AUCTION DESIGN CONSIDERATIONS FOR THE PUBLIC SECTOR SPECTRUM RELEASE

PREPARED FOR HUTCHISON 3G UK BY POWER AUCTIONS LLC

January 2015
1. Executive Summary

Power Auctions welcomes this opportunity to comment, on behalf of Hutchison 3G UK, upon Ofcom’s proposals to award spectrum in the 2.3 GHz and 3.4 GHz bands. Our main points argued herein are as follows:

**Withholding of demand information undermines efficiency and transparency.**

The most critical flaw in both the SMRA and the CCA rules proposed by Ofcom is that they withhold all demand information from bidders, even in aggregate between bidding rounds. The greatest advance in spectrum allocation in the past two decades has been the use of modern dynamic auction methods to determine winners, and Ofcom has adhered to this trend in its past auctions. However, the current consultation document proposes to go backward and to replace successful dynamic auction methods with essentially sealed-bid auction processes.

The consultation document would have bidders participate in a lengthy, but almost entirely opaque multi-round procedure, eliminating the standard benefits of dynamic auctions. This would undermine the key objectives of efficiency and transparency in spectrum allocation. In addition, the paucity of information would not only exacerbate the Winner’s Curse but make it impossible for upper management even to understand what the company is likely to win, making bidding governance unduly challenging.

**The proposed SMRA rules introduce a number of half-way measures that are dominated by the full CCA format, which has performed well in a number of recent auctions.**

The narrative developed in this document is that the SMRA rules presented by Ofcom contain a large number of ad-hoc changes that make the SMRA more like a CCA. These modifications include:

- A bidder-selected Minimum Spectrum Requirement (MSR), waivers, and a withdrawal rule, partially re-creating the CCA’s lack of an exposure problem;
- Bidders must raise their prices on all lots in a category they wish to win in order to raise their price on any lot, partially replicating the workings of a clock auction;
- Generic lots, as in a CCA; and
- An assignment round, as in a CCA.

These modifications potentially have unintended consequences:

- Bidders may be able to use the MSR to impose externalities on their opponents without paying the cost or even to exclude smaller rivals from the 2.3 GHz band;
- The MSR may also worsen the outcome by causing undersell;
- Waivers allow anti-competitive gaming by delaying commitment;
• Withdrawals permit total relaxation of eligibility for the purpose of excluding others from the spectrum, as well as creating unnecessary strategic complexity; and
• The proposed rule that a bidder wishing to submit any bids at a new price level must raise all of its Standing High Bids to the new price level may exacerbate both the auction’s complexity for bidders and the incentives for strategic demand reduction.

There are several aspects to our position. First, it should be emphasised that, with only a few more modifications, the SMRA proposed by Ofcom would become a full-fledged CCA—and without these unintended consequences. The additional modifications needed are:

• Migrating from the SMRA’s uniform pricing rule to the CCA’s opportunity-cost-based pricing rule would eliminate incentives for strategic demand reduction and market division—and, hence, any perceived need to withhold aggregate demand information;
• Introducing an optimisation-based winner determination would also internalise the externality from a bidder seeking a package that does not fit well with other bidders;
• Utilising an incrementing rule that makes no distinction between provisionally-winning bids and provisionally-non-winning bids expedites the progress of the auction while providing higher-quality feedback to bidders on demand;
• Introducing full package bidding eliminates exposure altogether, eliminating any need for ad hoc measures such as a bidder-selected Minimum Spectrum Requirement while creating better incentives for truthful bidding and obviating archaic and misguided options such as bid withdrawals; and
• Adding a supplementary bidding round for expressing demand for all possible packages, not only ones that include the previous round’s standing high bids, better serves Ofcom’s objectives of encouraging efficiency and minimising undersell.

Second, CCAs using state-of-the-art rules have performed exceedingly well in the UK and other jurisdictions. For example, the UK’s 2013 4G Auction accomplished all of the following:

• It accomplished Ofcom’s competition objective of awarding a 2x5 MHz block of scarce sub-1-GHz spectrum to a fourth national operator;
• It avoided any undersell;
• It raised revenues within the range achieved in other European 4G auctions; and
• It adhered to full disclosure of aggregate demand after every round.

Similarly, Canada’s recent 700 MHz auction could be considered a rousing success, simultaneously achieving the following:

• A 2x5 MHz block was awarded to a fourth operator throughout the country;
• It resulted in negligible undersell—all but 0.03% of spectrum (by reserve prices) was allocated;
• It raised very high revenues (CA$5.27 billion), without any apparent damage to efficiency; and
• It adhered to full disclosure of aggregate demand after every round (except for the final clock round).

The UK 4G auction’s use of an activity rule that was based purely on eligibility points, its incomplete integration of a competition constraint into the standard CCA rules, and gaps in the education of bidders how the CCA works may have made bidding unnecessarily complex and may have made the 2013 auction unnecessarily prone to surprise outcomes. However, the current proposals to withhold demand information, as well as for withdrawals, penalties, and eligibility points unrelated to licence value, would make the next auction more complex for participants and more prone to surprise outcomes.

**If a CCA is perceived to be too complex, a clock auction is a far better choice than an SMRA.**

For the US Incentive Auction planned for 2016, in which the 600 MHz band will be repurposed from traditional broadcasting to mobile broadband, the Federal Communications Commission recently released a Comment Public Notice proposing detailed auction rules. Power Auctions contends that if a CCA is perceived to be too complex for the PSSR, the clock auction design proposed in the Comment Public Notice would be a far better choice than an SMRA.

The Incentive Auction’s proposed forward auction is intended to be the clock auction design that is closest to the SMRA. Spectrum licences that are close substitutes are grouped together as generic spectrum. In every round, the auctioneer announces prices for each category of generic spectrum, and bidders respond by bidding the quantities of lots in each category that they desire. Following standard clock auction protocol, there are no Standing High Bidders selected after each round. Instead, every bidder is free to reduce its quantity to the extent that aggregate demand remains at least as great as supply, and no bidder is permitted to reduce its quantity to the extent that it would cause aggregate demand to become less than supply.

As such, this clock auction will run considerably faster than an SMRA and bidding will be simpler than in an SMRA. The auction will run faster because, whenever there is excess demand, the price of every licence in the band will increase. Bidding is simplified because bidders are permitted to name the prices at which they drop demand or switch bands (“intra-round bids”), rather than needing to decide among discrete increments. Moreover, truthful bidding is facilitated, as bidders only pay the intra-round price at which supply equals demand, not the end-of-round price. In addition, various strategic aspects of the SMRA, such as whether or not a bidder should raise its Standing High Bids, as well as waivers and withdrawals, are completely stripped out of the auction design. Finally, there is a natural measure of aggregate demand to report to bidders after every round—and the proposed Incentive Auction rules include such disclosure as the information policy adopted.

**A plain-vanilla SMRA is also preferable to Ofcom’s proposed SMRA.**

Even if one does insist on retrogressing to an SMRA, this can be accomplished better using plain-vanilla SMRA rules. Besides the disclosure of demand information, the key difference
between a ‘plain-vanilla’ SMRA and Ofcom’s proposed SMRA is that the ‘plain-vanilla’ SMRA treats every lot as unique. As such, bidding for one lot never requires placing a bid on another lot, so bidders are never required to raise their own Standing High Bids. By contrast, Ofcom’s proposed SMRA includes the requirement that a bidder wishing to submit any bids at a new price level must raise all of its Standing High Bids to the new price level.

The US AWS-3 auction (currently in progress) illustrates the lack of any need to withhold aggregate demand:

- It uses plain-vanilla SMRA rules;
- It has accumulated a record-breaking US$45 billion in revenues at this writing, despite offering only the 1700 MHz and 2100 MHz bands and despite the absence from the auction of one of the four large US operators; and
- It has adhered to full disclosure of aggregate demand after every round.

**Summary of our recommendations:**

Power Auctions’ recommendation is that Ofcom should study and assess whether the 2.3 GHz and 3.4 GHz spectrum bands are related to one another (i.e. substitutes or complements) or independent. (Hutchison 3G UK considers it likely that the two bands are partial substitutes for one another, as both bands can be used to provide network capacity.) The auction format that is selected should depend on whether the two bands are related or independent, and would always include full disclosure of aggregate demand information.

If Ofcom determines that the two bands are related, the recommended approaches to auction format are ranked in descending order in the following list:

1. A CCA closely adhering to the rules of the Canadian 700 MHz or 2500 MHz auction, in which aggregate demand is disclosed after every round (except for the final clock round);
2. A clock auction, closely following the rules proposed in December 2014 for the forward auction of the FCC’s Incentive Auction programme, in which aggregate demand is disclosed after every round; or
3. A plain-vanilla SMRA, closely following the rules of the current US AWS-3 auction, and in which aggregate demand is disclosed after every round.

Note that (2) and (3) are quite close to each other and would probably lead to very similar results, but (2) would expect to run much faster and be a much superior experience for bidders than (3). Thus, our view is that (2) basically dominates (3). Note also that, in either the CCA or SMRA, we differ substantially from the condoc’s approach to eligibility points, which we believe should be set in reasonable relation to the values of the respective licences—see below.

Conversely, if Ofcom determines that the two bands are independent, it should sequentially run two separate clock auctions, first for the 2.3 GHz band and then for the 3.4 GHz band (since the
former is of higher value and in greater scarcity than the latter). Each would be a simple clock auction for a homogeneous good. To avoid the perceived need for withholding aggregate demand information, Ofcom should consider utilising a “clinching” pricing rule, which eliminates bidders’ incentive for strategic demand reduction, rather than uniform pricing. Following these two separate clock auctions, Ofcom should conduct an assignment stage, as currently proposed, for winners.

We also comment briefly on some narrower auction design issues:

- It would be best to avoid allowing bidding waivers, which introduce bidding complexity and offer no real benefit. Ofcom would do better to use round extensions, as in past UK auctions, in their place.
- Since bidder-defined Minimum Spectrum Requirements may allow bidders to impose externalities on others without paying the cost or even to exclude rivals from the 2.3 GHz band, the maximum allowed MSR should be reduced from 20 MHz to 10 MHz. This will also have the side benefit of limiting the potential undersell that it produces to a maximum of only a single 5 MHz block per spectrum band.
- Eligibility points are optimally set in proportion to the items’ values. Ofcom’s proposal of attaching equal eligibility points for two different spectrum bands believed to be substantially different in value establishes an environment where bidders have strong incentive to engage in “parking”, which will increase the strategic complexity of the auction, further decrease transparency, and likely diminish the efficiency of the auction outcome. As such, we propose that Ofcom adopt somewhere between a 2:1 and 4:1 eligibility point ratio between spectrum blocks in the 2.3 GHz and 3.4 GHz bands.
- Ofcom proposes to introduce a relaxed activity rule for the CCA proposal. However, Ofcom does not propose a similar change to the activity rule for the SMRA design. A relaxed activity rule would solve at least two major problems in the proposed SMRA design. First, the choice of eligibility points becomes less critical. Second, the “parking” strategy loses its attractiveness.
- By design, standard SMRAs need a mechanism to break ties and select Standing High Bids from among otherwise equal bids of different bidders. Many SMRAs, including the one proposed by Ofcom, break such ties based on some non-random priority ranking. Such procedures create strategic opportunities for bidders and significantly complicate the bidding process. Modern SMRA designs break ties randomly, allowing bidders to focus their efforts and resources on efficiency-enhancing tasks such as price discovery, while clock auction designs eliminate the designation of Standing High Bids and thereby eliminate the need for this form of tie-breaking mechanism.
- One nonstandard element of this award is the presence of UK Broadband’s holdings in the 3.4 GHz band. The presence of these holdings can interfere with the normal allocation process in two ways. First, there is a nontrivial possibility of a non-contiguous spectrum award to one of the winners that potentially requires major changes to the product configuration. Second, serious auction design flaws can be present if UK Broadband decides to participate in the award. It is important to handle this element very carefully and in the most straightforward way possible.
2. Withholding of demand information undermines efficiency and transparency

The auctions literature has provided us with two fundamental prescriptions guiding effective auction design. First, an auction should be structured so that the price paid by a player—conditional on winning—is as independent as possible of her own bids (William Vickrey, 1961). Ideally, the winner’s price should depend solely on opposing participants’ bids—as in the sealed-bid, second-price auction—so that each participant has full incentive to truthfully reveal her value for the good. Second, an auction should be structured in an open fashion that maximizes the information made available to each participant at the time she places her bids (Paul R. Milgrom and Robert J. Weber, 1982a). When there is a common value component to valuation and when bidders’ signals are affiliated, an open ascending-bid format may induce participants to bid more aggressively (on average) than in a sealed-bid format, since participants can infer greater information about their opponents’ signals at the time they place their final bids.¹

Viewed in this way, the current condoc’s proposal is a giant step backward in auction practice. Ofcom proposes to withhold aggregate demand data from auction participants. This runs counter to Milgrom and Weber’s prescription of maximising the information made available to each participant at the time she places her bids. It runs opposite to international best practice. It defeats the purpose of running open ascending-bid auctions, makes it difficult for bidders to infer their opponents’ information, suppresses price discovery, exacerbates the winner’s curse, eliminates transparency, and leads to less efficient outcomes. At the same time, Ofcom proposes to utilise an SMRA, rather than the CCA format used in its previous 4G auction. This moves away from opportunity-cost-based pricing and toward uniform pricing—in an opposite direction to Vickrey’s prescription of making the winner’s price as independent as possible of her own bids. It diminishes incentives for truthful bidding and leads toward less efficient auction outcomes, counter to Ofcom’s stated objective.

2.1 The greatest advance in spectrum allocation in the past two decades has been the adoption of modern dynamic auction methods, including the disclosure of demand information to bidders after every round

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*:

2.1 *Open bidding is better than a single sealed bid*

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.²

Before the 1990s, spectrum rights tended almost always to be allocated by administrative hearings or by lotteries. Beginning about 1990, governments began to experiment with utilising auctions. But some of the initial uses of auction were famously unsuccessful, in large part because they used sealed-bid auctions, rather than modern dynamic auction methods.

One case in point occurred when New Zealand began auctioning spectrum in 1990. Following the advice of NERA, the economic consulting firm, the government adopted second-price sealed-bid auctions. Politically embarrassing newspaper headlines resulted, as winners paid prices far below their bids and sometimes paid next to nothing. “In one extreme case, a firm that bid NZ$100,000 paid the second-highest bid of NZ$6. In another the high bid was NZ$7 million and the second bid NZ$5,000.”³ This sort of outcome becomes much less likely in a modern dynamic auction; bidders can see that particular licences would currently sell at low prices and have the opportunity to switch into bidding for them.

The US programme that began in 1994 has utilised modern dynamic auctions and, as a result, has been much more successful. The Federal Communications Commission has conducted 63 spectrum auctions, with total revenues of US$78.5 billion (as well as 25 auctions for broadcast licences, with total revenues of US$1.4 billion), plus one spectrum auction in progress that has at this writing raised US$45 billion. All of the FCC’s spectrum auctions have used dynamic auctions and have disclosed demand information to bidders after every round. This was a conscious decision: “The FCC, following the theorists’ recommendation, chose an open auction ahead of a sealed-bid auction. The advantage of an open auction is that it reduces the force of the ‘winner’s curse.’ ... If bidders bid to avoid the winner’s curse, then anything that improves the bidders’ information is to the government’s advantage, in that it induces the bidders to be

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less cautious.” The only variation in information policy in US auctions has been whether each individual bid (including the identity of the bidder associated with the bid) would be disclosed after every round—or whether only the aggregate demand would be disclosed.

Ofcom began auctioning spectrum in 2000 and has successfully operated a number of spectrum auctions in the UK. The most significant of these were: the UK 3G Auction of 2000, an SMRA with full disclosure of all demand data, which raised £22.5 billion and was at its time the largest spectrum auction worldwide to date; and the UK 4G Auction of 2013, a CCA with disclosure of aggregate demand data, which raised £2.34 billion. That is, the 3G Auction generally conformed with the standard SMRA rules of the time, including that each individual bid (and the identity of the bidder associated with the bid) was disclosed after every round. The 4G auction generally conformed with standard CCA rules, including that the aggregate demand for each product was disclosed after every round.

### 2.2 A multi-round auction in which the only information disclosed is whether aggregate demand > supply is tantamount to a sealed-bid auction

Ofcom may believe that they are not stepping back from dynamic auctions by moving to an information policy in which aggregate demand is not disclosed. However, on this point, Ofcom is mistaken. In fact, a multi-round auction in which the only information disclosed is whether aggregate demand > supply is tantamount to a sealed-bid auction.

This can be seen formally by comparing the equilibrium of a second-price sealed-bid auction with the equilibrium of an ascending auction, in the standard model with correlated values considered by Milgrom and Weber. There are \( n \) symmetric bidders for a single item. Their private signals are “affiliated”, meaning that they are positively correlated in the exact way that preserves monotonicity of conditional expectations. The sealed-bid auction allows submission of bids that are any real number, while the ascending auction has prices increasing continuously. Milgrom and Weber (1982) show that the equilibrium bid function of the second-price, sealed-bid auction for a bidder with signal \( x \) is given by:

\[
b^*(x) = v(x, x), \text{ where } v(x, y) = E[V_1 | X_1 = x, Y_1 = y].
\]

In words, the equilibrium of the sealed-bid auction is for each bidder to bid the amount that the spectrum licence is expected to be worth to him in the event that there is an exact tie between his signal and his highest opponent’s signal. The equilibrium has the property that the highest-value bidder always wins the auction; moreover, the winner never regrets winning and each loser never regrets losing (at the requisite price).


Now consider the ascending auction without revelation of demand information. Our observation is that the exact same function \( b^*(x) \) as above is also the equilibrium of the sealed-bid auction. Now, \( b^*(x) \) has the interpretation that it is the price at which the bidder with signal \( x \) drops out of the auction if he has not already won.

The intuition why the equilibrium is exactly the same is that, when the only information disclosed is that aggregate demand > supply, the bidder in the ascending auction never learns any information other than that he still needs to bid. Consequently, his bidding strategy consists solely of determining a maximum amount that he is willing to bid, independent of any other information. This is exactly the same optimisation problem that the bidder solves in the second-price, sealed-bid auction.

In short, when aggregate demand information is withheld from bidders, they have no greater protection from the winner’s curse than in a sealed-bid auction. The multi-round auction is then tantamount to a sealed-bid auction.

The above equivalence is not limited to the Milgrom-Weber environment. For example, consider an auction for a homogeneous good in which the bidders have multi-unit demands. Suppose that you have an equilibrium bid function for the uniform-price, sealed-bid auction. Note that this bid function consists of various (price, quantity) pairs, as bidders will tend to demand smaller quantities as the price ascends. Still, the same bid function also provides the maximum price that the bidder is willing to bid for each quantity in the ascending auction.

Mitigating the winner’s curse is by no means the only advantage of dynamic auctions over sealed-bid auctions. For example, Eric Maskin argues forcefully that dynamic auctions have greater ability than sealed-bid auctions to allocate items efficiently:

> From the work of Vickrey (1961), it is known that the [second-price, sealed-bid] and English auctions are efficient under the assumption of private values, the case in which no buyer’s information affects any other buyer’s valuation (Proposition 1). The [first-price, sealed-bid] auction, however, is not efficient under strong symmetry and informational assumptions (Proposition 2). The English auction (but not the other two) remains efficient under common values (in which buyers’ valuations may depend on others’ private information), provided that each buyer’s information can be represented by a one-dimensional parameter (Proposition 4) (emphasis added).\(^6\)

This point should be particularly relevant to Ofcom, since efficiency is Ofcom’s foremost objective. Indeed, in the lead-up to the 4G Auction, Ofcom laid out an ambitious set of design principles, including:

More generally to facilitate the reduction in common value uncertainty: bidders are likely to be seeking to serve the same mobile broadband services market and are therefore likely to be valuing spectrum for similar purposes. Being able to validate their own estimates of value against the bidding decisions of other bidders should allow information relevant to the valuation of spectrum to be aggregated across bidders and improve economic efficiency.  

Without question, we have demonstrated that Ofcom is disregarding this design principle in proposing to withhold demand information from bidders. Without any good justification, the proposed non-disclosure policy will prevent valuation information from being aggregated across bidders and will have the effect of harming economic efficiency.

2.3 Limiting the reported information to aggregate demand is the appropriate response to concerns about market division by bidders

It has been pointed out, correctly, that reporting individual bid information (including the identity of the bidder associated with each bid) may be an excessive degree of disclosure. It may facilitate bidders’ ability to engage in market division, it may enable a bidder to 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.

and later in the same article:

The clock auction limits collusion relative to the simultaneous ascending auction. Signalling how to split up the items is greatly limited. Collusive strategies based on retaliation are not possible, because bidder-specific quantity information is not given. Further, the simultaneous ascending auction can have a tendency to end early when an obvious split is reached, but this cannot happen in the clock auction,

7 “Consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues,” 22 March 2011, paragraph 9.8(d), p. 110.

because the bidders lack information about the split. Also there are fewer rounds to coordinate a split.9

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 > supply. This is not only the assessment of academic commentators but also apparently the view of the US Federal Communications Commission. For its first decade of conducting SMRAs, the FCC reported all individual bids (including the associated bidder) after each round. However, in recent years, the FCC has changed its protocol to reporting only anonymized bids. Observe that this is just another version of disclosing aggregate demand—participants can see the number of bidders bidding for each licence, but not the identities of these bidders.

2.4 Withholding demand information creates governance challenges for bidders and encourages “surprise outcomes”

Prior to the last auction, Ofcom laid out other ambitious design principles, including:

To limit barriers to participation as far as possible: the auction should not unreasonably deter participation by any type of prospective bidder, including smaller bidders as well as large, sophisticated bidders. This implies that participating in the auction should be relatively simple, relatively low cost and low risk for bidders.” 10

Ofcom should take its settled design principles to heart in setting rules for the PSSR auction. In particular, in order to make participation relatively simple, Ofcom should avoid creating foreseeable governance challenges for bidders, and in order to make participation low risk, Ofcom should structure its auction rules to minimise “surprise outcomes”.

The lack of transparency inherent in an auction without demand information creates extraordinary challenges for a bidding team to explain to its senior management what they are likely to win. This creates a situation where the superiors who hold the purse strings do not understand what is going on in the auction, lose all trust in the bidding team’s strategy, and risk making material bidding mistakes.

A CCA or SMRA 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. A CCA or SMRA with disclosure of aggregate demand after every


10 “Consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues,” 22 March 2011, paragraph 9.8(g), p. 110.
round would allow bidders to switch their demand among different bands in light of other bidders’ information and decisions, also reducing “substitution risk”. 11

2.5  **Withholding demand information encourages bidders to probe and to “play games”, at the expense of truthful bidding and efficiency**

Ideally, a spectrum regulator would like a bidder to devote its preparation before the auction to establishing its valuations for the various possible combinations of spectrum and to focus its bidding during the auction on truthful expressions of these valuations. Unfortunately, withholding demand information from bidders works to the detriment of both of these ideals.

Before the auction in which demand information is withheld, the bidder would be wise to devote a considerable fraction of its preparations to obtaining competitive intelligence about its competitors, since without disclosure of demand information, the bidder will have little idea of what is going on in the auction or what it is likely to win. The auction process will provide little insight into opponents’ information and decisions, so the bidder will need to develop this insight independently. Obtaining competitive intelligence will be costly—discouraging participation in the auction—and the expenditure of resources on competitive intelligence will be socially unproductive.

Meanwhile, during the auction in which demand information is withheld, bidders would be naïve to bid truthfully. Rather than bid consistently for their most-valued licence combination at current prices, bidders will tend to probe and to “play games”. If the auctioneer will not inform bidders of the amount of excess demand and will only tell them whether aggregate demand > supply, the bidders’ only way to obtain this information is to divert their demands to less-preferred licences and thereby cause aggregate demand to become temporarily equal to supply—a fact which is revealed. 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 and to the detriment of efficient spectrum allocations.

2.6  **The only reasonable rationale for withholding demand information is to deter bidders from engaging in market division. However, this is only an issue with the SMRA pricing rule, not the CCA pricing rule**

Under the SMRA’s pricing rule (or any variation on the pricing rule of a uniform-price auction), 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

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11 “Consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues,” 22 March 2011, paragraphs 9.15 and 9.16, p. 111.
the bidder’s true value.\(^\text{12}\) The same forces also create incentives for bidders to engage in market division, particularly in dynamic auction formats with the pricing rule of the SMRA.\(^\text{13}\) By contrast, 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.\(^\text{14}\) 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.\(^\text{15}\)

Ofcom proposes to implement an SMRA in which the only demand information disclosed is whether aggregate demand > supply. As argued above, this would be tantamount to converting the multi-round auction into a sealed-bid auction. The only reasonable rationale for this severe information policy—and the only rationale provided—is to deter bidders from engaging in market division.\(^\text{16}\) However, given the economic literature summarised in the previous paragraph, a much more reasonable solution would be to replace the SMRA’s pricing rule with the Vickrey auction’s or CCA’s pricing rule. By doing so, the Public Sector Spectrum Release would realise the benefits of a dynamic auction with disclosure of aggregate demand information—including enhanced aggregation of bidder information, reduced common value uncertainty, a diminished winner’s curse, and greater efficiency.

To rephrase this conclusion, if Ofcom truly believes that the only viable way to run an SMRA is by withholding aggregate demand—we question this assessment in the next subsection, as there have been plenty of successful recent SMRAs with aggregate or full demand disclosure—then the obvious implication is that Ofcom should instead run a CCA. Since the CCA utilises Vickrey pricing, there should be no fear of a market division and no need to withhold demand.

Ofcom offers two rather unpersuasive reasons why it should also withhold demand information in the CCA. The condoc’s first rationale is that “disclosing this type of information might allow bidders to assess whether the clock rounds are reaching the end. In the extreme, this can


\(^{16}\) Condoc, paragraphs 6.48 – 6.51, p. 34.
facilitate tacit collusion.”¹⁷ As already demonstrated by the economics literature cited in the first paragraph of this subsection, this first rationale is simply incorrect. The condoc’s second rationale is that “if bidders know 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, allows bidders more room to place bids in the Supplementary Bid Round that impact the prices paid by their competitors.”¹⁸ 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. We describe a more constraining activity rule—the GARP-based activity rule—in section 7.1 of this comment.

2.7 Ofcom’s proposed approach of withholding demand information is untested and goes against international best practice

Ofcom’s proposed approach of withholding demand information from the SMRA or CCA is untested and extremely unusual. We have attempted to review recent auctions and we have only been able to identify three significant “peer-group” SMRA or CCA auctions in which aggregate demand information was withheld from bidders to a significant degree.

Importantly, we think that the untested nature of SMRAs and CCAs without demand disclosure largely invalidates Ofcom’s residual-risk analysis.¹⁹ A valid residual-risk analysis should be based on empirical experience. However, the auction formats whose risk is being assessed have aggregate demand information withheld from bidders, whereas almost all empirical experience derives from spectrum auctions that had aggregate or full demand disclosure.

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<td>Germany 4G Spectrum Auction</td>
<td>2010</td>
<td>SMRA</td>
<td>Full demand disclosed</td>
</tr>
<tr>
<td>Sweden 800 MHz Spectrum Auction</td>
<td>2011</td>
<td>SMRA w/ switching</td>
<td>Aggregate demand disclosed</td>
</tr>
<tr>
<td>Italy Multi-Band Spectrum Auction</td>
<td>2011</td>
<td>SMRA</td>
<td>Full demand disclosed</td>
</tr>
<tr>
<td>Portugal Multi-Band Spectrum Auction</td>
<td>2011</td>
<td>SMRA</td>
<td>Demand information withheld</td>
</tr>
<tr>
<td>Spain 800 MHz, 900 MHz and 2.6 GHz Auction</td>
<td>2011</td>
<td>SMRA</td>
<td>Aggregate demand disclosed</td>
</tr>
<tr>
<td>Switzerland Spectrum Auction</td>
<td>2012</td>
<td>CCA</td>
<td>Aggregate demand disclosed</td>
</tr>
<tr>
<td>Denmark 800 MHz Spectrum Auction</td>
<td>2012</td>
<td>CCA</td>
<td>Aggregate demand disclosed</td>
</tr>
<tr>
<td>Ireland Multi-Band Spectrum Auction</td>
<td>2012</td>
<td>CCA</td>
<td>Aggregate demand disclosed</td>
</tr>
</tbody>
</table>

¹⁷ Condoc, paragraph 6.80, p. 38.
¹⁸ Condoc, paragraphs 6.81 – 6.82, p. 39.
<table>
<thead>
<tr>
<th>Spectrum Auction</th>
<th>Year</th>
<th>Demand Disclosure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netherlands Multi-Band Spectrum Auction</td>
<td>2012</td>
<td>CCA</td>
</tr>
<tr>
<td>Czech 800 MHz, 1800 MHz and 2600 MHz Auction</td>
<td>2013</td>
<td>SMRA</td>
</tr>
<tr>
<td>UK 4G Spectrum Auction</td>
<td>2013</td>
<td>CCA</td>
</tr>
<tr>
<td>Australia Digital Dividend Auction</td>
<td>2013</td>
<td>CCA</td>
</tr>
<tr>
<td>Austria Multi-Band Spectrum Auction</td>
<td>2013</td>
<td>CCA</td>
</tr>
<tr>
<td>Slovakia 800, 1800 and 2600 MHz Spectrum Auction</td>
<td>2013</td>
<td>CCA</td>
</tr>
<tr>
<td>Norway 800, 900 and 1800 MHz Auction</td>
<td>2013</td>
<td>Sealed-bid</td>
</tr>
<tr>
<td>Canada 700 MHz Spectrum Auction</td>
<td>2014</td>
<td>CCA</td>
</tr>
<tr>
<td>US AWS-3 Spectrum Auction</td>
<td>Current</td>
<td>SMRA</td>
</tr>
</tbody>
</table>

As shown in Table 1, we have only identified three SMRA or CCA auctions in which demand information was withheld from bidders. In Portugal, an SMRA auction was held with information limited to whether aggregate demand > supply. The auction lasted only 9 rounds, and 10 licences went unsold. In Austria, a CCA auction was held with information initially limited to whether aggregate demand > supply. After prices became too high, the regulator amended the auction rules midway through the auction so that aggregate demand was disclosed: “Die Transparenz wurde nach 39 von 72 Clockrunden erhöht.” 20 In Slovakia, a CCA auction was held in which aggregate demand was disclosed only once per day, but the disclosure encompassed all auction rounds that were conducted that day.

In the plain-vanilla SMRA (at a 100% activity requirement) and in the standard CCA, demand is fully and accurately disclosed. By contrast, in some aggregate-demand disclosure implementations, such as the India 900 and 1800 MHz auction, it is impossible to determine demand accurately from the disclosures, since if a bidder raises its own bid, the total demand is sometimes partially obscured.

Assuming that Ofcom is convinced by our arguments to release aggregate demand information, the most useful statistic to report for each band in the SMRA (to control for raises of Standing High Bids) is the following: 21

\[
\sum_{\text{bidders}} \text{Max}(\text{New Bids MHz, Standing High Bids MHz})
\]


21 To also control for withdrawals, only unwithdrawn standing-high bids should be part of the sum. This equation assumes that bidders will continue to be required to raise their standing high bids on all blocks in a band if they bid for any at a higher price. If not, the union of the two sets of bids, rather than the maximum, should be used.
We recommend, in both designs, that aggregate demand information be provided for each lot category:

- In the CCA, aggregate demand for each band should be revealed to bidders after every round; and

- In the SMRA, for each band, the sum across bidders of the maximum of new bids and previous-round Standing High Bids should be reported.
3. The proposed SMRA rules introduce a number of half-way measures that are dominated by the full CCA format, which has performed well in a number of recent auctions

Ofcom has proposed a large number of changes to standard SMRA rules for this spectrum award. One of these—the introduction of generic lots and an assignment round, in lieu of specific lots—is a bona fide enhancement, adopting a highly desirable modern innovation that simplifies bidding and encourages efficient allocations. However, some of the other rules changes in the condoc are half-way measures that may result in unintended consequences. For example, the rule that a bidder wishing to place any bids at a new price level must raise its Standing High Bids to the new price level may both exacerbate the auction’s complexity for bidders and exacerbate strategic demand reduction. (That particular rule will be addressed in Section 5, when it is compared to the rules of a ‘plain-vanilla’ SMRA.) Another enhancement, the Minimum Spectrum Requirement (MSR), is a feature that allows bidders to protect themselves against winning economically insufficient amounts of spectrum. However, it also creates numerous gaming opportunities for bidders that can lead to inefficient outcomes. In case Ofcom proceeds with a non-combinatorial design, Power Auction suggests reducing the maximum allowable MSR from the proposed 20 MHz to 10 MHz, in order to limit strategic bidding opportunities while still affording full protection against 5 MHz allocations for a bidder who finds winning 5 MHz to be undesirable. Finally, Ofcom’s proposed rules retain two SMRA features, withdrawals and waivers, that are completely outdated and undesirable. Modern spectrum auction practice has developed superior mechanisms to deal with situations where bidders might find withdrawals and waivers to be useful, without creating strategic complexity or sacrificing efficiency.

3.1 Generic Blocks and the Assignment Round

Ofcom has made a good decision to avoid the traditional SMRA practice of treating each frequency block as a specific item. The use of “generic lots” is standard in auctions that use the CCA format, where treating each block as a specific item would have been quite challenging and counterproductive. Typically, there is a principal stage in which bidders bid for generic lots, followed by an assignment stage in which bidders bid for specific frequencies. Increasingly, the combination of generic lots and an assignment stage is becoming incorporated into other auction formats as well. Most notably, the Federal Communication Commission has proposed, for the US Incentive Auction planned for 2016, offering generic lots in a principal stage followed by an assignment stage within a clock auction format.

In a typical SMRA, specific frequency assignments are directly handled during the main stage of the auction. This often requires unnecessarily complex bidding strategies, as the bidder needs to focus not only on winning the desired number of lots, but also on making sure that they are contiguous. In addition, without mechanics allowing bidders to express a quantity of spectrum blocks, the typical SMRA usually results in a very slow auction. Bidders who are indifferent among many similar blocks will bid on each block in turn, causing massive time delays. In the
Canadian AWS auction, there were nearly 100 rounds at the end of the auction during which standing prices changed by only a few percent. By contrast, if the spectrum blocks placed in the same generic category are sufficiently similar to one another, generic lots allow bidders to compete with each other in a speedy manner without any harm to efficiency or revenues.

For the assignment round, Ofcom proposes to use a simple sealed-bid auction design with the pricing rule based on opportunity-cost principles. Assignment rounds organized this way provide bidders with excellent incentives to express their true values for specific frequencies.

Power Auctions strongly supports: (1) the use of generic blocks instead of specific lots for this award; and (2) Ofcom’s rules governing the assignment round.

3.2 Minimum Spectrum Requirement (MSR)

The Minimum Spectrum Requirement (MSR) feature is one of the tools intended to mitigate the exposure problem faced by bidders in the traditional SMRA. By design, the CCA completely eliminates the exposure problem. If bidders have serious exposure concerns, Ofcom should consider using the CCA design instead of introducing an extensive series of half-way measures that try to salvage the SMRA design.

The introduction of the MSR feature to the SMRA provides bidders with additional gaming opportunities. In general, it is relatively easy for bidders to drive up their opponents’ costs in an SMRA, due to the “uniform price” nature of the SMRA’s pricing rule. The only safeguard against this in the standard SMRA is the possibility that the bidder who attempts to drive up prices may “get stuck” winning undesired lots. The newly-proposed MSR feature can significantly reduce the probability of such bidders getting stuck, therefore enhancing their ability to drive up prices. For example, an opportunistic bidder who is interested only in purchasing in the 3.4 GHz band may wish to drive up prices in the 2.3 GHz band. If the opportunistic bidder declares an MSR of 20 MHz, he may bid up the prices of four 2.3 GHz blocks, confident that at some point he will be deemed Standing High Bidder on only two or three blocks. At that point, the MSR allows him to walk away from the 2.3 GHz band at no cost.

Another opportunity for strategic bidding is the potential for unsold lots created by the MSR feature. For example, a bidder may be able to declare an MSR of 20 MHz and displace another bidder who wants 10 or 15 MHz, without winning any spectrum in the band at the end. The bidder may thus be able to make 15 MHz sterile without paying anything. Note that a 15 MHz block in the 2.3 GHz band represents 37.5% of the spectrum available in this band. Depriving opponents of the available spectrum without paying for it can be an attractive strategy for certain bidders.

Ofcom should consider whether the advantages created by the 20-MHz MSR outweigh the newly-created gaming opportunities. To limit these opportunities, Ofcom can reduce the maximum level of the MSR from 20 MHz to 10 MHz. We believe that a 10 MHz MSR will be sufficient to eliminate any exposure problem for most bidders. Moreover, if the maximum level of the MSR is 10 MHz, the most unsold spectrum that the MSR can create is 5 MHz in each band.
(12.5% of the 2.3 GHz band). Furthermore, limiting the MSR to 10 MHz rather than 20 MHz makes it much more difficult for bidders to use the MSR to artificially drive up prices.

Another potential issue is the current MSR syntax. The proposed way of expressing MSR is too simplistic as it only allows bidders to specify minimum amounts of spectrum they need in each band separately. The 2.3 GHz and 3.4 GHz bands can be viewed as substitutes, so it is reasonable to provide bidders with a mechanism to express substitutability in their MSR’s across bands.

We illustrate the issue with an example. Suppose that a bidder is interested in acquiring 30 MHz of spectrum, where at least 20 MHz of it should be in the same band. The bidder desires either: 20 MHz in the 2.3 GHz band and 10 MHz in the 3.4 GHz band; or 10 MHz in the 2.3 GHz band and 20 MHz in the 3.4 GHz band. In order to ensure its minimum requirement, the bidder declares a minimum of 20 MHz for the 2.3 GHz band and a minimum of 20 MHz for the 3.4 GHz band.

Under the current rules, the bidder is guaranteed to get one of four outcomes listed in Table 2. However, none of these outcomes matches the bidder’s actual demand. This example illustrates how the current way of specifying the minimum spectrum requirement might get in the way of expressing a reasonable set of preferences.

<table>
<thead>
<tr>
<th>N</th>
<th>(2.3 GHz Band, 3.4 GHz Band)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(0 MHz, 0 MHz)</td>
<td>Losing</td>
</tr>
<tr>
<td>2</td>
<td>(20+ MHz, 0 MHz)</td>
<td>20 MHz or more in the 2.3 GHz Band</td>
</tr>
<tr>
<td>3</td>
<td>(0 MHz, 20+ MHz)</td>
<td>20 MHz or more in the 3.4 GHz Band</td>
</tr>
<tr>
<td>4</td>
<td>(20+ MHz, 20+ MHz)</td>
<td>20 MHz or more in the 2.3 GHz Band AND 20 MHz or more in the 3.4 GHz Band</td>
</tr>
</tbody>
</table>

Ofcom is also ignoring the efficiency implications of its MSR in its round-clearing algorithm. Ofcom may be faced with a situation in which a bidder who has specified a 20 MHz MSR might be selected to be the Standing High Bidder for 15 MHz of spectrum. Meanwhile, another bidder who did not specify any MSR may be bidding for 5 – 15 MHz of the same band, without being selected as the Standing High Bidder. In such a case, Ofcom should consider changing the tie-breaking rule so that, at a minimum, if a bidder is below its MSR, the algorithm should take a second pass and permit another bidder who would otherwise lose the tie break to win instead. (Note that the CCA avoids any need for such tedious intricacies, as it uses full package bidding and it solves a combinatorial optimisation at the end. Furthermore, note that the clock auction that we advocate in Section 4 as a strict improvement to the SMRA also avoids this issue, since it only selects Standing High Bids when aggregate demand ≤ supply, and it then selects every bid.)

Ofcom’s MSR implementation also results in a bidder potentially being partly outbid in one band and with insufficient eligibility to bid to its MSR in the other band. If a bidder who reaches
this point runs out of waivers still at this point, the bidder will be unable to proceed in the auction (without risking a high penalty by withdrawing) despite possibly having the highest value of all bidders for lots in the band it is trying to switch to.

To conclude, in case Ofcom insists on running an SMRA for the PSSR and includes the proposed MSR feature, we recommend introducing a way for bidders to express substitution across the two bands directly into the MSR—and we strongly recommend reducing the maximum MSR from 20 to 10 MHz.

3.3 Waivers and Withdrawals

Ofcom proposes retaining several outdated features of the traditional SMRA, including waivers and withdrawals, for the purpose of mitigating bidders’ exposure problem in the SMRA design. A waiver is an option for a bidder to be inactive in a given round without facing any reduction in its bidding eligibility in the next round. Ofcom suggests limiting the total number of waivers to three per bidder. A withdrawal is an option that allows a bidder to withdraw the Standing High Bid such that its eligibility can be used for other lots. A bidder is allowed to withdraw its high standing bid only if the bidder agrees to be financially liable for the full amount of its bid in the event that the auction ends without allocating the lots from which the bidder withdrew.

In general, the ability to abstain from active bidding to observe opponents’ decisions and their effects can severely undermine the price discovery process. Waivers also invite market division strategies by allowing a bidder to hold a credible threat of retaliation against his opponents while waiting for the opponents to disarm. Historically, there have been instances of bidders using withdrawals as signalling devices in SMRA auctions—and very few instances of withdrawals being used to escape from failed aggregations. As a result of such issues, there is a prevailing scepticism of both waivers and withdrawals in the auction community—note that newer auction formats such as clock auctions and the CCA have completely stricken waivers and withdrawals from their vocabulary. However, the condoc maintains that waivers can also be useful in at least two situations:

1. A bidder needs additional time to make a decision; or
2. A bidder wishes to observe other bidders’ behaviour before making a decision.

For the first type of situation, round extensions as implemented in the CCA design are far superior to waivers. Instead of creating strategic advantages, round extensions literally give the bidder more time to handle any time-consuming decisions or technical difficulties by extending the timescales of the current round.

For the second type of situation, Ofcom provides an interesting example where the bidder appears to have a legitimate purpose to use a waiver:

22 Condoc, 6.43, p. 33.
For instance, if a Standing High Bidder in a given band wishes to switch to bid on the other band, they may use a waiver to see if they are outbid first, instead of withdrawing.

Observe that waivers are most likely to be hoarded for use near the end of the auction and that at such a time, they will be least likely to be effective in freeing up sufficient eligibility to move to another band. Consequently, a waiver has only limited utility. There is also not very much likelihood of a failed aggregation, as the lots are all nationwide and are likely to be substitutes rather than complements.

Unless we are misreading the proposed rules, the penalty proposed for a withdrawal is potentially much more severe (the licence’s full value) than in most SMRAs. Moreover, even without that, withdrawals are likely to be of limited utility in this auction, for the same reasons that waivers will have only limited utility.

To the extent there might be an aggregation issue that needs to be addressed, an alternative way to handle such situations is to allow bidders to submit bids conditional on the end-of-round status of its standing high bids. Essentially, bidders are allowed to specify several sets of bids that can be submitted on its behalf once the auctioneer knows whether the standing high bids were superseded.

Organising bidding in this way also eliminates the need for the withdrawal feature. A similar approach is proposed by the FCC for its upcoming Incentive Auction. Details on conditional bids will be provided when, in Section 4, we describe a clock auction that dominates the proposed SMRA.

To conclude, we propose that the waiver and withdrawal features be replaced with the round extension and conditional bidding.

### 3.4 With only a few more modifications, Ofcom’s SMRA would become a full-fledged CCA

The additional modifications needed to make this auction a full-fledged standard CCA are:

- Migrating from the SMRA’s uniform pricing rule to the CCA’s opportunity-cost-based pricing rule would eliminate incentives for strategic demand reduction and market division—and, hence, any perceived need to withhold aggregate demand information;
- Introducing an optimisation-based winner determination would also internalise the externality from a bidder seeking a package that does not fit well with other bidders;
- Utilising an incrementing rule that makes no distinction between provisionally-winning bids and provisionally-non-winning bids expedites the progress of the auction while providing higher-quality feedback to bidders on demand;
- Introducing full package bidding eliminates exposure altogether, eliminating any need for ad-hoc measures such as a bidder-specified minimum quantity while creating better incentives for truthful bidding and obviating archaic and misguided options such as bid withdrawals; and
• Adding a supplementary bid round for expressing demand for all possible packages, not only ones that include the previous round’s standing high bids, better serves Ofcom’s objectives of encouraging efficiency and minimising undersell.

We put forth that these additional modifications would leave complexity only about the same as Ofcom’s SMRA proposal—some complexity such as the CCA’s pricing rule would be added, but other complexity such as the MSR, waivers, withdrawals and withholding of demand information would be removed. Meanwhile, comparing the two formats, it is clear that the CCA would result in vastly improved efficiency. The residual risk would also be much lower, since the additional modifications to make this a CCA have been successfully deployed in spectrum auctions around the world. There is no need for Ofcom to, in effect, reinvent the CCA by modifying the SMRA piecemeal. This is especially the case when the pieces Ofcom has chosen appear not to fit together as well as the components of the plain-vanilla SMRA, the clock auction proposed for the FCC’s Incentive Auction, or the CCA.

3.5 The CCA has been utilised widely and has performed well

Over the past decade, the Combinatorial Clock Auction (CCA) has rapidly established itself as one of the leading formats for government auctions of telecommunications spectrum. Its initial implementations were for relatively small auctions and some of these may be viewed as experimental. However, in the past few years, usage of the CCA has gained substantial momentum. From January 2012 through June 2014, the CCA was used in at least 10 major spectrum auctions worldwide, allocating prime sub-1-GHz spectrum on three continents and raising approximately $20 billion in revenues. (See Table 3.) Despite the existence of an existing auction format—the SMRA—the CCA has the potential of displacing it and becoming the new standard design choice for spectrum auctions.  

<table>
<thead>
<tr>
<th>Country and Auction</th>
<th>Year</th>
<th>Revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trinidad and Tobago Spectrum Auction</td>
<td>2005</td>
<td>$25.1 million ($US)</td>
</tr>
<tr>
<td>UK 10 – 40 GHz Auction</td>
<td>2008</td>
<td>£1.43 million</td>
</tr>
<tr>
<td>UK L-Band Auction</td>
<td>2008</td>
<td>£8.33 million</td>
</tr>
<tr>
<td>Netherlands 2.6 GHz Spectrum Auction</td>
<td>2010</td>
<td>€2.63 million</td>
</tr>
<tr>
<td>Denmark 2.6 GHz Spectrum Auction</td>
<td>2010</td>
<td>DKK 1.01 billion</td>
</tr>
<tr>
<td>Austria 2.6 GHz Spectrum Auction</td>
<td>2010</td>
<td>€39.5 million</td>
</tr>
<tr>
<td>Switzerland Spectrum Auction</td>
<td>2012</td>
<td>CHF 996 million</td>
</tr>
</tbody>
</table>

Many of the recent CCAs have performed exceedingly well, both in the UK and in other jurisdictions. For example, the UK’s 2013 4G Auction accomplished all of the following:

- It accomplished Ofcom’s competition objective of awarding a 2x5 MHz block of scarce sub-1-GHz spectrum to a fourth national operator;
- It avoided any undersell;
- It raised revenues “within the range achieved in other European 4G auctions”\(^{24}\); and
- **It adhered to full disclosure of aggregate demand after every round.**

Similarly, Canada’s recent 700 MHz auction could be considered a rousing success, simultaneously achieving the following:

- A 2x5 MHz block was awarded to a fourth operator throughout the country;
- It resulted in negligible undersell—all but 0.03% of spectrum (by reserve prices) was allocated;
- It raised very high revenues (CA$5.27 billion), without any apparent damage to efficiency; and
- **It adhered to full disclosure of aggregate demand after every round (except for the final clock round).**

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4. If a CCA is perceived to be too complex for the PSSR, a clock auction is a far better choice than an SMRA

For the US Incentive Auction planned for 2016, in which the 600 MHz band will be repurposed from traditional broadcasting to mobile broadband, the Federal Communications Commission recently released a Comment Public Notice proposing detailed auction rules. Power Auctions contends that, if a CCA is perceived to be too complex for the PSSR, the clock auction design proposed in the Comment Public Notice would be a far better choice than an SMRA.

4.1 Overview of the clock auction design proposed for the Incentive Auction

According to the FCC’s Incentive Auction Report and Order, the incentive auction will consist of reverse and forward auctions. The reverse auction will collect information about the prices at which broadcast television licensees would be willing to voluntarily relinquish some or all of their spectrum usage rights. The forward auction will consist of a clock phase and an assignment phase. The clock phase will identify the prices that potential users of repurposed broadcast television spectrum will pay for generic spectrum blocks. In the assignment phase, winners of blocks in the clock phase will bid for specific licences to use the spectrum.

On December 17, 2014, the FCC released a Comment Public Notice proposing detailed rules for the Incentive Auction programme. The forward auction rules proposed by the FCC have been designed to share some major features with the SMRA format, but to run to completion in a fraction of the time that an SMRA would require. Like an SMRA, the clock phase of the forward auction proceeds through a sequence of ascending prices for the licences. Also, like an SMRA with no bid withdrawals, once there is demand for a licence in the auction, the licence will not then go unsold. The key features that will allow the auction to run faster are the use of generic lots in combination with an assignment phase (i.e., the clock design), and intra-round bidding.


26 Certain aspects of the design proposed in the Comment Public Notice, such as “extended rounds” and the treatment of impaired licences, are special to the Incentive Auction and should obviously be ignored for purposes of the PSSR.


Here, we summarise the clock auction design proposed by the FCC for the forward auction that we contend would dominate Ofcom’s proposed SMRA:

1. In each round, the auctioneer announces a price range and bidders respond with bids within this price range (intra-round bids);
2. Bidders are allowed to place three types of bids—simple bid, all-or-nothing bids, and switch bids—which are processed sequentially and conditionally;
3. There are no Standing High Bids selected; however, aggregate demand is not allowed to drop below supply;
4. The auction ends when aggregate demand is less than or equal to supply for each licence category, and the clearing price is the lowest price at which aggregate demand does not exceed supply;
5. Bidders are given aggregate demand information for each licence category after every round;
6. Waivers and withdrawals are not allowed; and
7. Following a principal stage for determining the allocation of generic lots, winners will bid for physical frequencies in an assignment stage.

In the remainder of this section, we will highlight most of these features.

### 4.2 There are no Standing High Bids selected; however, aggregate demand is not allowed to drop below supply

The FCC has proposed to not allow a bidder to reduce the quantity of blocks it demands in a product if the reduction will result in aggregate demand falling below the available supply of licences in the product. Under this proposal, if a bidder demands fewer blocks of a product than it did in the previous round, the auction system will treat the bid as a request to reduce demand which will be implemented only if aggregate demand will not fall below the available supply of licences in the product. After bids are collected in each bidding round, the bids are processed. The results of bid processing include the quantity of a bidder’s requested demand that, after bid processing, was accepted and the price at which those bids were processed. This rule provides greater flexibility to bidders than the SMRA. In the SMRA, a Standing High Bidder cannot reduce its demand for a licence without risking a withdrawal penalty unless another bidder outbids him for that licence. In the design proposed by the FCC, a bidder can always reduce its demand for a generic lot unless that reduction would result in aggregate demand dropping below supply. At the same time, this rule guarantees that there will not be undersell for a lot category if, at some point during the auction, there is no excess supply for that lot category (i.e. if the reserve price is met for the entire available supply).

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4.3 Three types of bids

In order to help bidders manage their bidding given the requirement that a request to reduce demand may not be accepted, the FCC has proposed that bidders will be permitted to make the following three types of bids:31

- A “simple” bid indicates a desired quantity of blocks in a product at a price. A simple bid may be implemented partially if it involves a reduction from the bidder’s previous demand, and aggregate excess demand is insufficient to support the entire reduction.

- An “all-or-nothing” bid also indicates a desired quantity of blocks in a product, but allows the bidder to indicate that it wants the bid to be implemented fully or not at all. (However, it does not provide the bidder with a costless opportunity to escape from winning less than a minimum quantity. Instead, the bidder would stay in the auction for the minimum quantity and runs the risk that the clock price may continue increasing.)

- A “switch” bid allows the bidder to request to move its demand for a quantity of blocks from one product of generic licences to another product. A switch bid may be applied partially, but the increase in demand in the “to” product will always match in quantity the reduction in the “from” product.

We provide examples of each type of bid in Annex A.

The proposed bid types will allow bidders to express their demand for blocks without running the risk that they will be forced to purchase more spectrum at a higher price than they wish.32 When a bid can be applied only partially, the uniform price for the product will stop increasing at that point, since the partial application of the bid results in demand falling to equal supply. Hence, a bidder who makes a simple bid or a switch bid that cannot be fully applied will not face a price for the remaining demand that is higher than its bid price. On the other hand, if a bidder uses an all-or-nothing bid to request a reduction that cannot be applied because excess demand is insufficient to cover the entire requested reduction, the price for the product may continue to increase if there is any excess demand. In such cases, the FCC provides for an optional “backstop” bid to ensure the price for the product does not go above the amount the bidder specifies in its bid.

The bid types mentioned above allow bidders to execute strategies similar to the ones they would use in an SMRA, but more effectively.33 First, in an SMRA, when the price of a licence becomes too high, a bidder can reduce demand by refraining from bidding again on that licence. In the clock auction design proposed by the FCC, the simple bid performs that same function, that is, it allows a bidder to reduce demand for a product when its price rises above any price that the bidder may specify. Second, in an SMRA, when one licence price rises too high compared to that of another licence, a bidder can stop bidding for the first licence and

start bidding for the second. In the clock auction proposed by the FCC, a bidder can do the same by making a switch bid, in which it specifies that it will shift demand from one product to the other when the price of the first product gets too high. Finally, suppose that for some product, a bidder wants to buy two blocks if the price is sufficiently low, but wants to avoid acquiring just one block of that type. In an SMRA, when the prices of a set of licences are rising, the bidder can limit the possible outcomes by refraining from raising its bid on one licence and waiting to see what happens, possibly using a waiver. If there is demand by other bidders for both of its licences, it can then stop bidding on both. In the clock auction design proposed by the FCC, a bidder can accomplish the same by use of an all-or-nothing bid for a product. In the example, a bidder that is currently demanding two blocks of one product can specify that it will reduce its demand for that product to zero, but that it will not reduce its demand to just one block at the specified price.

4.4 Bidders are informed of aggregate demand for each licence category

As is standard in clock auctions, the FCC has proposed to disclose aggregate demand information for each licence category to bidders after every round. This facilitates price discovery and leads to more efficient outcomes.

4.5 No waivers or withdrawals

The FCC has proposed not to allow for activity rule waivers to preserve a bidder’s eligibility. Allowing waivers would create uncertainty with respect to the exact level of bidder demand, interfering with the basic clock price-setting. Waivers would introduce bidding complexity and allow anti-competitive gaming by delaying commitment. Similarly, the FCC has proposed not to allow bid withdrawals.

4.6 Following a principal stage for determining the allocation of generic lots, winners will bid for physical frequencies in an assignment stage

In this regard, the clock auction design proposed for the Incentive Auction is the same as proposed by Ofcom for the SMRA. Both are borrowing from the success of the CCA.

4.7 The design can be easily enhanced to include an MSR

The FCC’s incentive auction design does not include a Minimum Spectrum Requirement (MSR). Part of the explanation for this is that the Incentive Auction includes a forward auction and a reverse auction, and the revenues of the forward auction are required to pay the clearing costs of the reverse auction. Consequently, one of the design requirements for the forward auction was for revenues to monotonically increase as the auction progresses. This would not be the

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case with an MSR, as undersell is always a possible consequence of an MSR (see Section 3.2): undersell could cause revenues in the final round to be less than revenues in the penultimate round.

However, an MSR could easily be added to this version of a clock auction. Let $N$ denote the number of licences in a category and let $M$ denote a particular bidder’s MSR. Ordinarily, in this auction format, a bid to drop entirely out of a band is allowed if and only if it causes aggregate demand to remain at $N$ (or greater). With an MSR, a bid to drop entirely out of a band is allowed whenever it causes aggregate demand to remain at $N - M + 1$ (or greater). For example, with the MSR of two blocks that we recommend, the bidder is allowed to drop out if his reduction causes aggregate demand to fall to $N - 1$, but the dropping out is disallowed if it would cause aggregate demand to fall to $N - 2$.

4.8 Conclusion

The SMRA proposed in the condoc retains some of the least desirable features of the SMRA. By contrast, the Incentive Auction’s clock auction inherits the simplicity and brevity of the clock auction, while retaining the absence of undersell of the SMRA. If a CCA is perceived to be too complex for the PSSR, the Incentive Auction’s clock auction would be a far better choice than the proposed SMRA (or any other SMRA).
5. **A ‘plain-vanilla’ SMRA is also preferable to Ofcom’s proposed SMRA**

Ofcom proposes a number of nonstandard and controversial features for its SMRA proposal. While well intended, the majority of these enhancements significantly complicates the bidding process, wastes bidder resources and degrades the overall efficiency of the auction. In case Ofcom rejects both the CCA and Section 4’s clock auction design in favour of the old-fashioned SMRA, Ofcom should use time-tested ‘plain-vanilla’ SMRA rules instead of the condoc’s SMRA proposal.

5.1 **The proposal that a bidder wishing to submit any bids at a new price level must raise all of its Standing High Bids creates uniquely bad incentives**

In the condoc, Ofcom expresses an overriding concern about strategic demand reduction in spectrum auctions. The condoc also proposes a particular set of rules for the SMRA, with the requirement that a bidder wishing to submit any bids at a new price level must raise all of its Standing High Bids to the new price level. Unfortunately, while this proposed requirement will move the auction along more quickly than alternative protocols, it is also in fundamental conflict with Ofcom’s overriding concern about strategic demand reduction. Uniquely, the proposed feature provides the worst possible incentives for strategic demand reduction. By contrast, in the ‘plain-vanilla’ SMRA, the bidder is only required to re-bid, at the new price level, those previous bids that have been supplanted by an opponent as Standing High Bids. As such, the plain-vanilla SMRA is less susceptible to demand reduction. In the clock auction described in Section 4, the bidder is not given any choice between sticking with its Standing High Bids at a previous price level versus bidding for its full desired demand at a new price level; indeed, there is no concept of a Standing High Bid at all when price is still rising. As such, the clock auction is also less susceptible to demand reduction.

Ofcom proposes the tragic design choice of withholding demand information, based on a misplaced concern about strategic demand reduction, yet then advocates the auction format from its list of possibilities that is most predisposed toward strategic demand reduction. This is a basic inconsistency that needs to be remedied by Ofcom in its final choice of auction procedures.

5.2 **A ‘plain-vanilla’ SMRA never requires bidders to raise their own Standing High Bids**

There are two key differences between a ‘plain-vanilla’ SMRA and Ofcom’s proposed SMRA. First, the ‘plain-vanilla’ SMRA treats every lot as unique. As such, bidding for one lot never requires placing a bid on another lot. In short, bidders are never required to raise their own Standing High Bids. Second, bidders are provided with information about all bids after every round. Either this information includes the bidders’ identities (full demand information) or the bids are anonymized (which is equivalent to providing aggregate demand information).
In this section, we summarise the rules of the ‘plain-vanilla’ SMRA:

**Abstract’ lots**

A ‘plain-vanilla’ SMRA design requires specific lots for its operation—distinct lots available in a supply of one. An SMRA design that will operate with generic lots requires substantial changes to its design. A good example of the use of generic lots is the clock auction described in details in Section 4. However, Ofcom can still use the standard SMRA procedure for this award while still bring some of the advantages of using generic lots to the table.

An ‘abstract’ lot approach has been used in German 3G Auction in 2000 and German 4G Auction in 2012 and can be described as follows. All products in the auction are available in the quantity of one, but similar to the generic lots, they do not correspond to specific frequencies until the assignment round. For this particular award, there will be eight products offered in the 2.3 GHz band (products A1-A8) and thirty products offered in the 3.4 GHz band (products B1-B30). The principal stage of the auction adheres to the standard SMRA rules with specific lots. Once the principal stage is closed, the awarded quantities for each bidder are determined by summing all products within the same band. For example, a bidder who won products A1, A3, A4 and A7 is declared a winner of 20 MHz in the 2.3 GHz band. The assignment round is carried out in the usual way.

This approach can result in an auction lasting literally hundreds of rounds since bidders will be constantly switching back and force among identical lots (albeit these rounds can be very short due to the strategic simplicity). On the positive side, the approach will allow Ofcom to use the standard ‘plain-vanilla’ SMRA rules that have been used many times in many countries.

**Withdrawals and waivers**

Some SMRAs permit limited use of withdrawals. Traditionally, the withdrawal policy allows a bidder who failed to make an aggregation to withdraw its bids such that other bidders could bid for those lots at the same price.

Withdrawals are likely to be of little value for this particular award because bidders will not be able to see that their opponents have withdrawn due to a poor information policy. Furthermore, the Minimum Spectrum Requirement mitigates quantity exposure in each band, further reducing the value of withdrawals. And, since all of the lots are nationwide, there is no risk of failed geographic aggregations.

The history of spectrum auction contains very illustrative examples of bad withdrawal policies. In particular, in the Mexico MMDS auction in 1998, a poorly specified withdrawal policy effectively stalled the progress of the auction with the same bidder repeatedly bidding and withdrawing with no actual change in the prices. Eventually, the auction was stopped until bidders agreed on a new set of rules to move forward. Ofcom’s withdrawal policy, as currently worded, may permit bidders to alternate between placing bids in one band and withdrawing
bids in the other band allowing the auction to run indefinitely.\textsuperscript{36} Out of an abundance of caution, Power Auctions recommends that if the withdrawal rule is kept, that it be made clear that successive withdrawals trigger additional penalties.

In early SMRAs, bidders were able to reduce their activity without a drop in their bidding eligibility by using waivers. Waivers were introduced to allow bidders to free up enough eligibility points to move from one set of lots to another. Modern auction designs, as the clock auction that will be used for the FCC Incentive Auction, allow bidders to achieve the same results without also creating major strategic bidding opportunities.

More information on the withdrawals and waivers can be found in Section 3.3 of this report. Power Auctions recommends eliminating both features from the SMRA proposal. Similar to the CCA proposal, the round extension feature can be used to deal with unexpected technical difficulties.

\textit{Disclosure of the aggregate demand}

Standard SMRA rules always included disclosure of either individual demand information or aggregate demand information in each round. In sharp contrast, Ofcom suggests to withhold any demand information for the duration of the auction. The current SMRA proposal goes against best international practices, effectively eliminating almost all advantages of the dynamic auction. Given the magnitude of this issue, Section 2 of this report provides an extensive set of arguments in favour of the disclosure of demand information after each round.

\textit{Minimum Spectrum Requirement (MSR)}

Section 3.2 provides a discussion on the minimum spectrum requirement. This feature protects bidders from winning economically insufficient amount of spectrum in each band. At the same time, it creates several opportunities for strategic bidding. To limit strategic bidding opportunities, Power Auction recommends to lower the maximum possible amount for the MSR from 20 MHz to 10 MHz per band.

\textit{Interaction of the MSR and Standing High Bids}

Ofcom’s proposed determination of standing high bids does not interact well with the minimum spectrum requirement feature.\textsuperscript{37} Suppose that standing high bids for 15 MHz have to be selected from the bids submitted by two bidders. Each bidder is bidding for 20 MHz, but only one of them has a 20 MHz MSR. According to the rules, either of these two bidders can be selected as a standing high bidder for the 15 MHz, but only one can stand. If the MSR bidder


also has an MSR in the other band, it may need to make a withdrawal to switch to the other band. The interaction between the MSR and standing high bids appears to be ill-thought-out. Power Auction recommends that MSR-related considerations be factored into the determination of the standing high bids. Or, better, we recommend that a CCA or the clock auction of Section 4 be adopted, so that there is no notion of Standing High Bidder at all.

**Priority-based tie breaks**

By design, standard SMRAs need a mechanism to break ties between otherwise equal bids from different bidders. Many SMRAs, including the one proposed by Ofcom, break such ties based on some non-random priority ranking. Such a procedure creates strategic opportunities for bidders and significantly complicates the bidding process. Modern SMRA designs break ties randomly allowing bidders to focus their efforts and resources on efficiency-enhancing tasks such as price discovery. Section 8 of this report provides an in-depth analysis of this issue. In line with the modern practices, Power Auctions recommends replacing the non-random tie breaking procedures with randomised tie-breaking procedures. Alternatively, Ofcom can permit bidder-named prices to avoid ties. Such bids should not be disclosed to other bidders, but should be used to determine standing high bids.

**Price incrementing policy**

Given the pay-as-bid pricing of the SMRA, large price increments can result in inefficiencies. Allowing bidders to name last-and-final price when reducing its demand, or the ability to offer bids that are higher than the current round price by a bidder-specified amount, have the potential to reduce the inefficiency of allocation in the SMRA due to high bid increments.

**Eligibility points and activity rules**

Traditionally, eligibility points for different categories are based on general estimates of the underlying values. Ofcom is proposing a 1:1 eligibility point ratio for the two categories in this award. At the same time, Ofcom proposes a reserve price ratio somewhere between 2:1 and 5:1. This creates a strong incentive for bidders to ‘park’ eligibility on the 3.4 GHz band. Since prices for 2.3 GHz spectrum are likely to be higher, insincerely bidding for 3.4 GHz spectrum preserves more eligibility points per pound than bidding on the 2.3 GHz band.

The plain-vanilla SMRA only requires the bidder to bid a portion of its eligibility in the early part of the auction. This protects the bidder from the need to optimise its early bidding exactly so as to preserve its eligibility. It is implemented via an ‘eligibility multiplier’ that multiples the eligibility points associated with a bid by a factor greater than 1, permitting the bidder to retain greater eligibility than its bid. For example, there might be a 1.25 eligibility multiplier in the early part of the auction, effectively requiring the bidder to bid only at least 80% of the eligibility it wishes to retain.
Detailed arguments on the eligibility points and activity rules can be found in Section 6 of this document. Power Auctions recommends using between a 2:1 and a 4:1 eligibility point ratio for this award. Ofcom should utilize the time-tested eligibility multiplier if it does not implement a different form of relaxed activity rule for the SMRA.

**Table 4: Comparison of Auction Features**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Ofcom SMRA</th>
<th>Plain-Vanilla SMRA</th>
<th>Incentive Auction clock</th>
<th>Ofcom CCA</th>
<th>PA-proposed CCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generic Lots</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Pay as bid</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Demand Revelation</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Opportunity cost assignment</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Opportunity cost base prices</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Eligibility points based on expected values</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Withdrawals</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Bidding extensions</td>
<td>x</td>
<td>x</td>
<td>Optional</td>
<td>✓</td>
<td>Optional</td>
</tr>
<tr>
<td>Bidders may bid their own prices</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Priority-based tie breaks</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Bid increments that vary with demand</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Relaxed activity rule</td>
<td>x</td>
<td>x</td>
<td>Optional</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Eligibility multiplier less than 100% in early part of auction</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Eligibility waivers</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Must bid higher for all lots in category if outbid in part</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Minimum spectrum requirement cap</td>
<td>20 MHz</td>
<td>x</td>
<td>10 MHz easily added</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Package bidding</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Winner determination optimisation</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Supplementary bidding</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
6. **If the 2.3 GHz and 3.4 GHz bands are independent, running two separate clock auctions sequentially is the simplest and the most straightforward auction procedure**

Ofcom should carefully assess whether the 2.3 GHz and 3.4 GHz spectrum bands are related to one another in any significant way (i.e. whether the lots in these bands are likely to be viewed as substitutes or complements by prospective participants). Hutchison 3G UK considers it likely that the two bands are at least partial substitutes for one another, as both bands can be used to provide network capacity.

If Ofcom determines that the two bands are weakly related to (or independent of) each other, Ofcom should consider auctioning the two bands sequentially, starting with the 2.3 GHz band and continuing with the 3.4 GHz band. The 2.3 GHz band should be auctioned first since it is of higher value and in greater scarcity than the 3.4 GHz band. Auctioning them in the correct order will partially offset any mild dependencies between two bands.

Each of the two auctions would be a simple clock auction with generic lots. In each round, Ofcom would announce the current clock price and bidders would submit their desired quantities. The simple monotonic activity rule should be used: the number of lots demanded by a bidder cannot exceed the number of lots demanded in the previous round. The simple clock auction would end when the aggregate demand falls to the level of supply.

To avoid any perceived need for withholding aggregate demand information, Ofcom should consider using a “clinching” pricing rule instead of the uniform pricing rule.\(^{38}\) The clinching pricing rule is a dynamic implementation of the opportunity cost pricing principle. A simple and well-defined procedure dynamically calculates Vickrey prices for all winners. Relying on Vickrey pricing instead of uniform pricing eliminates all incentives for strategic demand reduction.

The clinching procedure can be demonstrated with the following example, patterned after the 2.3 GHz band. Suppose that the auctioneer wishes to allocate eight (8) generic licences. There are four bidders participating in the auction. The clock starts at £2 million per licence and ends at £10 million per licence. A summary of the bids placed by all bidders in the simple clock auction for this band is provided in Table 5.

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Table 5: Illustrative Example with Clinching Pricing Rule

<table>
<thead>
<tr>
<th>Clock Price</th>
<th>Bidder A Demand</th>
<th>Bidder A Clinches</th>
<th>Bidder B Demand</th>
<th>Bidder B Clinches</th>
<th>Bidder C Demand</th>
<th>Bidder C Clinches</th>
<th>Bidder D Demand</th>
<th>Bidder D Clinches</th>
</tr>
</thead>
<tbody>
<tr>
<td>£2 mil</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>£5 mil</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>£6 mil</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>£7 mil</td>
<td>4</td>
<td>2 at 7</td>
<td>4</td>
<td>2 at 7</td>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>£10 mil</td>
<td>4</td>
<td>2 at 10</td>
<td>2</td>
<td>2</td>
<td>2 at 10</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Licences</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Payment</td>
<td>34 = 7 + 7 + 10 + 10</td>
<td>14 = 7 + 7</td>
<td>20 = 10 + 10</td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Under the clinching procedure, a bidder “locks in” the price for its licences at the moment its opponents have stopped demanding them. Bidder A’s payments are calculated as follows. At a clock price of £6 million, Bidder A’s opponents have stopped demanding 8 licences in total. At £7 million, its opponents drop their aggregate demand to 6 licences, i.e. they stopped demanding two of the licences that Bidder A demands. Therefore, Bidder A is mathematically guaranteed to win them—and “clinches” them at £7 million each. When the clock price reaches £10 million, Bidder A’s opponents further reduce their aggregate demand to 4, ending the clock phase and allowing Bidder A to “clinch” another two licences at a price of £10 million each. In total, Bidder A wins four licences and pays £34 million (7 + 7 + 10 + 10). The payments of Bidders B and C are calculated in similar fashion.

The clinching procedure does not require any significant changes to accommodate the Minimum Spectrum Requirement feature. Power Auctions recommends using the MSR (with the maximum MSR changed to 10 MHz, as discussed in Section 3.2) in the clock auction for each band to protect bidders against winning a small amount of spectrum.

Once the winnings of generic spectrum and payments are determined for each band, the assignment round is carried out to assign generic lots to specific frequencies, as described in the condoc.

Auctioning two bands separately dramatically reduces complexity of this award in several areas.

First, the activity rule takes the easiest possible form in a clock auction for homogeneous items—monotonicity in demanded lots. This activity rule does not require: (1) any choice of eligibility points for its operation; (2) any relaxations to accommodate non-strategic bidders; or (3) any refinements to preclude strategic bidding strategies like ‘parking’.

Second, it would allow Ofcom to use the clinching pricing rule. The problem of dynamically calculating Vickrey payments in auctions with heterogeneous products has troubled researchers for many years. However, for the homogeneous case, the answer has been known for many years—the clinching procedure. The pricing rule allows bidders to track their payments in real time while retaining the opportunity cost nature of the pricing rule. Thus, it
combines the strengths of the SMRA and CCA formats, while simultaneously avoiding their key weaknesses.

Third, the sequential clock design does not require waivers, withdrawals, determination of Standing High Bidders or bid prioritisation procedures that overcomplicate Ofcom’s SMRA proposal.

And, most importantly, there is no need to withhold demand information from bidders. As described, this approach implements Vickrey pricing. Thus, as argued above in Section 2.6, there is no tendency toward market division and no case for non-disclosure of demand.
7. **Detailed design issue: Eligibility points and activity rules**

We have serious reservations regarding: (1) the eligibility points proposed for the 2.3 GHz and 3.4 GHz award; and (2) the activity rule proposed for the SMRA.

### 7.1 Eligibility Points

Ofcom proposes to assign one eligibility point to each lot in both 2.3 GHz and 3.4 GHz bands. Their main justification is to allow bidders to substitute lots across two bands on a per MHz basis. The exact choice of eligibility points is especially important for the proposed SMRA format since it is based on a pure eligibility-point-based monotonic activity rule to determine feasible switches.

In their attempt to avoid creating unnecessary barriers for switching between two bands, Ofcom disregards the issue of creating an overly comfortable environment for strategic bidding through what is known as a “parking strategy”—bidding for inexpensive spectrum that has low value relative to assigned eligibility points just to preserve their eligibility for going after more valuable spectrum in later rounds.

As a first general principle, eligibility points in a spectrum auction should be set roughly in proportion to the expected values of the associated licences. This is a point that has been made repeatedly in the literature and followed in practice ever since the advent of spectrum auctions. This principle applies both to older spectrum auction formats (such as the Simultaneous Multiple Round Auction (SMRA)) and modern spectrum auction formats (such as the Combinatorial Clock Auction (CCA)).

The principle can be found clearly by looking at the writings of Professor Paul Milgrom (generally recognized as inventing the SMRA format), as well as the writings of Professors Lawrence Ausubel and Peter Cramton (who together with Paul Milgrom are generally recognized as the inventors of the CCA). In writing about the US Broadband PCS Auction, the first large SMRA auction, Professor Milgrom wrote:

> A bidder’s eligibility to make new bids during the auction is controlled by the “activity rule.” Formally, the rule is based on a “quantity” index, such as spectrum bandwidth or population covered by a license, that roughly corresponds to the value of the license. During the auction, a bidder may not have active bids on licenses that exceed its eligibility, measured in terms of the index.³⁹

The same principle can be found in a recent report by Professors Ausubel and Cramton. The report, written for the US Department of Interior for the design of auctions of wind energy

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lease areas, reviews existing practice and assesses both SMRAs and CCAs. While reviewing US
spectrum practice to date, they write:

*The activity rule for FCC auctions works as follows. Each lot has a number of eligibility
points assigned to it based on the required deposit for that lot (which is typically the
starting price for that lot) and therefore the eligibility points for a lot are roughly related
to the value of the lot.* Activity in a given round must be at least \( x \) percent of the bidder’s
eligibility.\(^{40}\)

Moreover, the principle is no different for a clock auction or a CCA than it is for an SMRA. As
Professors Ausubel and Cramton write:

*To measure activity it is necessary to assign each lot a number of eligibility points that
reflects the estimated relative value of the lot.*\(^{41}\)

The rationale for assigning eligibility points based on the relative value of the licences is that if,
to the contrary, excessive eligibility points are assigned to low-valued licences, an incentive is
created for “parking”—a form of strategic bidding. As Professor Cramton recently wrote (in a
conspicuous recent article published on the CCA), activity rules will create an incentive for
parking eligibility on lots that a bidder is not truly interested in, “especially if the eligibility
points are not a good measure of relative value across lots.”\(^{42}\)

Various national regulatory authorities have taken this general principle quite seriously in
organizing spectrum auctions. For example, the Canadian Government’s decision paper for its
700 MHz auction, in which spectrum is licensed on a regional basis (so there is a gross disparity
in the values of different regional licences), the Government determined:

*Giving consideration to the relative value of the spectrum in the determination of the
eligibility points supports substitution between licences that are similar in value and
enhances price discovery. The proposed eligibility points reflect this approach and take into
consideration the population per service area, bandwidth per block and the relative value of
the spectrum, as expressed in the opening bids.*\(^{43}\)

for the US Department of Interior, at p. 17, *Emphasis added.* Available at:
http://www.boem.gov/uploadedFiles/BOEM/Renewable_Energy_Program/Regulatory_Information/Aus
ubelCramtonPaper1.pdf.

\(^{41}\) Ibid, at p. 30.


\(^{43}\) Industry Canada, “Licensing Framework for Mobile Broadband Services (MBS) — 700 MHz Band,” 13
March 2013. See paragraphs 153–165. Available at:
Most interestingly, Ofcom, in their final decision on their Digital Dividend Auction, wrote:

*When developing our consultation proposals, we set out two main guiding principles for identifying specific values related to these properties. The first principle is to provide a reasonable reflection of likely relative prices of the different categories of available spectrum. The second principle is to facilitate bids that reflect genuine preferences in light of round prices; this involves supporting switches of demand between lot categories that are sufficiently similar, if price changes for the relevant categories warrant it.*

Ofcom then reached the following conclusion:

*Information from recent European Auctions suggests that spectrum at 2.6 GHz has a much lower value than spectrum at 800 MHz. There are also uncertainties regarding the prospects for use of the unpaired 2.6 GHz spectrum (category E) as well as 2.6 GHz concurrent low power spectrum (category D).*

*In relation to 2.6 GHz lots, the eligibility points we selected reflect our assessment of likely relative values for all available lots as discussed in section 8. We note that these values mitigate the risk of bidders parking demand on lower value spectrum.*

As a second general principle, eligibility points should be set to form convenient exchange ratios that permits switching back and forth between similar products without spending bidding eligibility. Without the possibility of such substitutions, the value of a multi-category auctions falls because bidders can only express their relative preferences in one direction.

Ofcom’s choice of eligibility points suggests a judgment that 2.3 GHz and 3.4 GHz bands have approximately similar values for bidders. This is highly doubtful since the 2.3 GHz band offers (1) better propagation properties and (2) immediate availability of the equipment and therefore can be viewed as significantly more valuable, especially, in the short-run. In fact, Ofcom simultaneously suggested a reserve price of £1m per 5 MHz of the 3.4 GHz spectrum and a reserve price range of £2.5m-£5m per 5 MHz for the 2.3 GHz band. The reserve price ratio suggests that lots in the 2.3 GHz band should receive 2.5-5 eligibility points instead of 1 eligibility point. A ratio of 2:1 is close enough to this ratio, but also permits switching back and forth between 2x10 MHz of 2.3 GHz and 2x20 of 3.4 GHz. Given the uncertainty of the reserve price estimates this should mitigate the risk of “parking” well, while preserving the usefulness of a multi-category auction. We propose that Ofcom adopt an eligibility point ratio somewhere between 2:1 and 4:1, for spectrum blocks of equal bandwidths in the 2.3 GHz and 3.4 GHz bands.

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The recently proposed class of activity rules for dynamic auctions, based on the generalized axiom of revealed preference (GARP), can be considered as an attractive alternative for this particular auction. A GARP-based activity rule can appear unnecessarily complex in general multi-product environments, but with just two product categories, the GARP rule is actually quite simple. The major advantage of the GARP activity rule is that it does not require eligibility points for its operation, therefore eliminating the need to set them in the first place. Instead, it operates using the relative price change between two categories allowing bidders to shift their demand to the category that became relatively inexpensive.

### 7.2 Activity Rules

Ofcom proposes to adopt a relaxed activity rule for the CCA proposal. In comparison to a traditional eligibility-point rule, the relaxed rule presents bidders with an opportunity to submit bids that exceed their current bidding eligibility if such bids are consistent with their bidding choices made in prior rounds. The motivation for the relaxed rule in the CCA is well known. If the auctioneer wants to employ the final price cap to constrain the supplementary bids, bidders should be permitted to bid truthfully in the final clock round. The traditional eligibility-point rule prevents truthful bidding if it requires an increase in bidder’s eligibility in some round. The final price cap is highly desirable for the CCA as it incentivizes bidders to bid truthfully when they think the clock phase is about to end. More importantly, the use of the final price cap eliminates unnecessary instability between a tentative final clock allocation and the ultimate winning allocation.

Various implementations of the relaxed activity rule have been used in recent CCA auctions. The condoc’s proposed activity rule closely follows the relaxed activity rule used in the Ireland Multiband auction (2012), differing only slightly from the hybrid activity rule of the Canadian 700 MHz (2014) and 2500 MHz (2015) auctions. The differences between these two implementations are subtle enough to be immaterial for the purposes of the current award.

Together, the relaxed activity rule and the final price cap provide strong incentives for bidders to bid for their preferred package during the clock rounds. We strongly support the use of the relaxed activity rule and the final price cap for the CCA proposal.

Surprisingly, Ofcom does not propose a symmetrical change to the activity rule for their SMRA design. The SMRA design provides bidders with the ultimate stability (the final clock allocation is the winning allocation at all times) which is “equivalent” to having the final price cap in the CCA design (it is equivalent when the clock stage of the CCA allocates all items to bidders). It

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seems natural to give an SMRA bidder an opportunity to exceed its bidding eligibility if such bid is fully consistent with its prior bidding history. The simplicity of the product space for this particular award—there are only two categories—creates a very convenient environment for Ofcom to replace an outdated activity rule with its modern successor.

A relaxed activity rule will solve at least two major problems of the proposed SMRA design. First, the choice of eligibility points becomes less critical as bidders will be allowed to go back and forth between the bands whenever the adequate relative price change occurs. It will allow Ofcom to set eligibility points in proportion to their underlying values instead of the 1:1 eligibility ratio chosen to fix the problem of the monotonic eligibility-point rule. Second, a strategy of “parking” bidding eligibility for potential use in future rounds becomes less attractive. Consequently, bidders can be less conservative about their decisions to reduce eligibility and be more engaged in the price discovery process.

Power Auctions recommends that Ofcom use the hybrid eligibility-point/revealed-preference activity rule of the Canadian 700 MHz (2014) and 2500 MHz (2015) auctions if it selects the SMRA. 48

48 This would be essentially equivalent to using the chain-bid approach of the Ireland auction, which the condoc proposes for the CCA. However, since there is no supplementary bidding round or optimisation in an SMRA, it is unclear what a chain bid would precisely mean in an SMRA.
8. Detailed design issue: Priority-based tie breaking increases complexity and creates gaming opportunities

The particular details of Ofcom’s SMRA proposal resemble auction rules for India’s 3G and BWA spectrum auctions. One similarity between the rules is especially worrisome. Proposed auction rules for the SMRA alternative create a “priority ranking” for the otherwise equal bids that came from different bidders. The clock round in which the bid was received determines the priority ranking. The bid that came in an earlier round is preferred to the same bid that was submitted later. With these auction rules, a bidder who expects to be tied with another bidder at a higher price level has strong incentives to strategically time its bids. Under some scenarios, the “priority ranking” feature creates incentives for bidders to outbid their own bids, greatly complicating the round-to-round bidding decisions and wasting bidding resources.

For the SMRA proposal, the “priority ranking” is created by the following rules:49

- When displacing standing high bids for lots with a standing high bid at a price lower than the round price, the most recently established standing high bids will be displaced first; and
- “Remaining Supply” is defined so as to exclude standing high bids at the current price implying existing standing high bidders at this price remain standing high bidders.

A sophisticated bidder can attempt to use the “priority ranking” in order to win blocks at one bidding increment lower than less sophisticated bidders. Alternatively, a sophisticated bidder can attempt a parking strategy that takes advantage of losing the priority ranking tie break to preserve eligibility and raise other bidders’ costs with low or no risk of winning such bids.

In contrast, the CCA rules never prioritize otherwise equal bids using the submission time as the basis. It does not matter whether the bid came from one clock round or another, or even if it was submitted in the supplementary round. All that matters is the ability of the bid to maximize the value of the winning allocation.

Financial rewards from mastering trivial strategies based on the “priority ranking” feature of the rules can be substantial. Instead of focusing their efforts on refining their own bids and valuations, bidders spend tremendous amounts of time, effort and resources on competitive intelligence to take advantage of the “priority ranking” loopholes. The feature is very destructive to a normal bidding experience.

We strongly recommend that the auction design for awarding spectrum in 2.3 GHz and 3.4 GHz bands should avoid incentivising bidders to participate in “rat races” based on some artificial priority ranking of otherwise equal bids.

\[49\text{Condoc, A6.55 i), p. 135.}\]
9. Detailed design issue: UK Broadband’s 3.4 GHz holdings

One nonstandard element of this award is the presence of UK Broadband’s holdings in the 3.4 GHz band. The presence of these holdings can interfere with the normal allocation process in at least two ways: (1) there is a nontrivial possibility of a non-contiguous spectrum award to one of the winners and (2) there is the potential for serious auction design flaws if UK Broadband decides to participate in the award.

Non-contiguous Winnings

The available spectrum in the 3.4 GHz band will not be contiguous if UK Broadband does not participate in the auction. In this scenario, bidders bidding for spectrum in the 3.4 GHz band would face an unusual exposure problem during the principal stage: the winning of multiple 5 MHz blocks does not guarantee that the bidder will receive a contiguous block of the equivalent size. Instead, multiple block winnings in the 3.4 GHz may be split across two non-contiguous frequency ranges.

If Ofcom believes that bidding in the 3.4 GHz band will be undermined due to a possibility of a non-contiguous award, it should consider design changes that would allow bidders to specify whether a non-contiguous award is acceptable to them during the principal stage. This can be accomplished in at least two ways.

The easiest way to remove exposure is to divide the 3.4 GHz band into two different bidding categories: fourteen 5 MHz blocks in the lower part (3410 MHz to 3480 MHz) and sixteen 5 MHz blocks in the upper part (3500 MHz to 3580 MHz). With this configuration, bidders would be able to bid directly for contiguous and non-contiguous spectrum in the 3.4 GHz band at all times. Another option is to keep one generic category with thirty 5 MHz lots but allow bidders to specify: (1) the number of blocks they want in the 3.4 GHz band; and (2) whether these blocks are required to be contiguous.

Special Treatment for UK Broadband

Ofcom wants to reorganize the 3.4 GHz band in the event that UK Broadband decides to participate in this award. The reorganization includes converting UK Broadband’s current non-contiguous holdings totalling 40 MHz into one contiguous 40 MHz block (or more, if UK Broadband acquires any additional spectrum in the 3.4 GHz band). In order to achieve its goal, Ofcom will be introducing special auction rules for UK Broadband. It is very important for Ofcom to avoid introducing any unintended design flaws when incorporating these rules.

National regulatory authorities often incorporate competition measures into their auction designs in order to promote competition in the downstream markets. Competition measures range from standard tools such as spectrum caps (Canadian 700 MHz Auction) and set-asides (Slovakia 800, 1800 and 2600 MHz Auction) to more exotic provisions such as the “spectrum
floor” (UK 4G Auction). Frequently, these generally desirable competition policies end up being integrated into the auction design in ad hoc and controversial manners that do not adhere to first principles for designing auctions.

While the current auction design proposals for the 2.3 GHz and 3.4 GHz award do not contain any nonstandard competition provisions, very similar issues might arise in the context of UK Broadband’s holdings. For example, adding the UK Broadband holdings directly into the principal stage of the auction with a competition constraint that only UK Broadband can win them (at a zero price) is essentially equivalent to creating a set-aside.

Given the limited possibilities to comment on future auction rules, we strongly suggest that the issue of UK Broadband holdings is dealt with in the most transparent and noncontroversial way. If UK Broadband decides to participate in this auction, 40 MHz of its current holdings must never be added to the principal stage of the auction. In case of participation in the principal stage, UK Broadband should be treated as any regular bidder who bids for spectrum in addition to its current holdings in the 3.4 GHz band. The 40 MHz of UK Broadband holdings are only added to the assignment stage for the 3.4 GHz band, where UK Broadband can bid for one contiguous lot consisting of: (1) UK Broadband’s 40 MHz of current holdings; and (2) UK Broadband’s principal stage winnings in the 3.4 GHz band (if any).

In short, UK Broadband must be treated as a regular bidder for purposes of the principal stage. We provide this clarification in order to avoid any doubt. We believe that our views are fully consistent with Ofcom’s intentions for dealing with the 3.4 GHz band holdings of UK Broadband, but we provide this clarification in an abundance of caution.

10. Recommendations

Based upon the reasonably exhaustive analysis presented in this paper, we offer the following recommendations in relation to the PSSR.

10.1 Recommendations on auction format

Power Auctions’ recommendation is that Ofcom should study and assess whether the 2.3 GHz and 3.4 GHz spectrum bands are related to one another (i.e. as substitutes or complements) or whether they are independent. (Hutchison 3G UK considers it likely that the two bands are partial substitutes for one another, as both bands can be used to provide network capacity.) The auction format that is selected should depend on whether the two bands are related or independent, and it would always include the disclosure of aggregate demand information for each band, after every round.

If Ofcom determines that the two bands are related, the recommended approaches to auction format are ranked in descending order in the following list:

1. A CCA closely adhering to the rules of the Canadian 700 MHz or 2500 MHz auction, in which aggregate demand is disclosed after every round (except for the final clock round);
2. A clock auction, closely following the rules proposed in December 2014 for the forward auction of the FCC’s Incentive Auction programme, in which aggregate demand is disclosed after every round; or
3. A plain-vanilla SMRA, closely following the rules of the current US AWS-3 auction, and in which aggregate demand is disclosed after every round.

Note that (2) and (3) are quite close to each other and would probably lead to very similar results, but (2) would expect to run much faster and be a much superior experience for bidders than (3). Thus, our view is that (2) basically dominates (3). Note also that, in either the CCA or SMRA, we differ substantially from the condoc’s approach to eligibility points, which we believe should be set in reasonable relation to the values of the respective licences—see Section 7.1.

Conversely, if Ofcom determines that the two bands are essentially independent, it should sequentially run two separate clock auctions, first for the 2.3 GHz band and then for the 3.4 GHz band (since the former is of higher value and in greater scarcity than the latter). Each would be a simple clock auction for a homogeneous good. To avoid the perceived need for withholding aggregate demand information, Ofcom should consider utilising a “clenching” pricing rule, which eliminates bidders’ incentives for strategic demand reduction, rather than uniform pricing. Following these two separate clock auctions, Ofcom should conduct an assignment stage, as currently proposed, for winners.
10.2 Recommendations on information policy

On information policy, we conclude that Ofcom’s proposed withholding of demand information from bidders would be a giant step backward in spectrum auction practice. It would run counter to Ofcom’s objective of promoting efficiency, rendering the perhaps 100 rounds of the auction largely superfluous and being no more conducive to price discovery than a sealed-bid auction. It would also run counter to international best practice; it is difficult to find examples of multi-round spectrum auctions in which aggregate demand information was withheld from bidders. Finally, it is a completely unnecessary step backward, as both CCAs and SMRAs have performed well in practice with disclosure of aggregate demand information after every round. Indeed, running a major spectrum auction with the proposed information policy itself creates substantial risks, as the information policy would then differ dramatically from those under which the CCA and SMRA have demonstrated track records of success.

Specifically, we recommend that Ofcom adopt the following information policies:

- In the CCA format, the aggregate demand for each category of licences should be disclosed to bidders after every round (except for the final clock round, when it should be withheld so as to discourage predatory bidding in the supplementary bidding round);

- In a clock auction, the aggregate demand for each category of licences should be disclosed to bidders after every round; and

- In the SMRA format, the aggregate demand for each category of licences should be disclosed to bidders after every round—to make this disclosure useful, it must correctly account for situations where bidders raise their own Standing High Bids.

10.3 Recommendations on other specific auction design points

We also comment briefly on some narrower auction design issues:

- It would be best to avoid allowing bidding waivers, which introduce bidding complexity and offer no real benefit. Ofcom would do better to use round extensions, as in past UK auctions, in their place.

- Since bidder-defined Minimum Spectrum Requirements may allow bidders to impose externalities on others without paying the cost or even to exclude rivals from the 2.3 GHz band, the maximum allowed MSR should be reduced from 20 MHz to 10 MHz. This will also have the side benefit of limiting the potential undersell that it produces to a maximum of only a single 5 MHz block per spectrum band.

- Eligibility points are optimally set in proportion to the items’ values. Ofcom’s proposal of attaching equal eligibility points for two different spectrum bands believed to be substantially different in value establishes an environment where bidders have strong incentive to engage in “parking”, which will increase the strategic complexity of the auction, further decrease transparency, and likely diminish the efficiency of the auction outcome. As such, we propose that Ofcom adopt somewhere between a 2:1 and 4:1 eligibility point ratio between spectrum blocks in the 2.3 GHz and 3.4 GHz bands.
• Ofcom proposes to introduce a relaxed activity rule for the CCA proposal. However, Ofcom does not propose a similar change to the activity rule for the SMRA design. A relaxed activity rule would solve at least two major problems in the proposed SMRA design. First, the choice of eligibility points becomes less critical. Second, the “parking” strategy loses its attractiveness.

• By design, standard SMRAs need a mechanism to break ties and select Standing High Bids from among otherwise equal bids of different bidders. Many SMRAs, including the one proposed by Ofcom, break such ties based on some non-random priority ranking. Such procedures create strategic opportunities for bidders and significantly complicate the bidding process. Modern SMRA designs break ties randomly, allowing bidders to focus their efforts and resources on efficiency-enhancing tasks such as price discovery, while clock auction designs eliminate the designation of Standing High Bids and thereby eliminate the need for this form of tie-breaking mechanism.

• One nonstandard element of this award is the presence of UK Broadband's holdings in the 3.4 GHz band. The presence of these holdings can interfere with the normal allocation process in two ways. First, there is a nontrivial possibility of a non-contiguous spectrum award to one of the winners that potentially requires major changes to the product configuration. Second, serious auction design flaws can be present if UK Broadband decides to participate in the award. It is important to handle this element very carefully and in the most straightforward way possible.
Annex A. Examples of FCC clock auction bid types

Example: Bidder Places a Simple Bid Demanding 2 Blocks at $5,500

Suppose that in the prior round, the bidder demanded 4 blocks at that round’s clock price of $5,000. In the current round, the clock price is $6,000, and the bidder places a simple bid reducing its demand to 2 blocks at price $5,500.

To the auction system, this bid means the following:

➢ If the price is below $5,500, the bidder is willing to purchase 4 blocks.
➢ If the price is exactly $5,500, the bidder is willing to purchase 2, 3, or 4 blocks.
➢ If the price is above $5,500, the bidder is willing to purchase only 2 blocks.

The graph below illustrates how the auction system interprets this simple bid:

If a simple bid is partially applied, then the processed demand of the bidder is a quantity that is strictly between the bidder’s processed demand before the simple bid was applied and the quantity that the bidder specified in the bid.

The simple bid is applied depending on the level of excess demand for the product at $5,500:

➢ If demand exceeds supply by more than 2 blocks, the bid is fully applied:
  o The bidder will hold 2 blocks and the clock increases up to $6,000.
➢ If demand exceeds supply by exactly 2 blocks, the bid is also fully applied:
  o The bidder will hold 2 blocks and the clock stops at $5,500
➢ If demand exceeds supply by only 1 block, the bid is partially applied:
  o The bidder will hold 3 blocks and the clock stops at $5,500.
➢ If demand does not exceed supply, the clock has already stopped and the bid is not applied:
  o The bidder will continue to hold 4 blocks at a price below $5,500.

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Note that prices continue to increase up to the clock price in a round as long as demand exceeds supply. If demand equals supply after applying a simple bid either in full or in part, the clock stops at the price where this occurred.

Therefore, in the example above, if the simple bid is applied in full at $5,500 and there is still excess demand, the bidder may end the round holding 2 blocks at the clock price of $6,000. Otherwise, if applying the simple bid fully or partially results in supply equaling demand, the clock price stops at that point, in this case $5,500. Hence, the remaining demands of a bidder whose bid is partially applied will be accepted at the stopped clock price of $5,500.

**Example: Bidder Places an All-or-Nothing Bid Demanding 2 Blocks at $5,500**

Suppose that in the prior round, the bidder demanded 4 blocks at that round’s clock price of $5,000. In the current round, the clock price is $6,000, and the bidder places an all-or-nothing bid reducing its demand to 2 blocks at price $5,500.

To the auction system, this bid means the following:

- If the price is below $5,500, the bidder is willing to purchase 4 blocks.
- If the price is $5,500 or higher, the bidder is willing to purchase either 2 or 4 blocks, but not 3 blocks.

The graph below illustrates how the auction system interprets this all-or-nothing bid:

![Graph illustrating how the auction system interprets an all-or-nothing bid](image)

This all-or-nothing bid is applied depending on the level of excess demand at $5,500:

- If demand exceeds supply by more than 2 blocks, the bid is fully applied:
  - The bidder will hold 2 blocks and the clock continues increasing, up to $6,000.
- If demand exceeds supply by exactly 2 blocks, the bid is also fully applied:
  - The bidder will hold 2 blocks and the clock stops at $5,500.
- If demand exceeds supply by 1 block, the bid is not applied at all:
  - The bidder will hold 4 blocks and the clock continues increasing, up to $6,000.
- If demand does not exceed supply, the bid is not applied at all:
  - The bidder will hold 4 blocks at a price below $5,500.
An all-or-nothing bid is either applied in full or is not applied at all; it is never applied partially. However, unlike the simple bid above, the all-or-nothing bid will not stop the clock if it cannot be applied. This leaves the possibility that the bidder may continue to hold 4 blocks as the price rises all the way to the current clock price. If the bidder wishes to prevent this, it has the option of associating a “backstop” with an all-or-nothing bid to reduce its demand.

Example: Bidder Places a Switch Bid for 2 Blocks from Category 1 to Category 2 at $5,500

Suppose that in the prior round, the bidder demanded 4 blocks in Category 1 at that round’s clock price of $5,000, and no blocks in Category 2. In the current round, the clock price for Category 1 blocks is $6,000, and the bidder places a bid to switch its demand by 2 blocks from Category 1 to Category 2 at price $5,500.

To the auction system, this bid means the following:

- If the price of Category 1 is below $5,500, the bidder is willing to purchase 4 blocks in Category 1.
- If the price of Category 1 is exactly $5,500, the bidder wishes to switch demand from Category 1 to Category 2 by up to 2 blocks.

Note that the bidder does not specify a quantity for Category 2 blocks in its bid. By placing the bid, the bidder indicates a willingness to purchase up to 2 blocks of Category 2 at the current clock price.

This switch bid is applied depending on the level of excess demand in Category 1 at $5,500:

- If demand exceeds supply by 2 or more blocks in Category 1, the bid is fully applied:
  - The bidder will hold 2 blocks in Category 1 and 2 blocks in Category 2.
- If demand exceeds supply by only 1 block in Category 1, the bid is partially applied:
  - The bidder will hold 3 blocks in Category 1 and 1 block in Category 2.
- If demand does not exceed supply, the bid is not applied at all:
  - The bidder will continue to hold 4 blocks in Category 1 and none in Category 2.

In all cases, the bidder’s total demand across the categories is still 4. However, a switch bid may be applied partially in the sense that the number of blocks that are switched from Category 1 to Category 2 may be smaller than the maximum number of blocks that the bidder was willing to switch, depending on whether it is possible to reduce the bidder’s demand for Category 1.