming that mobile demand at all levels is capable of being supplied by a willing mobile operator in a way that is at least profit neutral.

But the falling intensity of need by operators for each incremental unit of spectrum is amplified in the UK by the falling marginal value (in terms of both revenue and profit) of incremental traffic, such that it is not at all clear that operators will actually install additional spectrum or build additional sites unless the total cost of ownership/operation of this increment is minimised. Under these circumstances a high annual spectrum licence cost will act as a very significant deterrent to provision of future supply of capacity. This will be to the overall loss of the UK as a whole, given the high value placed by Ofcom, the UK government, and consumers on the benefits of high volumes of mobile data.

The view that it is customers who drive greater value from data usage than operators can be seen from the Analysys Mason report for BIS and DCMS in 2012[27], where it was calculated that the size of the current and prospective consumer surplus (2011 £24-28bn, 2012-2021 NPV £246-314bn) was considerably greater than the producer surplus (2011 £6bn, 2012-2021 NPV £27bn).

We consider this below, separately from the position of the consumer and the mobile operator.

Ofcom is taking steps to ensure that the consumer will benefit from increasing the consumption of mobile data

The consumer benefits from the provision of high speed mobile services in the UK have been extensively discussed by Ofcom – not only from a national point of view, but also from a regional and rural viewpoint. The first paragraph from the Ofcom website on spectrum in relation to the 2013/14 annual plan states:

> "*Given the value to citizens and consumers of services that are enabled by spectrum, managing spectrum is a significant responsibility. To ensure maximum benefit is realized for UK consumers and citizens from spectrum use, we seek to provide efficient and effective access to spectrum, including incentives for its efficient use and to enable spectrum to move to higher value uses and users*."

Also the opening paragraphs of the mobile data strategy document state:

> *"1.1 The objective of our mobile data strategy is to identify and prioritise actions which Ofcom could undertake* ***to facilitate the continued long term growth in consumer and citizen benefits from increasing use of mobile data services[28]****. In doing so we recognise that increases in the efficiency of delivering mobile data services, particularly through technology and network improvements, will be important for minimising the impact of this growth on other services.*

[27] Analysys Mason Final report for BIS and DCMS, The impact of radio spectrum on the UK economy and factors influencing future spectrum demand, November 2012
[28] Vodafone emphasis

> *"1.3 Mobile data services, and the applications they support, already deliver substantial benefits to UK citizens and consumers. These services include provision of mobile broadband to consumer devices such as smart phones and laptops as well as emerging machine-to-machine (M2M) communications, for example to cars. At the same time, the demand for mobile data is growing rapidly and there are reasons to believe that it could continue to grow materially in the future.*
>
> *1.4* ***Meeting this growing demand could substantially increase the benefits of mobile data services to consumers, and the UK economy more generally[29].*** *Sustaining mobile data growth, in particular the delivery of high-capacity services to rural areas, could also make a significant contribution to citizen benefits, contributing to digital inclusion and facilitating social participation.*"

Later in the mobile data strategy document, in 3.20 and 3.21 Ofcom makes clear that its concern is of national supply of high-capacity services, rather than supply only in areas of maximum demand:

> *"Additional coverage,* ***in particular demand for increasingly widespread and homogenous coverage of high-speed services[30]****, will continue to be important for consumers and citizens[31]"*
>
> *3.21 Meeting this growing demand could substantially increase the benefits from mobile services to consumers, and the UK economy more generally.* ***Sustaining mobile broadband growth, including the delivery of high-capacity services to rural areas, could also make a significant contribution to citizen benefits, contributing to digital inclusion and facilitating social participation[32]****. Conversely, if the supply of mobile data services falls behind levels demanded, this could lead to a relative scarcity, resulting in higher prices and a loss of consumer benefit."*

It would be difficult therefore to overstate the importance to Ofcom of ensuring that high-speed mobile data services are provided across the UK. However, such supply can only be assumed to be likely to be made by the mobile operators where it can be considered to be profitable. Any such evaluation must be made by comparing the incremental revenue from provision with the incremental costs of supply, of which spectrum is potentially a key component. The opportunity for incremental revenue however, would appear to be limited

But it is not clear that operators will benefit from increasing the supply of mobile data (and hence not clear that they will be able to provide such supply)

The ability of operators to provide the additional capacity to meet any anticipated demand increase is dependant on the economics to the operators of such provision. A falling revenue per incremental unit of spectrum will mean that the value to operators of

[29] Vodafone emphasis
[30] Vodafone emphasis
[31] MDS at 3.20
[32] Vodafone emphasis

utilising incremental spectrum above that necessary to achieve basic coverage is diminished – this again suggests that 900MHz is worth significantly less than 800MHz.

If there is little or no additional revenue available to operators from the provision of additional capacity but such provision is expensive, then it is not at all obvious that the capacity will be provided. But given that high levels of usage are deemed by Ofcom to be to the benefit of the UK as a whole, then high spectrum charges that deter future investment in capacity are very clearly not a useful outcome for the UK as a whole.

Two recent forecasts of future UK mobile revenue are provided in the Analysys Mason report to BIS and DCMS referred to above, and in the (previously redacted section[33] of) the DotEcon & Aetha report to Ofcom July 2012.

Analysys Mason provides in figure 4.11 a forecast of mobile revenue:

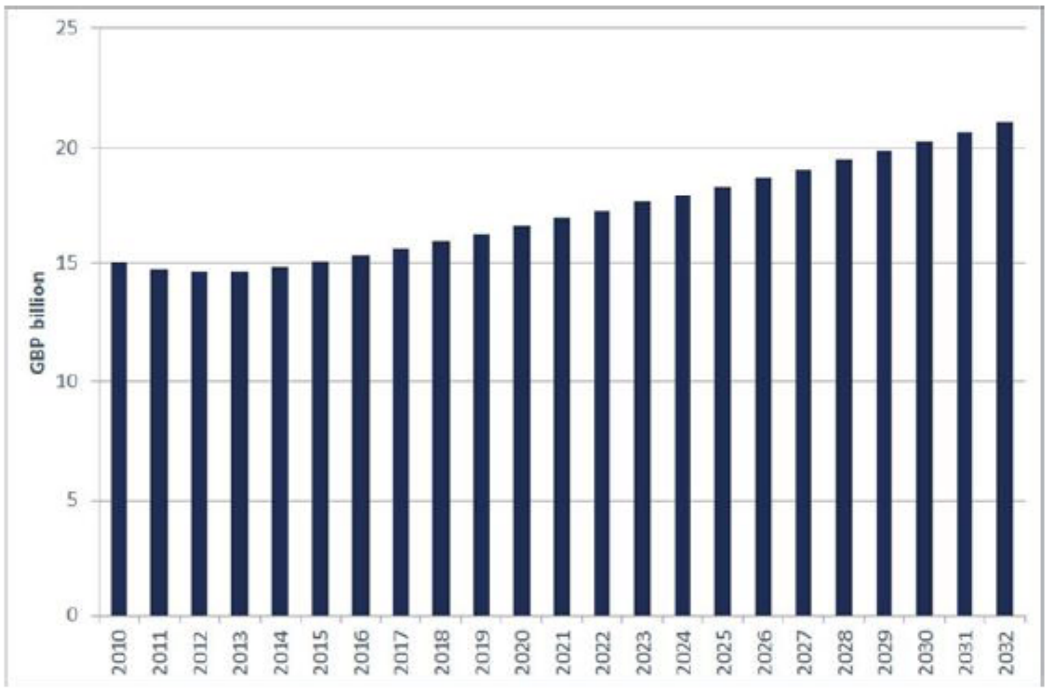
> *"Putting our forecasts for the number of users and the ASPUs together, and considering other sources of revenue (messaging, interconnect payments from fixed operators in the UK and foreign operators, etc.), we forecast fairly consistent total service revenue (in **nominal terms**[34]) of £18.3–19.8 billion for the UK mobile industry over the next decade (see Figure 4.11 below)."*

Figure 4.11: Total service revenue – historical values and forecast [Source: Analysys Mason, 2012]

DotEcon & Aetha, in their confidential report for Ofcom as part of the July 2012 auction statement, made a broadly similar conclusion. The assumption, from paragraph 165 of their report, was that spending per user would rise by 1% per annum in nominal terms – the basis for this assumption was not properly explained. (But clearly this is a decrease in real terms.) When applied to total users, the following calculation emerged.

[33] Only made visible as part of the current consultation process, at Vodafone's request
[34] Vodafone emphasis

Figure 8: Forecast evolution of total UK mobile market revenues



This total revenue outcome is below the Analysys Mason equivalent in 2021 but continues rising thereafter. The nominal increase we see on the chart is from £15bn in 2015 to approximately £21.5bn in 2032: however in real terms, there is an expectation of a fall in revenue, as clearly there is as well in the Analysys Mason revenue forecast.

We can conclude from these studies that there is no real expectation that operators will be able to extract substantial additional value from the provision of additional spectrum to satisfy the additional data demand – certainly not in any linear way in relation to traffic volume and potentially not at all in real terms. It is very difficult to tie this in with the spectrum fee proposed in the consultation that is flat only in real terms.

Conclusion

The Analysys Mason study above very clearly establishes that the most valuable use of spectrum is mobile. But high spectrum fees will act as a deterrent to the provision of data capacity. If there are considerable to benefits to consumers from the consumption of increasing quantities of data, but there is no certainty of any significant revenue increase available to mobile operators, then it is not axiomatic that such additional capacity will be capable of being economically provided by the operators, and this will be to the detriment of UK plc.

The impact of this is most likely to be felt in rural areas of lower traffic. In urban areas where traffic is dense, it may, depending on circumstances be economical to increase the number of sites so as to accommodate the traffic increase by sharing it across more sites without acquiring additional spectrum. However this option is much more unlikely to be possible in rural areas.

High mobile spectrum fees therefore where they are above the opportunity cost level of alternative use, will not be to the benefit of the UK as a whole, but may act most adversely in rural areas.

4. Conclusion on 900MHz vs. 800MHz relative value in the context of long run 900MHz fee setting

As we mentioned above, Ofcom's own international benchmarking would suggest that a value discount of 20-40% taken from those three countries where 800MHz and 900MHz were auctioned simultaneously should have been applied in Ofcom's view of the value of 900MHz. Given that there are sound reasons to expect a substantial discount percentage, this observation alone makes Ofcom's present view in the consultation of a UK discount of only 17%[35] contradictory and untenable. Moreover the weight of available evidence, which we have primarily taken from Ofcom's own spectrum work, suggests that in the UK a greater level of value discount than that generally applicable in past international auctions should be applied to the historic 800MHz UK auction outcome to arrive at a post-auction forward looking value of 900MHz. The failure of Ofcom to draw on its own extensive work on spectrum in the present consultation to assist it not only in a proper interpretation of the available UK and international auction data, but also more generally in the consultation is inexplicable.

Our view of this evidence therefore is that any application of the historic international benchmarking data to derive the current forward looking market value of 900MHz in the UK should therefore be at the lower end of the observed range and therefore at the maximum should be at 60% of the UK historic 800MHz value of £19.7m, i.e. around £12m per MHz. Ofcom should have considered the factors discussed in this annex when considering the level of licence fee to be set for 900 MHz and 1800 MHz spectrum in 2014. However Ofcom has failed to do so.

But there is a further step in the analysis that Ofcom has as yet failed to take, that also suggests the need for a low value for 900MHz fee setting. Ofcom is very obviously not just attempting to set a rate that is appropriate for 2014. Rather it is setting a rate that it intends to use for an extended period, the duration of which is somewhat unclear to operators. Given the long life cycles of network investment, it is important that for investment certainty the spectrum fee is set now for an extended period. The uncertainty that arises from the prospect of indeterminate fee revision at an unknown future date is a significant deterrent to current network investment and efficient and productive use of spectrum. We discuss in more detail the defects of Ofcom's test for re-examining the level of spectrum fees in Annex 1.

Irrespective of these defects, in order to provide appropriate investment certainty now, Ofcom has an obligation to establish not only that the fee that it sets in 2014 is in line with the 2014 value of the spectrum, but also that the stream of fees that it is setting in 2014 for 2015 and subsequent years is also in line with the likely underlying values of the spectrum in 2015, 2016 and future years. Ofcom has failed to consider this in any rigorous manner. By implication, given the way that it has provisionally spread its assessment of the current lump sum value, in a real terms straight line manner, Ofcom must be assuming that the value of the spectrum derived from the 2013 auction is unchanged in real terms at 2014 and will be so for an extended future period.

Ofcom has not tested this assumption, and in any event based on the evidence in this annex we do not believe that it is plausible. In order to be able for investment certainty to set a fee that can be consistently applied for a number of years, Ofcom should ensure that the fee that it sets in 2014 will be capable of being in line with the

[35] Or from the viewpoint that excludes co-existence costs, 7%

underlying market value for an extended period. Given that the evidence cited in this annex, most of which is drawn from Ofcom's own work, very clearly shows that the general trend of spectrum value is downward, it follows therefore that in order to maximise the length of time for which it might reasonably be seen to be in line with market value, any fee set in 2014 should be at the very bottom of any range of plausible 2014 value.

We can conclude therefore that in order to ensure as much investment certainty as possible, the view of 900MHz spectrum value in 2014 should be set, as a maximum, at £12m per MHz, i.e. at 60% of the 2013 UK auction value of £19.7m. A lower value than this would increase the chance that it would be at a level that continues to be appropriate in future years.