ANNEX 1 OF THREE'S RESPONSE TO OFCOM'S CONSULTATION ON AWARD OF THE 700MHZ AND 3.6-3.8GHZ SPECTRUM BANDS

AWARD OF THE 700 MHZ AND 3.6-3.8 GHZ SPECTRUM BANDS

PREPARED FOR HUTCHISON 3G UK BY POWER AUCTIONS LLC

Non-Confidential

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1. Executive Summary

Power Auctions welcomes this opportunity to comment, on behalf of Hutchison 3G UK ("H3G"), upon Ofcom's consultation on the award of the 700 MHz and 3.6 – 3.8 GHz spectrum bands.

We have two basic critiques of the auction design proposed in the consultation:

(1) By procuring coverage obligations through a spectrum auction where bidders are subject to a positive price constraint, Ofcom is biasing the spectrum component of the auction in favor of the bidders that can provide the coverage obligation most cheaply. These, in turn, are likely to be the MNOs that currently have the largest networks. It should be expected that it will lead to these operators winning more spectrum than they would win in an efficient allocation. This both goes against efficiency and goes in the opposite direction of the usual policy of an entrant reservation. Indeed, instead of being a competition policy, it is an anti-competition policy or an incumbent reservation. The auction design for the coverage obligations makes scenarios possible where Ofcom may procure each coverage lot at a cost of as much as twice its maximum discount, creating significant risk that the coverage obligations would fail cost-benefit analysis. Furthermore, this risk is needlessly exacerbated by procuring two coverage lots without roaming obligations, when Ofcom's objectives would in any case be better served by procuring a single coverage lot with a mandatory roaming obligation.

(2) The proposed information policy is undesirably opaque, while the proposed activity rule (specifically, assigning zero eligibility points to the coverage lots) is highly nonstandard and falls short of its objective.

These two critiques of the proposed design lead us to recommend two corresponding improvements:

(1) Our preeminent recommendation is that no coverage lots should be offered in the auction unless the positive price constraint can be eliminated. If Ofcom is adamant on including coverage, notwithstanding the risks of substantial distortions and inefficiencies arising from the positive price constraint, then Ofcom should at minimum include only one coverage lot, not two (as this would halve the inefficiency). In addition, Ofcom should attach a mandatory roaming obligation to this coverage lot and set a maximum discount for this coverage lot at no greater than one-half of the lowest estimate of its social benefit, to assure that procurement of coverage passes cost-benefit analysis.

(2) We recommend an information policy wherein the exact aggregate demand for each coverage lot is disclosed to bidders after every clock round, except for the final clock round, and an activity rule that is proportionate to the auction. If Ofcom adopts our recommendation that no coverage lots should be offered in the auction unless the

positive price constraint can be eliminated, then Ofcom is already aware of the appropriate activity rule. If Ofcom is adamant on including coverage, notwithstanding the risks of substantial distortions and inefficiencies arising from the positive price constraint, then the revised activity rule that we offer in Section 4.5 would eliminate the presence of lots with zero eligibility points, as well as make it possible for Ofcom to adopt a transparent information policy.

2. The Proposed Auction Procedures May Allocate Coverage Obligations When Cost is as Much as Double the Benefit

2.1 There is a distinction between the role of revenues in a spectrum auction and the role of costs in a procurement auction

In designing spectrum auctions, the primary objective of Ofcom and other major spectrum regulators worldwide is to achieve efficiency, rather than to maximise revenues. A typical enunciation of Ofcom's consistent view is included in the SRSP:

> ***Ofcom view***
>
> *Ofcom does not have a duty to generate revenue from spectrum use*
>
> *4.61 Our main objective in exercising our power to set licence fees under section 12 of the WT Act is to promote the optimal use of spectrum. While it is true that we pass receipts from spectrum licence fees to the UK Exchequer we do not have a duty to raise revenues. This is not a consideration that we take into account when setting fees, neither do we aim to deliver a "fair rate of return" of a state resource as suggested by "Three".*
>
> *4.62 Decisions on any proposal to change spectrum use, as suggested by BPA/UKMP, will be taken by us in the context of whether such action will promote the optimal use of spectrum, what the overall benefit to society might be and any existing constraints on our doing so.*[1]

The same view is also prevalent in the academic literature. For example, Professor Cramton's article on the CCA states:

> *The goal for the government should be efficiency, not revenue maximization. The government should focus on ensuring that those who can put the spectrum to its highest use get it. Focusing simply on revenue maximization is short-sighted. Many steps such as technical and service flexibility, and license aggregation and disaggregation, improve efficiency and thereby improve revenues. But short-run revenue maximization by creating monopolies, which would create the highest profits before spectrum fees, and therefore would sustain the largest fees, should be resisted. Indeed, competition, which ultimately will lead to greater innovation and better and cheaper services, will likely generate greater government revenues from*

[1] Ofcom (2010), "SRSP: The revised Framework for Spectrum Pricing", p. 34.

> *a long-run perspective. The government can best accomplish this objective with an efficient auction that puts the spectrum to its best use.*[2]

As such, revenues should play only a secondary role in spectrum auction design. So long as the bidding exceeds a modest reserve reflecting the value of holding onto the spectrum for future allocation, efficiency is best served by simply allocating the spectrum licence to the bidder who values it the most, usually corresponding to the bidder who is willing to pay the most.

However, in designing procurement auctions for public goods, a regulator who is concerned primarily with efficiency must also pay attention to the level of costs. The reason is that the procurement mechanism must not only identify the lowest-cost provider of the public good, but it should also provide information as to whether the public good should be provided in the first place. In particular, if the costs associated with provision of the public good would exceed the benefits of the public good, then a proper cost-benefit analysis would imply that the public good should not be produced.

The distinction can be made clear by referring to two examples. First, let us consider the optimal way for a regulator who cares only about economic efficiency to allocate a spectrum licence, in a scenario with symmetric bidders and where the regulator does not attach any value to withholding the spectrum for future allocation. In that case, the regulator should conduct an ascending-bid auction where the price starts at zero and stops when only a single bidder remains willing to purchase at this price. Observe that no other data need enter into the specification of the mechanism.

Second, let us consider the optimal way for a regulator who cares only about economic efficiency to procure a public good in a scenario with symmetric bidders and where the regulator believes that the benefit associated with the public good equals B. Even excluding budgetary practicalities, it would not be optimal for the regulator to conduct a descending-bid auction where the price starts at infinity and stops when only a single bidder remains willing to provide the public good for this price. For example, suppose that the descending-bid auction stopped at a price $p > B$. Then the winning bidder would not have indicated whether its cost of providing the public good exceeded the benefit of the public good—i.e. the mechanism would not have established if the public good survives a proper cost-benefit analysis. To include this test, the procurement mechanism should be a descending-bid auction where the starting price, M, is no greater than B and where the price stops when only a single bidder remains willing to provide the public good. If the auction attracts no bidders at the starting price, M, this does not mean that the auction has failed, but that the public good has failed its cost-benefit test.

Ofcom appears to be thinking in exactly this way in Annex 13 of the Consultation document. For example, in ¶A13.4, Ofcom correctly writes:

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[2] Cramton, Peter (2013), "Spectrum Auction Design," *Review of Industrial Organization*, 42:161-190, at p. 163, https://rd.springer.com/content/pdf/10.1007%2Fs11151-013-9376-x.pdf.

> *The maximum discount has two functions in our proposed auction design, both of which have informed our provisional approach to setting the maximum discount:*
>
> *it provides an incentive for bidders to bid for a coverage obligation; and*
>
> *even where there are bids for a coverage obligation, it limits when an obligation is awarded to reflect the balance between costs and benefits.*

However, Ofcom begins to depart from this theme, in subtle ways, when in ¶A13.19, Ofcom elaborates:

> *The second function of the maximum discount in the award is to limit the circumstances in which a coverage obligation is awarded, to seek to ensure that an obligation is only awarded where we consider that the benefits it will deliver are likely to exceed the opportunity costs. The opportunity cost would consist of both the resource cost of an obligation, and any change in the allocation of spectrum that could result from awarding it.*

In ¶A13.19 and subsequent paragraphs, Ofcom misconstrues the appropriate measure of cost that should be utilised in the cost-benefit analysis of a public good. The appropriate cost measure includes not only the resource cost of providing the public good, but also the price paid to procure the public good (to the extent that it exceeds the resource cost). The reason that the price should properly be included in the relevant cost is that societal resources are not unlimited, and this payment limits what other public goods can be provided by the Government.

For example, suppose that a public authority provides £400m in tax breaks for the construction of a football stadium that would provide a public benefit of £200m. By Ofcom's reasoning, the public authority should inquire only as to the resource cost of building the stadium. In particular, if the resource cost of the stadium is only £100m (and the remaining £300m of the tax break is a redistribution to the stadium owners), then Ofcom is somehow satisfied that this is a good use of public resources. Ofcom ignores the fact that the arrangement leaves £400m less in resources available for other public goods. A proper cost-benefit analysis would clearly compare the public benefit of £200m with the foregone tax revenues of £400m—and lead us to conclude that the benefits that the stadium will deliver are unlikely to exceed the public cost.

This misinterpretation of the appropriate cost measure leads Ofcom to the mistaken conclusion that the relevant cost of providing a coverage obligation is bounded by the maximum discount (i.e. starting price), M. However, as we shall see in the following sections, it is straightforward to produce a detailed example in which the maximum discount for each coverage lot is assumed to be £350m, but in which the relevant cost of providing two coverage lots turns out to be £1322m. This example will illustrate the general principle that Ofcom's proposed auction procedures can generate *both* a revenue reduction of M for each coverage lot *and* a distortionary effect of M for each coverage lot, generating a total cost measure of as much as $2M$ for one coverage lot or $4M$ for two coverage lots.

2.2 The "positive price constraint" introduces important distortions

Ofcom asserts in ¶A13.55 that:

> *As set out previously in this annex, we would expect the opportunity cost associated with awarding coverage obligations to reflect both of the following components: (1) the net cost of the obligation to bidders; and (2) the opportunity costs associated with any change in the allocation of spectrum. We would expect both of these to be reflected in loss in bid value. The maximum discount imposes a limit to the sum of these components of opportunity cost, enabling the auction to determine whether a bid including the coverage obligation is a winning bid.*

This analysis proves to be problematic. It would be correct if the proposed auction was a CCA in which bid amounts and payments were permitted to be negative. However, the analysis is problematic because the proposed auction is a CCA in which the bid amounts and payments are actually constrained to be positive (or more precisely, greater than or equal to £1,000).

According to ¶A16.28:

> *The round prices in turn determine the bid amount for a package containing at least one lot. This is calculated as* ***the greater of £1,000*** *or the sum of round prices for all the lots contained in the package (emphasis added).*

Moreover, ¶A16.33 describes how base prices are determined:

> *The second-price principle Ofcom would apply is known as the Vickrey-nearest minimum revenue core (VN-MRC) pricing rule,* ***subject to the constraint that all base prices must be at least £1,000*** *(emphasis added).*

The highlighted calculation of ¶A16.28 and constraint of ¶A16.33 (which, together, will henceforth be referred to as the **"positive price constraint"**) introduces an important distortion. Ofcom acknowledges the existence of the distortion in ¶7.98:

> *If the price of the spectrum a bidder has won is less than the discount for a coverage obligation, then the bidder would not be realising the full discount. In such circumstances, bidders may have an incentive to increase the amount of spectrum they are bidding on to increase their effective discount up to the full amount (or a large enough effective discount to offset their costs of the coverage obligation). This could result in a change in the allocation of spectrum compared to an auction with no coverage obligations.*

However, ¶A13.55, quoted above, understates the import of the distortion, asserting: "The maximum discount imposes a limit to the sum of these components of opportunity cost". The net cost of the obligation to bidders is indeed "reflected in loss in bid value"—and may equal any amount up to *M*, the maximum discount, for each coverage lot. However, the relevant cost associated with the bid distortions is *not* "reflected in loss in bid value", and may also equal any

amount up to *M*. In some sense, the source of the incorrect analysis is that the distortion induces untruthful bidding, and so the bids are no longer reflective of the bidder's true values for spectrum. We shall see that, together, the social cost associated with each coverage lot can be as much as 2*M*—i.e. social cost of as much as 4*M* for two coverage lots.

2.3 An Illustrative Example

In this example, we assume for simplicity that there are no SDL lots. Other than this simplification, the supply of lots is as in the real auction. For reserve prices and maximum discounts, we take the central point of Ofcom's ranges, as summarized in ¶7.10:

Category	**Supply**	**Reserve Price / Maximum Discount**
700 MHz FDD	6	£170m
3.6 GHz TDD	24	£20m
Coverage obligations (C)	2	£350m

For simplicity, we further assume that the values across bands are additive for each bidder, and that the cost of providing the coverage obligation is also additive. The values and costs in this example are given in the following table:

Bidders	Bidder 1	Bidder 2	Bidder 3	Bidder 4
Value for 700 MHz FDD	2 – 500 4 – 850	2 – 600 4 – 900	2 – 20 4 – 30	2 – 10 4 – 15
Value for 3.6 GHz TDD	4 – 200 + 35 for each additional block up to 8 + 34 for each additional block 9 to 24	4 – 200 + 35 for each additional block up to 16 + 34 for each additional block 17 to 24	4 – 4 + 1 for each additional block up to 10	4 – 8 + 2 for each additional block up to 10
Cost of Coverage Obligation	400	400	15	15
Efficient Allocation	(4,8)	(2,16)	(0,0) + C	(0,0) + C

As summarized in the bottom row of the table, the efficient allocation in this example is: Bidder 1 is allocated (4,8) (i.e. 4 blocks of 700 MHz and 8 blocks of 3.6 GHz spectrum); Bidder 2 is allocated (2,16); Bidder 3 is allocated (0,0) + C (i.e. no spectrum but one coverage lot); and Bidder 4 is also allocated (0,0) + C.

2.4 Benchmark: A spectrum-only CCA

Our benchmark is a spectrum-only CCA. Given the well-behaved value and cost profiles, we would expect there to be truthful bidding, which would generate the efficient allocation of Section 2.3 and would not require a core adjustment. We solve it as follows:

- The solution of the Winner Determination Problem with all bidders present is: Bidder 1 wins (4,8), Bidder 2 wins (2,16), Bidders 3 and 4 win (0,0).
- Total value (with all bidders present) = 850 + 600 + 200 + 4x35 + 200 + 12x35 = 2410.
- The solution of the Winner Determination Problem if Bidder 1 is absent is: Bidder 2 wins (2,24), Bidders 3 and 4 win (0,0), unsold (4,0).
- Total value (if Bidder 1 is absent) = 600 + 4x170 + 200 + 12x35 + 8x34 = 2172.
- The incremental surplus of Bidder 1 = 238. Therefore, Bidder 1 pays 952.
- The solution of the Winner Determination Problem if Bidder 2 is absent is: Bidder 1 wins (4,24), Bidders 3 and 4 win (0,0), unsold (2,0).
- Total value (if Bidder 2 is absent) = 850 + 2x170 + 200 + 4x35 + 16x34 = 2074.
- The incremental surplus of Bidder 2 = 336. Therefore, Bidder 2 pays 884.
- Bidder 3 wins (0,0) and therefore pays 0.
- Bidder 4 wins (0,0) and therefore pays 0.
- The Auctioneer's Net Revenues are 1836.

2.5 Analysis of an unconstrained CCA with coverage lots

Next, consider an "unconstrained CCA", i.e. a CCA with coverage lots in which the bid amounts and payments were permitted to be negative. Again given the well-behaved value and cost profiles, we would expect there to be truthful bidding, which would generate the efficient allocation of Section 2.3 and would not require a core adjustment. We solve it as follows:

- The solution of the Winner Determination Problem with all bidders present is: Bidder 1 wins (4,8), Bidder 2 wins (2,16), Bidders 3 and 4 win (0,0) + C.
- Total value (all bidders present) = 850 + 600 + 200 + 4x35 + 200 + 12x35 – 30 = 2380.

- The solution of the Winner Determination Problem if Bidder 1 is absent is: Bidder 2 wins (2,24), Bidders 3 and 4 win (0,0) + C, unsold (4,0).
- Total value (if Bidder 1 is absent) = 600 + 4x170 + 200 + 12x35 + 8x34 – 30 = 2142.
- The incremental surplus of Bidder 1 = 238. Therefore, Bidder 1 pays 952.
- The solution of the Winner Determination Problem if Bidder 2 is absent is: Bidder 1 wins (4,24), Bidders 3 and 4 win (0,0) + C, unsold (2,0).
- Total value (if Bidder 2 is absent) = 850 + 2x170 + 200 + 4x35 + 16x34 – 30 = 2044.
- The incremental surplus of Bidder 2 = 336. Therefore, Bidder 2 pays 884.
- The solution of the Winner Determination Problem if Bidder 3 is absent is: Bidder 1 wins (4,8), Bidder 2 wins (2,16), Bidder 4 wins (0,0) + C.
- Total value (if Bidder 3 is absent) = 850 + 600 + 200 + 4x35 + 200 + 12x35 – 350 – 15 = 2045.
- The incremental surplus of Bidder 3 = 335. Therefore, Bidder 3 is paid 350.
- The solution of the Winner Determination Problem if Bidder 4 is absent is: Bidder 1 wins (4,8), Bidder 2 wins (2,16), Bidder 3 wins (0,0) + C.
- Total value (if Bidder 4 is absent) = 850 + 600 + 200 + 4x35 + 200 + 12x35 – 15 – 350 = 2045.
- The incremental surplus of Bidder 4 = 335. Therefore, Bidder 4 is paid 350.
- The Auctioneer's Net Revenues are 1136.

The solution of an unconstrained CCA with coverage lots for this example illustrates Ofcom's reasoning in Annex 13. Ofcom's revenues are £700 million lower than in the spectrum-only CCA. (If there were three low-cost providers of the coverage obligation, then the revenue reduction would get competed lower.) Each coverage obligation is provided if and only if there is an MNO who can provide it for less than the maximum discount. Thus, the maximum discount imposes a limit on the relevant cost of the coverage lot, as claimed by Ofcom.

The only difficulty is that this claim holds only for an unconstrained CCA, not for a CCA with a "positive price constraint", which is what Ofcom actually proposes for the 700 MHz and 3.6 – 3.8 GHz award.

2.6 Analysis of a CCA with coverage lots and a positive price constraint

Finally, let us consider the auction mechanism proposed by Ofcom, i.e. a CCA with coverage lots and a "positive price constraint". Because of the constraints that bids must be positive numbers and payments must be positive numbers, [✂]

and the mechanism does not generate the efficient allocation of Section 2.3.

[✂]

Summing over all bidders, the total intrinsic value of the spectrum allocation is 1750. By comparison, the total intrinsic value of the efficient spectrum allocation was 2410. Thus, we conclude that there is an additional relevant cost of awarding coverage obligations, reflecting the opportunity cost associated with the inefficient allocation of spectrum, of 660.

The total appropriate cost measure of awarding coverage obligations in this example is the sum of 662 (the reduction in Ofcom's net revenues) and 660 (the reduction in intrinsic spectrum values). That is, the total relevant cost is 1332—almost four times the maximum discount!

One of the sources of Ofcom's mistake is that Ofcom assumes that [✂]Calculating the total relevant cost of the resulting inefficient allocation of spectrum must be done with intrinsic values, rather than bid values, and this cost is additive with the cost of compensating the providers of the coverage obligations.

To put it differently, in the cost-benefit analysis of whether procuring the coverage obligation is a worthwhile expenditure, the appropriate cost that should be considered by Ofcom is the sum of the *revenue expended on procurement* and the *inefficiency induced by distortion*. When procuring two coverage lots at a maximum discount of *M*, each of these two summed terms can be as great as 2*M*, and so the cost that needs to be set against the benefit of the procurement obligation can be as great as 4*M*.

2.7 Example 3 of Annex 13 omits the revenue expended on procurement

Example 3 of Annex 13 of the Consultation reaches the wrong conclusion because it omits the revenue expended on procurement. This is seen, most easily, by replicating Ofcom's Figure A13.4 for the data of our example of Section 2.3, as we do in the following Figure 1:

Figure 1: Replication of Ofcom's Figure A13.4 for our Example of Section 2.3

	Power Auctions' Scenario
Highest bid value for combination that **includes** bids for coverage obligations (A)	1720

Highest bid value for combination that **does not include** bids for coverage obligations (B)	2380
Bid value for combination with **same spectrum allocation** as A, but does not include bids for coverage obligations (C)	1750
Net cost to bidder of the coverage obligations (C – A)	30 (=1750 – 1720)
Opportunity cost of changing the allocation of spectrum (B – C)	630 (=2380 – 1750)
Overall opportunity cost of awarding coverage obligations (net costs + opportunity costs of changing spectrum allocation)	660 (=30 + 630)
Outcome	Coverage lots awarded There is a change in the allocation, with an associated opportunity cost of 630

Specifically, the number 1720 in row 1 of Figure 1 comes from the line labeled "The total bid value (all bidders present)" in Section 2.6. The number 2380 in row 2 of Figure 1 comes from the line labeled "Total value (all bidders present)" in Section 2.5. The number 1750 in row 3 of Figure 1 comes from taking the sum labeled "The total bid value (all bidders present)" in Section 2.6 and replacing each occurrence of the number 5 with the number 20. (This calculates the bid value for the same spectrum allocation as row 1, but without the two coverage lots—recall that in the example, Bidders 3 and 4 each bid 5 for the coverage lot, but their values for the spectrum alone are each 20.) Row 4 of Figure 1 is simply row 3 minus row 1. Row 5 of Figure 1 is simply row 2 minus row 3. Row 6 of Figure 1 is simply row 4 plus row 5.

Thus, we see that Figure 1, by replicating Ofcom's Figure A13.4 for the data of Section 2.3, recalculates the narrowly-construed opportunity cost associated with the inefficient allocation of spectrum of Section 2.6, which was shown to equal 660. However, Figure 1 omits another significant cost: the subsidy given to the winning Bidders 3 and 4 (in terms of reduced auction revenues) to extend their coverage to 90%. In our example, we have seen that this subsidy is another 662, and it is completely omitted from Ofcom's calculation. This subsidy represents an additional relevant cost to society because it comes at the expense of the provision of other public goods.

2.8 The intuition for distortion: The positive price constraint may be binding

The key requirement for the occurrence of distortion is the assumption that a low-cost provider of the coverage obligation may find the positive price constraint to be a binding constraint. This is a plausible assumption for the following reasons:

(1) It is plausible that the MNOs with the highest existing holdings of spectrum have the lowest costs of providing coverage. Due to diminishing marginal values, it is also plausible that the same MNOs have the lowest intrinsic values (but not necessarily the lowest strategic values) for additional spectrum.

(2) If Ofcom was certain that the positive price constraint would not be binding, then there would have been no need for Ofcom to include the calculation of ¶A16.28 and the constraint of ¶A16.33 in the auction rules.

(3) If Ofcom was certain that the low-cost providers of coverage were also necessarily the high-valuation demanders of spectrum, then there would have been no need for Ofcom to introduce the unbundled coverage lot into the auction design.

(4) If Ofcom was certain that the low-cost providers of coverage were also necessarily the high-valuation demanders of spectrum, then there would have been no need for Ofcom to assign zero eligibility points to the coverage lot. (See the detailed discussion of zero eligibility points and the activity rule in Section 4, below.)

(5) Ofcom does not have any certainty as to the various MNOs' costs of providing coverage or to their value of spectrum. That is why Ofcom is planning to conduct an auction for the spectrum and coverage obligation, in the first place.

2.9 The role of spectrum trading

If one knew that low-valuation users of spectrum acquired at auction would resell their spectrum to the higher-valuation users of spectrum, then one would have substantially fewer concerns about the distortion induced by the positive price constraint. For example, in the example of Section 2.6, if one could be sure that Bidders 3 and 4 would promptly resell their inefficiently-won spectrum to Bidders 1 and 2, then associated with the award of coverage obligations would be the reduction in Ofcom's net revenues of 662, but not the reduction in intrinsic spectrum values of 660. Rather, the inefficient allocation of the auction would correct itself through spectrum trading.

However, Ofcom cannot consistently take the position that spectrum trading justifies disregarding the inefficiency that is demonstrated in Section 2.6. In "Annual Licence Fees for UK Broadband's 3.4 GHz and 3.6 GHz spectrum", published just one day before the current consultation document, the limitations of spectrum trading appear to be the principal rationale for annual licence fees (ALFs) based on market value. Ofcom writes:

> 3.3 *We also considered the question of the potential interplay between setting spectrum fees and spectrum trading, and concluded that many secondary markets are unlikely to be sufficiently effective to promote the optimal use of the spectrum without the additional signal from AIP fees, and that fees based on AIP principles are likely to continue to be needed to play a role complementary to spectrum trading for most licence sectors.*

Ofcom further states:

> 3.7 *We consider that there remain good reasons to set fees based on the opportunity cost for spectrum, in accordance with the policy position in the SRSP, even where spectrum trading is possible, in order to meet our statutory duty of securing optimal use of the radio spectrum.*

Ofcom also writes:

> 4.17 *We also recognise that mobile operators can trade or acquire spectrum licences, and that in principle this creates incentives for operators to only hold licences for which they are the highest-value users. However, as discussed in paragraphs 4.22 to 4.26 below, we consider there is a risk that MNOs may be less responsive to the opportunity cost of holding spectrum (through forgoing the revenue from trading it) than to ALFs based on market value. This implies that trading may not in itself be sufficient to ensure that spectrum is allocated most efficiently.*

Ofcom argues:

> 4.28 *In any case, these relatively limited examples do not suggest the presence of a liquid spectrum market. Our view is not that operators necessarily or entirely ignore the opportunity cost of their spectrum holdings, but that they may be less responsive to foregone revenue from trading spectrum than to ALFs based on market value. This view is not contradicted by the existence of limited trades at other frequencies.*

And Ofcom concludes:

> 4.36 *… Furthermore, while we also recognise that mobile operators can trade spectrum licences, we consider there is a risk that MNOs may be less responsive to the opportunity cost of holding spectrum (through forgoing the revenue from trading it) than to ALFs based on market value. This implies that trading may not in itself be sufficient to ensure that spectrum is allocated most efficiently.*

When one makes note that the spectrum being awarded pursuant to the current consultation will not be subject to ALF until 20 years after the auction, it might seem utterly disingenuous for Ofcom to argue that spectrum trading eliminates the inefficiency demonstrated in this section.

However, Ofcom comes very close to making such an argument. In ¶A13.39 of the present consultation, Ofcom remarks:

> *However, there may be circumstances where loss in total bid value is not equivalent to the true opportunity cost of awarding a coverage obligation. This would suggest we should adjust the maximum discount in order to maintain an appropriate balance between costs and benefits in the winner determination.*
>
> *…*
>
> • *If the loss in total bid value overstates the full opportunity costs, this would suggest we should increase the maximum discount. An example of this potential overstatement is if, despite a bidder winning more spectrum as a result of winning the coverage obligation, the efficient allocation may still be achieved through a post-auction trade between the coverage bidder and the bidder that has the highest intrinsic value. The result of any such trade would be that the spectrum still ends up with the bidder who has the highest intrinsic value for it. This would mean that the eventual opportunity cost of awarding a coverage obligation (i.e. after the post-auction trade) would be less than the loss in total bid value in the auction. A lower maximum discount may therefore lead to a coverage obligation not being awarded, despite the benefits exceeding the true opportunity costs.*

Ofcom cannot have its cake and eat it too. If Ofcom truly believes that the substantial inefficiency associated with the proposed auction design can be disregarded, due to "post-auction trade between the coverage bidder and the bidder that has the highest intrinsic value" [3], for spectrum that is not subject to ALF until 2040, then Ofcom loses its rationale why the (identical) UK Broadband spectrum should be subject to an ALF based on market value beginning in 2019. Conversely, if Ofcom adheres to the view that ensuring efficient use of the UK Broadband spectrum requires an ALF based on market value beginning in 2019, then Ofcom is also obliged to recognize that "trading may not in itself be sufficient" [4] to correct the inefficiency of its proposed auction design for (identical) spectrum that will not be subject to an ALF until 2040.

[3] Consultation, ¶A13.39.

[4] Ofcom (2018), "Annual Licence Fees for UK Broadband's 3.4 GHz and 3.6 GHz spectrum", ¶4.17.

3. The Proposed Information Policy is Undesirably Opaque

3.1 Disclosure of aggregate demand and supply in dynamic auctions provides useful feedback to bidders

There is a clear consensus among academic commentators that the greatest advance in spectrum allocation in the past two decades has been the widespread adoption of modern dynamic auction methods, including the disclosure of demand information to bidders after every round. Representative of this consensus is what Professor Peter Cramton wrote in the chapter entitled "Spectrum Auctions" of the *Handbook of Telecommunications Economics*:

> An essential advantage of open bidding is that the bidding process reveals information about valuations. This information promotes the efficient assignment of licenses, since bidders can condition their bids on more information. Moreover, to the extent that bidder values are affiliated, it may raise auction revenues (Milgrom and Weber 1982), since the winner's curse is reduced. Bidders are able to bid more aggressively in an open auction, since they have better information about the item's value.[5]

Similarly, in a procurement auction, a dynamic auction format where aggregate supply information is disclosed after each round allows bidders to condition their bids on more information and promotes efficiency.

Ofcom recognizes the benefits of revealing information on aggregate demand levels in ¶7.184:

> *In circumstances where there is common value uncertainty (i.e. the value of the spectrum is common but unknown to bidders), information about the level of aggregate demand in each lot category may allow individual bidders to improve their estimates about how much the spectrum is worth. Such information can also assist package discovery, assisting bidders to identify the packages that they have the best opportunity to win.*

Before the 1990s, spectrum rights tended almost always to be allocated by administrative hearings or by lotteries. Beginning in about 1990, governments began to experiment with utilising auctions. Many of the early dynamic auctions used full disclosure information policies, disclosing each individual bid (including the identity of the bidder associated with the bid) after every round. The consensus today is that full disclosure is an excessive degree of disclosure, because it may facilitate bidders' ability to engage in market division, it may enable a bidder to

[5] Cramton, Peter (2002), "Spectrum Auctions," in Martin Cave, Sumit Majumdar, and Ingo Vogelsang, eds., *Handbook of Telecommunications Economics*, Amsterdam: Elsevier Science B.V., Chapter 14, 605-639.

signal its opponents, and it may enhance incumbents' ability to exclude entrants from the market. Meanwhile, the individual bids may be finer information than bidders need for purposes of assessing opponents' information. For these reasons, clock auctions and CCAs typically limit the reported information to aggregate demand and do not report individual bids.

This position was advocated, for example, in the academic paper that proposed the CCA:

> The clock phase has several important benefits. First, it is simple for the bidders. At each round, the bidder simply expresses the quantities desired at the current prices. … Limiting the bidders' information to a reporting of the excess demand for each item removes much strategizing. Complex bid signalling and collusive strategies are eliminated, as the bidders cannot see individual bids, but only aggregate information.[6]

Experience has shown that reporting aggregate demand information strikes the right balance between the extreme of reporting all individual bids and the opposite extreme of only reporting whether aggregate demand exceeds supply. This is not only the assessment of academic commentators but also the view of the US Federal Communications Commission, which has evolved from using a full disclosure information policy to reporting only aggregate demand in the context of a clock auction. This information policy has also been used in auctions conducted in other sectors, such as for the procurement of electricity.

3.2 Masking of the aggregate demand for spectrum lots in ranges of 20 MHz is unnecessary in a CCA

In ¶A16.104, Ofcom proposed the following information policy for spectrum lot categories:

> *After the end of each primary bid round, other than the final primary bid round, we propose to inform bidders whether the level of excess demand for each spectrum lot category is less than or equal to the nearest higher multiple of 20 MHz (e.g. less than or equal to 20 MHz, less than or equal to 40 MHz, etc). If there were no excess demand for a spectrum lot category, we would simply inform bidders that demand is less than or equal to 20 MHz.*

This information policy adds a degree of uncertainty (compared to disclosing aggregate demand) about the actual aggregate demand for a spectrum category and about whether the clock rounds are nearing an end. Ofcom offers two rather unpersuasive reasons why it should add this uncertainty.

[6] Ausubel, Lawrence M., Peter Cramton and Paul Milgrom (2006), "The Clock-Proxy Auction: A Practical Combinatorial Auction Design," in Peter Cramton, Yoav Shoham, and Richard Steinberg (eds.), *Combinatorial Auctions*, MIT Press, Chapter 5, pp. 115-138, at p. 117.

The first rationale is that revealing precise levels of aggregate demand may open up opportunities for strategic bidding which, in the extreme, can facilitate tacit collusion (¶7.186). The economics literature demonstrates that this rationale is incorrect. Specifically, in auctions along the lines of the Vickrey auction or CCA, winners are determined by calculating the allocation of items that maximises value in relation to the bidders' expressed bids, while the price paid by a winner is based on the opportunity cost of allocating the items to him as opposed to his competitors. Since the price paid is independent of the bidder's own bids, incentives for truthful bidding are created, and it is a weakly dominant strategy for a bidder to bid his true value.[7] Moreover, in dynamic versions of the Vickrey auction, there are no incentives for bidders to engage in market division. The economist's prediction in a dynamic Vickrey auction is an efficient allocation and pricing related to true opportunity cost.[8] By contrast, under the pricing rule of a uniform-price auction (such as an SMRA), a bidder's bid for a second unit has the possibility of setting the price paid for the bidder's first unit won, etc., so incentives for "strategic demand reduction" are created. As a result, bids for a first unit are set equal to value, but bids for second and subsequent units are shaded relative to the bidder's true value.[9] The same forces also create incentives for bidders to engage in market division, particularly in dynamic uniform-price auctions.[10]

Ofcom's second rationale for adding uncertainty in the information policy is that if bidders know that the clock rounds are not likely to end soon, they may bid for a larger package than they would otherwise, based on their valuations, in an attempt to relax their Relative Cap. A more relaxed Relative Cap, in turn, would allow bidders more room to place bids in the Supplementary Bid Round that impact the prices paid by their competitors (¶7.186). This is rather tenuous justification for such a severe information policy. There is no evidence provided that this reflects real bidder behaviour in any auction; it is purely speculative. Moreover, even if true, it could be remedied by imposing a more constraining activity rule than the Relative Cap, such as the GARP-based activity rule that will be used in the upcoming Canadian 600 MHz Auction.

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[7] Vickrey, William (1961), "Counterspeculation, Auctions, and Competitive Sealed Tenders," *Journal of Finance*, 16(1), pp. 8–37.

[8] Ausubel, Lawrence M. (2004), "An Efficient Ascending-Bid Auction for Multiple Objects," *American Economic Review*, 94(5), pp. 1452–1475.

[9] Ausubel, L. M., P. Cramton, M. Pycia, M. Rostek and M. Weretka (2014), "Demand Reduction and Inefficiency in Multi-Unit Auctions," *Review of Economic Studies*, forthcoming, http://restud.oxfordjournals.org/content/early/2014/07/27/restud.rdu023.full.pdf?keytype=ref&ijkey=jGg1ddzGeMl0NpK.

[10] Ausubel, Lawrence M. and Jesse A. Schwartz (1999), "The Ascending Auction Paradox," mimeo, University of Maryland and Vanderbilt University.

The information policy proposed by Ofcom would provide some of the benefits of an open auction, but stops short of providing the full benefits associated with an information policy where aggregate demand is disclosed after each round. Specifically, a CCA with disclosure of aggregate demand after every round would allow valuation information to be aggregated across bidders, reducing common value uncertainty and making outcomes more predictable. Moreover, disclosure of aggregate demand after every round would allow bidders to switch their demand among different bands in light of other bidders' information and decisions, also reducing "substitution risk".

3.3 Nondisclosure of the aggregate supply of coverage lots asymmetrically favours MNOs who can provide the coverage lot more cheaply

Ofcom has proposed to reveal no aggregate demand information on the coverage obligations after each primary bid round (¶A16.105). Such an information policy would be a step back from dynamic auctions and would favor MNOs who can provide the coverage obligation more cheaply.

Ofcom motivates this proposal in two ways. First, as described in ¶7.196,

> *This is because there is more scope for bidders to bid on coverage strategically due to our proposal to associate no eligibility points with coverage. An example of strategic bidding would be a signalling strategy, whereby bidders bid on coverage lots in one clock round, and then do not bid on coverage in another. We consider that this risk is mitigated by revealing no demand information on coverage.*

As described in Section 4 of this document, if no eligibility points are associated with coverage, then there is more scope for strategic bidding irrespective of whether aggregate demand for the coverage category is disclosed to bidders. We therefore recommend associating eligibility points with coverage.

Second, ¶7.197 states:

> *In addition, unlike spectrum lots, there should be no common value uncertainty among bidders for coverage. This is because bidders' valuation for coverage should be based on their own assessment of the cost of (and revenue from) the coverage obligation.*

This statement is incorrect because there may be common value uncertainty among bidders for coverage. For instance, one bidder may have better estimates of the costs associated with providing coverage in certain areas or of the revenue from currently underserved areas.

With the proposed information policy, the auction process will provide little insight into opponents' information and decisions with respect to the coverage obligation category. As a result, bidders will need to develop this insight independently and will devote a considerable fraction of their preparations to obtaining competitive intelligence about their competitors. Obtaining competitive intelligence will be costly—discouraging participation in the auction—and the expenditure of resources on competitive intelligence will be socially unproductive.

If no aggregate demand information on the coverage obligations is revealed, bidders will observe whether the price of the coverage obligation category has increased from the previous round. Based on this information, each bidder can infer whether aggregate demand exceeded supply in the previous round. A bidder that was bidding for the coverage obligation will have an information advantage and will be able to infer whether at most one other bidder was bidding for the coverage obligation.[11] The potential of this information advantage may motivate bidders to probe and to "play games". But, to the extent that bidders probe and play games, the price signals become less informative throughout the auction and bidders run the conscious risk of getting "stuck" on suboptimal combinations.

All in all, the withholding of information works to the detriment of price discovery. The efficiency of the auction can be improved with a more transparent information policy.

[11] Knowledge of how many bidders are actually bidding for the coverage obligation could be useful, for example, in calculating the value of a so-called "knockout bid" in the supplementary round.

4. Assigning Zero Eligibility Points to the Coverage Lots is Highly Nonstandard and Falls Short of its Objective

4.1 Few, if any, spectrum auctions have assigned zero eligibility points to any lot

Activity rules are one of the key elements of modern spectrum auctions. The most standard activity rule, known as point monotonicity, is implemented by assigning positive eligibility points to each product in the auction and then imposing a requirement that a bidder's demand in successive auction rounds is always non-increasing in eligibility points.

Most crucially, when a bidder reduces its demand and its bidding eligibility falls, a bidder will not be able to demand bundles that exceed its reduced eligibility in future rounds. Thus, the activity rule ensures that a bidder who wants to eventually acquire a large number of lots cannot "hide" its demand and is required to bid for a large number of lots from the beginning of the auction.

The most important assumption behind the point monotonicity activity rule is that the eligibility points are strictly positive. Only with positive eligibility points does a reduction in demand correspond to a reduction in eligibility. In contrast, with zero eligibility points, a reduction in demand has no effect on eligibility, and the activity rule loses its purpose—bidders can add or drop lots with zero eligibility points at will. Therefore, assigning zero eligibility points to lots is extremely nonstandard. We are unaware of any spectrum auction, or any other dynamic auction to date, that utilized points, in which any lots have been assigned zero eligibility points.

In general, eligibility points for different products in the auction are set in proportion to their underlying value to facilitate substitution among products during the auction. The high-value lots receive a large number of eligibility points (and high reserve prices), and the low-value lots receive a small number of eligibility points (and low reserve prices). In the current consultation, Ofcom adopts the standard approach for spectrum lots. It proposes to assign 4 eligibility points for each 700 MHz lot (with the reserve price in the £100m – £240m range) and 1 eligibility point for each 3.6 GHz lot (with the reserve price in the £15m – £25m range). However, for the coverage obligation lot, Ofcom proposes to assign zero eligibility points while simultaneously proposing a reserve price in the £300m – £400m range.

Assigning zero eligibility points to the coverage obligation lot invites strategic bidding that can be costly for the auction outcome. In ¶7.196 of the consultation, Ofcom not only recognises the zero-eligibility issue as problematic, but makes things even worse by proposing another nonstandard and harmful policy in attempt to mitigate it:

> *We propose revealing no information on aggregate demand for coverage lots. This is because there is more scope for bidders to bid on coverage strategically due to our proposal to associate no eligibility points with coverage. An example of strategic*

> *bidding would be a signalling strategy, whereby bidders bid on coverage lots in one clock round, and then do not bid on coverage in another. We consider that this risk is mitigated by revealing no demand information on coverage.* (¶7.196)

In Sections 4.2—4.4, we demonstrate that Ofcom's proposal to assign zero eligibility points to the coverage lot is misguided, and does not serve its intended purpose. As such, this feature is strictly detrimental for the proposed CCA design since it invites strategic bidding and forces Ofcom to withhold aggregate demand information for the coverage obligation lot.

4.2 The relaxed activity rule does not require zero eligibility points to operate properly

For this award, Ofcom is proposing to adopt an activity rule that consists of a point monotonicity rule and an exception that allows a bidder to place bids (referred to as "relaxed primary bids") that violate the bidder's eligibility as long as those bids are consistent with truthful bidding. This activity rule (and its close variants) has been used in recent spectrum auctions in Ireland and Canada. The motivating reason for allowing a bidder to exceed its eligibility limit (i.e. for permitting an exception) is well known. An activity rule based on eligibility points can interfere with truthful bidding: a bidder who is truthfully reporting its demand in each round can find itself "trapped" when its truthful demand is not monotonic in eligibility points.[12] An exception is then introduced to accommodate truthful bidding.

Ofcom supports its proposal to assign no eligibility points for the coverage obligation lots as follows:

> *We propose no eligibility points for the coverage obligation lots. This is due to the possibility that bidders may not find it most profitable to bid on coverage from the start of the auction. This can arise when the spectrum package a bidder is interested in has a lower price than the maximum discount. Having no eligibility on coverage allows a bidder to include a coverage lot to their spectrum package with less difficulty in later clock rounds, once spectrum prices have increased.* (¶7.163)

The reasoning provided in ¶7.163 is misleading. Given that relaxed bids are allowed and assuming that their implementation is correct, a bidder that is bidding truthfully should be able to bid on the coverage obligation lot (even if it assigned a positive number of eligibility points) in later rounds by placing a relaxed primary bid as long as this action is consistent with truthful bidding. But then it is unclear why Ofcom is proposing to assign zero eligibility points for the

[12] For an in-depth discussion of activity rules, see Ausubel, Lawrence M. and Oleg Baranov (2019), "Revealed Preference and Activity Rules in Dynamic Auctions," working paper, http://www.ausubel.com/auction-papers/Revealed-Preference-and-Activity-Rules-in-Dynamic-Auctions.pdf

coverage obligation lot in addition to proposing relaxed bids that are a standard solution to issues such as one described in ¶7.163.

In our view, the most likely reason for Ofcom's ad-hoc proposal of "zero eligibility points" is that the relaxed bids implementation is not appropriate for the proposed auction design (which includes the positive price constraint). Section 2 describes the positive price constraint in detail and explains why this constraint introduces important distortions, even without considering the activity rule. This section focuses on the interaction between the positive price constraint and the activity rule.

The positive price constraint creates a conflict with a typical implementation of relaxed bids, such as the one proposed in the consultation. We illustrate this issue in two steps. First, in Section 4.3, we provide a typical example for which Ofcom's "zero eligibility points" solution actually works. Then, in Section 4.4, we show that a small change to the example renders the solution completely useless.

In Section 4.5, we propose an alternative general solution that resolves the conflict and does not require assigning zero eligibility points to the coverage obligation lot. Consequently, this alternative does not require withholding the aggregate demand information for the coverage obligation lot.

4.3 [✂]

4.4 [✂]

In ¶7.164, Ofcom correctly states that a bidder will face restrictions in the Supplementary Bids Round if it does not bid on its most profitable package in the last clock round:

> *Even though there are no eligibility points on coverage lots, we still consider there to be good incentives for bidders to include coverage lots in their clock round bids when it is most profitable to do so. This is due to the restrictions placed by the Final Price Cap in the Supplementary Bids Round if bidders do not end the clock round bidding on their most profitable package.*

It is unfortunate that Ofcom simultaneously proposes an activity rule that can by itself force a bidder to bid for a suboptimal package.

4.5 An alternative activity rule that does not require assigning zero eligibility points to any lot

Allowing bidders to bid truthfully is one of the fundamental principles of auction design. In Section 4.4, we demonstrate that the proposed activity rule can prevent truthful bidding. This is

undesirable and can lead to suboptimal outcomes. In fact, one famous example of an activity rule potentially "trapping" a bidder occurred in the UK 4G auction in 2013. In Round 38, Everything Everywhere (EE) reduced its eligibility from 1200 points (eight C blocks) to 9 points (nine E blocs). In subsequent rounds, the clock price of C blocks stayed the same while the clock price of E blocks increased 16 times! It is quite possible that EE would have preferred to switch back to demanding C blocks, but the activity rule used in the auction did not allow it.[13]

It is easy to spot the exact component that causes the misalignment between truthful bidding and the implementation of the relaxed primary bids in the current proposal (and more generally, the implementation of revealed preference constraints). For the proper operation, relaxed bids require that the clock prices that are used for calculating revealed preference constraints are the same ones the bidder was facing when submitting its demand bid. In contrast, Ofcom uses the unconstrained clock prices for imposing revealed preference constraints, while bidders face the constrained clock prices in primary rounds due to the positive price constraint.

Therefore, in case Ofcom insists on using the positive price constraint in the auction, all revealed preference constraints imposed by Ofcom should reflect the clock prices that bidders face under this constraint. We illustrate our proposed solution with examples from sections 4.3 and 4.4.

[✂]

Finally, we note that the same approach should be taken for all revealed preference constraints, both for the purposes of relaxed bids and for deriving the bid limits in the supplementary round.

[13] See Section 7 in Ausubel, Lawrence M. and Oleg Baranov (2019), "Revealed Preference and Activity Rules in Dynamic Auctions," working paper, http://www.ausubel.com/auction-papers/Revealed-Preference-and-Activity-Rules-in-Dynamic-Auctions.pdf

5. If a coverage obligation is retained, Ofcom should auction only one coverage lot and attach a roaming obligation

In the consultation, Ofcom is proposing to use public funds (in the implicit form of a reduction in auction revenues) to procure two coverage obligation lots. In other words, Ofcom is proposing to allocate up to two subsidies to two MNOs to offset the costs of expanding their networks in scarcely populated areas that are currently unserved.

Ofcom's proposal to include two coverage obligation lots in the auction is puzzling. It is likely that, if two coverage obligations are awarded in the auction, the areas that will receive improved coverage from the two winners will have substantial overlap. But then Ofcom is proposing to spend public funds to subsidise building two duplicate networks in areas that are so scarcely populated that even building out just one network needs to be subsidised.

As described in ¶4.95, BT/EE questioned the case for a second geographic coverage obligation, and argued that a single operator extending its coverage out towards 92% should be sufficient to deliver the full benefits of coverage to the people in those areas. BT/EE argued that the incremental benefit of a second provider in terms of additional consumer choice would be low, particularly because prices would remain set on a national level.

A potential economic reason for awarding two coverage lots would be to ensure that customers residing in overlapping areas have a choice between two providers. Having two providers of the same service brings competition forces into play, benefiting consumers in these areas. However, if the areas are very scarcely populated, only a small number of consumers would benefit from these competitive forces.

As described in ¶4.96 and ¶4.97, Ofcom expects that a second coverage obligation would mostly benefit customers who travel through these areas, and not the customers who are residing in these areas:

> *Having considered BT/EE's comments, we remain of the view that two geographic obligations would deliver significantly more benefits than a single obligation, by delivering benefits to a larger pool of consumers, because the customers of the second obligated operator would also benefit.*
>
> *We believe there would be relatively limited switching as a result of the coverage obligations. This is because, whilst we expect there to be some direct benefits to people living in areas where coverage is improved, much of the benefit will accrue to people who travel through and visit these areas, either from neighbouring communities, or from further afield. We set this out in more detail in annex 11. We therefore consider that a similar number of customers would benefit from the second geographic obligation (i.e. the customers of the second obligated operator, who would also experience the benefits of improved coverage) as from the first.*

Unlike customers residing in these areas, customers who "travel through these areas" do not need to have a choice between two providers. These customers only need service in the areas that currently have no coverage. Ofcom proposes to include a second coverage obligation lot in order to benefit the customers of the MNO that wins the second coverage lot in addition to the customers of the MNO that wins the first coverage lot. But, by the same reasoning, Ofcom can generate a much better outcome: expand the pool of customers who benefit from the improved coverage to the customer base of all four MNOs, while simultaneously reducing public spending by 50% or more.

To achieve this, Ofcom merely needs to include one coverage obligation lot in the auction and to attach a mandatory roaming agreement to the coverage obligation so that all four MNOs have access to the new network. This approach dominates the approach that Ofcom has proposed in many dimensions. First, only one physical network will be built, which is socially optimal given the low population density. Second, the customers of all four MNOs (not just two) will receive the benefit of using the network when traveling through the currently-unserved areas that will get coverage. Third, since the networks of all four MNOs will effectively be enhanced, this approach will enhance competition by avoiding asymmetrically strengthening two of the MNOs (likely the two strongest) relative to the other two MNOs. Fourth, public spending will be reduced because only one coverage obligation will be subsidized. Fifth, limiting the supply of the coverage obligation lots in the auction to just one lot can enhance competition in the auction, further reducing public spending. Finally, if Ofcom insists on using its proposed auction design with the positive price constraint, the potentially substantial distortions from this constraint (demonstrated in Section 2) will automatically be halved by limiting distortions to only one coverage lot.

6. In an efficient auction, Ofcom should account for differences in social value of the coverage obligation generated by different MNOs

The four MNOs are asymmetric in terms of their geographic coverage prior to the auction and in terms of their expected geographic coverage levels in the long run in the absence of coverage obligations. According to ¶A11.144:

> *As set out in chapter 4, the operators are likely to have different levels of geographic coverage prior to the auction. We estimate that (absent any coverage obligations) Vodafone, O2 and H3G's geographic coverage levels may be around 82% in long run, while BT/EE may have a higher level of coverage of around 84%.*

This has two important implications. *First*, each MNO would incur a different cost to meet the requirements of a coverage obligation. Expanding a network from a coverage level of 82% to a coverage level of 90% is more costly than expanding a network from a coverage level of 84% to a coverage level of 90%.

Second, the social value (and thus Ofcom's value) of awarding a coverage obligation depends on the identity of the winner. If a winner of the obligation is a bidder who already has an extensive network, the social improvement from the coverage obligation lot is limited. In contrast, a winner with a smaller footprint would generate a larger social benefit by meeting the same coverage requirements. In other words, the value that UK consumers will derive from a 90% coverage obligation by a given MNO depends on the MNO's coverage level in the counterfactual without any coverage obligations. Thus, based on Ofcom's estimates above, the social value will be lower if a coverage obligation is provided by BT/EE than if a coverage obligation is provided by one of the other MNOs.

The fact that the social value of a coverage obligation depends on the identity of the MNO is not taken into account in Ofcom's proposed auction design. Specifically, in the proposed design, all bidders will face the same price for the coverage obligation, regardless of their current geographic coverage levels. This may result in inefficient outcomes.

We illustrate the potential inefficiencies by providing a simple example with one coverage obligation. Before the auction, Bidder 1 has a larger coverage level than Bidder 2. The cost of providing the coverage obligation is 60 for Bidder 1 and 70 for Bidder 2. The social value is 100 when the coverage obligation is provided by Bidder 1, and 120 when it is provided by Bidder 2. If both bidders face the same price in the auction, the bidder with the lower cost (that is, Bidder 1) will win the coverage lot, and the surplus created in the auction will be 100 – 60 = 40. However, this outcome is not efficient because the maximum social surplus is created when Bidder 2 wins the coverage obligation (120 – 70 = 50). Thus, the design that Ofcom is proposing,

where both bidders face the same price in the auction, fails to achieve efficiency when the value of the coverage obligation depends on the identity of the winner.

To restore efficiency in this example, the auctioneer should make a small modification to the auction design known as an "indifference curve". For the purposes of comparing offers from bidders, the auctioneer should view an offer by Bidder 1 to provide the coverage obligation at price P as being equally competitive to an offer by Bidder 2 to provide the coverage obligation at price P + 20. (In other words, the auctioneer handicaps Bidder 2 by 20 relative to Bidder 1 in the contest to provide coverage, because the social value when the coverage obligation is provided by Bidder 2 is 20 greater than when the coverage obligation is provided by Bidder 1.) Observe that making this minor modification would fully restore efficiency.

If Ofcom is adamant on including a coverage obligation in the auction, notwithstanding the risks of substantial distortions and inefficiencies arising from the positive price constraint described in Section 2, Ofcom should address the inefficiency described in this section by estimating the differences in social values when the coverage obligation is provided by different bidders and directly incorporating those differences into the auction design with the "indifference curve" approach. It should be noted that the same modification works irrespective of whether Ofcom procures one or two coverage lots.

7. Recommendations

As acknowledged by Ofcom in the Consultation, Article 8 of the Framework Directive requires national regulatory authorities to take all reasonable steps toward "ensuring there is no distortion or restriction of competition in the electronic communications sector and encouraging efficient use and effective management of radio frequencies".[14] In this report, we have demonstrated important ways in which the proposed auction design of the 700 MHz and 3.6 – 3.8 GHz award departs from these objectives. Broadly speaking, the issues that we have identified relate to the way in which coverage obligations are superimposed on the CCA format, and to the activity rule and information policy in the clock rounds. In each case, we have shown that it may distort the allocation of spectrum and result in inefficient use of radio frequencies.

In this final section, we shall conclude by describing reasonable steps that Ofcom may take to reduce or eliminate the distortions and inefficiencies that have been described in the report. As we understand the obligations of national regulatory authorities under Article 8, we believe that Ofcom is required to take versions of these reasonable steps. We summarise our recommendations, as grouped by these two aspects of the auction design.

7.1 The superimposing of coverage obligations on a CCA for spectrum

As we have seen in Section 2, the way in which coverage obligations are superimposed on the CCA for spectrum introduces potentially large distortions and inefficiencies into the award and makes it possible that the social cost of procuring the coverage lot(s) will exceed their social benefit. Moreover, the extent of inefficiency is related to the number of coverage lots and to the maximum discount for each coverage lot.

We have shown that the positive price constraint is the source of the distortions and inefficiencies in an otherwise efficient CCA for spectrum—and that the potential magnitude of the distortions and inefficiencies is unacceptably large. In particular, if Ofcom adopts the midpoint (£350m) of its proposed range for the maximum discount and if Ofcom includes two coverage lots in the auction, we have demonstrated that the appropriate cost measure of procuring the coverage obligation could be as much as £1400m. This potential social cost is both objectively a large number and one that is far in excess of any estimates that we have seen of the social benefit. Consequently, our preeminent recommendation is: *no coverage lots should be offered in the auction unless the positive price constraint can be eliminated*.

If Ofcom is adamant on including coverage, notwithstanding the risks of substantial distortions and inefficiencies arising from the positive price constraint, then Ofcom should at minimum include only one coverage lot, not two (as this would halve the inefficiency) and, in addition,

[14] Consultation, ¶3.3.

the maximum discount for this (one) lot should be set at no greater than one-half of the lowest estimate of the benefit of a coverage lot. This would help to assure that, when procured, the coverage lot passes cost-benefit analysis. Nonetheless, there would still be a possibility that the coverage lot would not improve social welfare, given the uncertainty around these estimates.

In the consultation document, Ofcom states that "In our view the benefits of our proposed obligations are at least as high as £400m to £500m".[15] However, the text is ambiguous about whether £400m is the lowest estimate of the benefit of *each coverage lot* or the lowest estimate of the benefit of *the proposed two coverage lots together*. If it is the lowest estimate of the benefit of each coverage lot, this reasoning implies that the maximum discount should not exceed £200m. If it is the lowest estimate of the benefit of two coverage lots together, then the maximum discount should not exceed £100m.

As seen in Section 5, attaching a mandatory roaming obligation to the coverage lot, so that all four MNOs have access to the new network, dominates the approach proposed in the consultation in many dimensions. It would maximise the social value of the coverage lot, minimising the likelihood that the relevant cost of the coverage lot exceeds its social benefit, and it would enhance competition.

7.2 The activity rule and information policy in the clock rounds

As we have seen in Sections 3 and 4, the proposed information policy is undesirably opaque, while the proposed activity rule (specifically, assigning zero eligibility points to the coverage lots) is highly nonstandard and falls short of its objective. Consequently, *we recommend an information policy wherein the exact aggregate demand for each coverage lot is disclosed to bidders after every clock round, except for the final clock round, and an activity rule that is proportionate to the auction*.

If Ofcom adopts our preeminent recommendation that no coverage lots should be offered in the auction unless the positive price constraint can be eliminated, then Ofcom is already aware of the appropriate activity rule. If Ofcom is adamant on including coverage, notwithstanding the risks of substantial distortions and inefficiencies arising from the positive price constraint, then the revised activity rule that we offer in Section 4.5 would eliminate the presence of lots with zero eligibility points, as well as make it possible for Ofcom to adopt a transparent information policy.

[15] Consultation, ¶A13.22.