Discussion document on the award of available spectrum 1452 – 1492 MHz: Auction design

This document discusses the auction design relating to the proposed grant of wireless telegraphy licences to use the 1452-1492 MHz spectrum

Discussion document

Publication date: 15 February 2007

Closing Date for Responses: 12 April 2007

Contents

Section 1

Introduction

1.1 Ofcom, in March 2006, consulted on its proposals for the award of available spectrum in the 1452 – 1492 MHz frequency band[1] ("the consultation document"). In the consultation document, Ofcom set out a number of factors relevant to the spectrum award. These included:

- the current use of the available spectrum (Section 2);
- background on potential uses of the available spectrum, based on a market study commissioned by Ofcom (Section 2);
- potential substitute spectrum that could be used to deliver similar services as those identified in the market study (Section 2);
- Ofcom's powers and duties (Section 3);
- Ofcom's approach to spectrum management, including its objectives for the award (Section 4);
- a range of international issues and an assessment of how these could impact on potential users of the available spectrum (Section 5);
- options for packaging the spectrum for the award (Section 6);
- issues to consider when determining auction formats for the award of spectrum (Section 7);
- options of auction formats for auctioning the available spectrum (Section 7); and
- proposed technical and regulatory conditions that would be specific to the wireless telegraphy licences that would be awarded to allow use of the available spectrum (Section 8).

1.2 As explained in the consultation document, Ofcom's main objective in this award is to promote the optimal use of the electro-magnetic spectrum, particularly in the 1452 – 1492 MHz frequency band. The proposals in the consultation document (and in this discussion document) are designed to secure that objective.

Developments since the consultation document

1.3 The consultation document concluded that it would be appropriate to award the available spectrum using a simultaneous, multiple round auction (SMRA), rather than using sequential or single round formats. Ofcom also believed that it would be appropriate for the available spectrum to be awarded using specific lots rather than generic lots. However, Ofcom, in the consultation document did not conclude on the precise auction format to be used, in particular, Ofcom made no judgement as to whether or not to use package bidding in the award.

[1] "Award of available spectrum: 1452-1492 MHz", Ofcom, 31 March 2006, http://www.ofcom.org.uk/consult/condocs/1452-1492/

1.4 As a result of Ofcom's analysis set out in the consultation document, two alternative SMRA auction formats were proposed, a SMRA with augmented switching rules and a SMRA with limited package bidding. Both of these formats had advantages and disadvantages, in particular relating to exposure to substitution and aggregation risks and challenges to implementation.

1.5 As stated in the consultation document[2], Ofcom has continued to study the formats in order to inform which auction design is preferable. As part of that work, a further auction design has been suggested to Ofcom, with this auction design having the potential to be able to address a number of issues relevant to this award. This further auction design is a simultaneous multiple-round clock auction ("combinatorial clock" auction). The combinatorial clock auction appears to have a number of advantages over both the SMRA with augmented switching rules and the SMRA with limited package bidding. In particular, the combinatorial clock auction could remove the exposure risk for bidders, reduce the threshold problem, allow price discovery and help bidders to effectively express their preferences. To the extent that these advantages were to materialise in any award, then this auction format would be likely to lead to the desired outcome of securing an efficient allocation of the available spectrum.

1.6 Much of the content of this discussion document is based on work that has been commissioned by Ofcom from Professor Peter Cramton and DotEcon and it has also drawn on a number of academic papers[3].

Purpose of this document

1.7 The purpose of this document is to explain the key features of the combinatorial clock auction format and set out how such an auction format may be expected to work in practice. Ofcom will then summarise the two auction formats set out in the consultation document and compare these with the combinatorial clock auction format. Annex 5 of this document reproduces Annex 9 from the consultation document, which described the main features of the two auction formats included in the consultation document.

1.8 Ofcom is seeking stakeholders' views on the auction formats and will take into account in formulating its decision for the award of the available spectrum any comments that it receives in response to this document.

1.9 At this point this document does not seek to fully address all of the points made by respondents to the original consultation or to revisit the other areas relevant to the award of the available spectrum which were addressed in the consultation document, e.g. options for packaging the available spectrum or the associated technical and regulatory conditions specific to the wireless telegraphy licences. As such this document should be read in conjunction with the consultation document. In addition Ofcom is simultaneously publishing a sister document that is looking at the technical conditions associated with the award of this spectrum. Ofcom's decision on all of these issues will be set out in its Statement on this award expected in the summer of 2007.

[2] Paragraph 7.31.

[3] References that may be of particular interest in relation to this award are:
- Ausubel, Lawrence M., Peter Cramton, and Paul Milgrom (2006), "The Clock-Proxy Auction: A Practical Combinatorial Auction Design," in Peter Cramton, Yoav Shoham, and Richard Steinberg (eds.), *Combinatorial Auctions*, Chapter 5, 115-138, MIT Press; and
- Day, Robert W. and S. Raghavan (2005), "Fair Payments for Efficient Allocations in Public Sector Combinatorial Auctions," Working Paper, University of Maryland.

1.10 Ofcom would welcome comments or views on any aspect of this document by 12 April 2007. In particular

Do stakeholders agree that Ofcom should award the 1452-1492 MHz band using a combinatorial clock auction format or have any other comments on the contents of this document?

Structure of this document

1.11 Section 2 of this document explains the key features of the combinatorial clock auction format and sets out how such an auction format may be expected to work in practice. Section 3 summarises the two auction formats included in the consultation document and compares each of three auction formats being considered. Section 4 summarises the next steps.

1.12 Annex 1 sets out the process for responding to this document, with Annex 2 setting out Ofcom's consultation principles. Annex 3 contains a consultation coversheet, with Annex 4 setting out the question to which Ofcom is seeking stakeholders' responses. Annex 5 reproduces Annex 9 of the consultation document, which described the main features of a SMRA with augmented switching rules and a SMRA with limited package bidding.

Section 2

Key features of the combinatorial clock auction format for the award of available spectrum in the 1452 – 1492 MHz frequency band

Introduction

2.1 Ofcom, in Section 7 of the consultation document, set out the two potential auction formats that it considered to be candidates for securing the objective of an optimal allocation of the available spectrum. The two candidate auction formats were:

- a SMRA with augmented switching rules; and
- a SMRA with limited package bidding.

2.2 However, Ofcom concluded that neither of these auction formats appeared to be clearly superior to the other for the award of the available spectrum, with each format having its own advantages and disadvantages. Ofcom stated that in order to inform which format was preferable that it intended to study both formats in further detail and consider the comments received in response to the consultation document.

2.3 As set out in Section 1, Ofcom, since publication of the consultation document has studied a further auction format which could potentially address a number of the particular issues relevant to this award. This auction format, the combinatorial clock auction, in particular appears to be able to remove the exposure risk for bidders, reduce the threshold problem, allow price discovery and help bidders to express their preferences effectively.

2.4 This Section explains the key features of the combinatorial clock auction format and describes how such an auction format may be expected to work in the award of spectrum in the 1452 – 1492 MHz frequency band. This Section also identifies the key rules for this auction format.

Combinatorial clock auction

2.5 For illustration purposes, in the combinatorial clock auction as with the other two auction formats being considered, Ofcom assumes the 40 MHz of available spectrum would be packaged into 17 specific lots: 16 lots, each of approximately 1.7 MHz, that correspond to spectrum blocks LA to LP and one block of 12.5 MHz for the 1479.5 – 1492 MHz band[4]. The auction rules required for other packaging solutions would be very similar to the ones described here.

[4] The detailed rights of use associated with each block is described in the Maastricht 2002 Special arrangement, the March 2006 consultation and the February 2007 technical conditions discussion document.

2.6 The combinatorial clock auction is a two stage auction. The first stage is a multiple round, open clock auction where bidders have the opportunity to bid on their most preferred package of lots in each round.

2.7 The second stage is a combinatorial sealed bid auction where bidders have an opportunity to express their preferences for packages of lots by bidding best and final offers. Bidders have the opportunity to bid best and final offers on all combinations of lots for which they were eligible to bid during the clock stage. This allows bidders to express their willingness to pay for combinations of lots which they would be happy to win even though they did not bid on them during the clock stage of the auction (for example because in each round they preferred another combination of lots at the prices set by the auctioneer or because the clock stage ended before the bidder had an opportunity to bid its willingness to pay on a combination of lots). A combination of these bids may allow the auctioneer to assign more of the available spectrum than was achieved at the end of the clock stage of the auction, and hence achieve a more efficient assignment.

2.8 The remainder of this Section explains the key features of the combinatorial clock auction and sets out how such an auction format may be expected to operate in practice. It also identifies the key rules for this auction format.

The clock stage

Introduction to clock auctions

2.9 The clock stage is a multiple round, open clock auction. In general, a clock auction has a number of categories of lots, where within each category lots are largely perfect substitutes for all bidders[5]. Demand is expressed in terms of the number of lots a bidder requires within each category.

2.10 Clock auctions involve a particularly simple statement of demand by bidders. Faced with prices for each category of lot, bidders state the number of lots they want. If the bidder is behaving straightforwardly, this means it is indicating its most preferred bundle of lots at a given set of prices. Demand is expressed for a package of lots and the bidder is never allocated a subset of any package of lots on which it bids.

2.11 Given a set of prices, bidders state the number of lots they want in each category. Summing individual demands and comparing with the number of available lots gives excess demand for each category of lot. Where there is excess demand for a category, price is increased. The price adjustment process is strictly upwards, so prices never decrease. If a category is in excess supply (whilst others are in excess demand), that price remains constant.

The clock stage in this award

2.12 In the context of the spectrum award being considered, as explained in the consultation document, there are significant differences between available lots and it is not possible to identify subsets of lots that are sufficiently close substitutes to be treated as categories. Therefore, in the present case there is the unusual feature that each lot is an individual category. As such there would be 17 clocks running simultaneously. This makes the clock auction in the context of the award of the

[5] For example, CO_2 abatement auctions in the UK have operated with a single category of lot, where bidders simply say how many lots they want at a given price.

available spectrum significantly different from most practical applications of clock auctions to date.

2.13 At the beginning of each round of the clock stage the auctioneer announces prices for each of the 17 lots. Each bidder identifies its preferred package of lots that they would most like to win at the announced prices. Subject to eligibility, in each round each bidder can express a desire for any package of lots e.g. if a bidder has eligibility to bid on five lots, its preferred package of lots can contain any combination of up to five lots. At the end of each clock round, the auctioneer will assess all of the bids received and identify for which lots there exists excess demand (and the extent of this excess demand). If there is excess demand for any lots, then the auctioneer will raise the price on those lots (the amount of such increase may vary with the level of excess demand) whilst the price of lots for which there is no excess demand remains the same (but does not fall). In the next clock round each bidder responds with its preferred package of lots at the new prices.

2.14 The clock stage ends at the first (lowest) price point at which there is no excess demand on any lot i.e. where there is only one bidder on any lot or where a lot is unsold at that price (demand is zero at that price).

The best and final offers stage

2.15 Following the clock stage there will be the “best and final offers” stage. The best and final offers stage includes a single round combinatorial sealed bid auction, which is open to all bidders from the clock stage. However, the rules governing what bidders can bid in this best and final offers stage will differ depending on whether the bidder has retained eligibility such that it was present in the auction at the end of the clock stage.

2.16 In each round of the clock stage of auction, bidders are only able to bid on their most preferred package of lots at prevailing prices and prevailing eligibility. This means that bidders may not have had an opportunity to express their willingness to pay for all feasible combinations of lots which they would be happy to win at prevailing prices (only their most preferred combinations). In order to allow bidders an opportunity to express their preferences across all potential packages of available lots (given the bidder’s eligibility) at the end of the clock stage bidders will be allowed to submit best and final offers for all combinations of lots for which they were eligible to bid during the clock stage. This opportunity to submit best and final offers ensures that bidders can express how much they would be willing to pay for any feasible package, other than their most preferred package, at the prices prevailing in each round.

2.17 The best and final offer that a bidder will be allowed to make on each of the eligible packages is capped at the total price of that package, with this total price being calculated by taking the prices announced at the beginning of the round in which they reduce eligibility. For example, a bidder wishing to bid on a combination of five lots will, where there are unsold lots at the end of the clock stage, be able to submit best and final offers for all combinations of five lots, with the amount that it is able to offer capped at the sum of the prices of those lots in the round at which it reduced its eligibility below five[6].

[6] Note that this bidder will also be able to bid on packages containing other numbers of lots (subject to it having had eligibility in the clock stage to do so). The amount that such a bidder can bid for these other combinations of lots will again be capped by the sum of the prices of those lots in the round in which it reduced its eligibility.

2.18 The exception to this is for those bidders that remain present in the auction at the end of the clock stage. These bidders will not have had an opportunity to express their willingness to pay for those combinations of lots for which they have retained eligibility. Therefore, for these combinations of lots, the amount that these bidders can bid will not be capped. For example, if at the end of the clock stage a bidder has retained eligibility to bid on five lots, it will be able to submit uncapped bids on all single lots and combinations of two, three, four and five lots. However, for combinations of lots for which it has reduced eligibility through the clock stage e.g. for combinations of six or more lots, the amount that can be bid will be capped in the manner as described above i.e. at the sum of the prices of those lots in the round at which it reduced its eligibility.

2.19 Once all of the best and final offers have been submitted, Ofcom will assess all of the bids received through both the clock stage and the best and final offers stage and identify the winning combination of bids. The winning combination of bids:

- maximises the total amount bid; whilst at the same time
- includes at most only one bid from each bidder[7]; and
- awards each lot at most to one bidder.

2.20 The bidders that made those bids are the winning bidders.

The pricing rule

2.21 Ofcom will also compute the price to be paid by each individual winning bidder. This price is calculated according to a second price rule. The characteristics of this second price rule are that:

- the total amount of money paid is minimised; but at the same time
- no losing bidder or combination of bidders (including combinations of losing and winning bidders) would, on the basis of their bids, be willing to pay more.

2.22 This is the end of the process. The winning bidders, upon payment of a licence fee equal to the price calculated according to the second price rule, will be granted a licence for the use of the specific frequency lots contained in their winning bid.

Auction rules

2.23 The main rules of the combinatorial clock auction are:

- package bidding;
- the bid increments;
- the activity rule;
- information policy;
- extensions; and

[7] All bids from a bidder are mutually exclusive.

- termination conditions.

Package bidding

2.24 The clock stage is conducted as a package auction. A bid expresses the bidder's preferred package of lots at the prices specified for each round.

2.25 All the bids a bidder makes in the auction (in both the clock stage and the best and final offers stage) are mutually exclusive; that is, at most one of the bidder's bids will be accepted. Further, all of the bidder's bids are kept live throughout the auction; that is, all bids made in the clock stage carry through to the best and final offers stage[8]. At the end of the best and final offers stage, a bidder may find that one of its bids in the clock stage is part of the winning combination of bids.

2.26 This approach eliminates the exposure problem. Subject to a bidder's eligibility it can always explicitly bid for the complete spectrum packages that it desires. Because bids are mutually exclusive, at the end of the auction the bidder will only ever win one of the packages that it has explicitly bid for. A bidder can bid, both in the clock stage and the best and final offers stage for packages of complementary lots without creating a risk that it will win only part of what it is bidding for.

Bid increments

2.27 The prices in the first round of the auction would be the reserve prices. In later rounds, Ofcom would increase the price of lots that were in excess demand (where there is more than one bidder bidding for a lot) but would leave unchanged the price of each category of lot where demand for that lot was either one or zero at the prevailing price. The clock price for a lot can never decrease. As prices increase, it would be expected that demand would reduce until eventually demand for each lot was less than or equal to supply.

2.28 The bid increment may be a fixed amount or a fixed percentage of the clock price. Ofcom will have discretion throughout the auction to alter the maximum amount of the bid increment from round to round, but will always announce any change in advance of the round in which the change is implemented. It could also be that on lots with greater excess demand, the price will increase at a faster rate than the price of lots with more modest excess demand. However, it is important that Ofcom retains discretion over the rate of price increases on individual lots as too large price increments could lead to significant changes in demand, with bidders switching away from higher priced lots en-mass to lower priced lots. If this were to occur, then this could be detrimental to the price discovery process.

Activity rule

2.29 As with the other auction formats, each lot in the auction would have an associated number of eligibility points. Ofcom proposes to assign one eligibility point per lot LA-LP, as they have very similar spectrum endowment (1.7 MHz). Lot Q (the 12.5 MHz lot) is considerably larger in terms of spectrum endowment, so it is appropriate to assign it a higher level of eligibility points. Ofcom anticipates assigning more than one eligibility point to this lot.

[8] This is true to the extent that the bidder has not superseded an earlier bid on a package of lots by a subsequent higher bid on the same package. Only the higher bid would carry through to the winner determination stage.

2.30 Bidders have an eligibility that limits the number of lots on which they can bid. Each lot has an associated number of eligibility points. Prior to the auction, bidders would submit a deposit linked to the number of eligibility points that they require given the maximum number of lots that they wish to bid for. This determines their eligibility in round 1 of the auction.

2.31 In subsequent rounds, each bidder's eligibility is determined by their bidding activity in the previous round. In order to maintain eligibility from one round to the next, bidders continue to bid on the same number of lots as the previous round. If in a round a bidder wishes to reduce the number of lots for which it submits bids, it will lose its eligibility. The amount of eligibility that it will have will correspond to the total of the eligibility points on which it has bid.

2.32 As the clock stage progresses, bidders cannot increase the total number of lots on which they are bidding. This means that as prices increase, a bidder may maintain or decrease the total quantity of lots that it is bidding on, but it cannot increase its total quantity of lots.

Information policy

2.33 There are different options for transparency. In general, it is preferable to reveal information of those items, such as excess demand, which improve efficiency (in this case because of improved price discovery). However the information revealed can also risk creating problems such as opportunities for tacit collusion. Where there is strong competition the benefits of transparency tend to outweigh the costs and full transparency is the best policy. However, when competition is weak, then concealing information can help to avoid tacit collusion.

2.34 Ofcom proposes that a combinatorial clock auction for the award of 1452 – 1492 MHz would be fully transparent.

Extensions

2.35 To guard against problems as a result of, for example, technical breakdown, the auctioneer will allow bidders who have failed to submit their bid before the required deadline, a limited extension of time in which to do so (and also the opportunity to submit their bid by other means, for example by phone or by hand). The number of such extensions available to each bidder will however be strictly limited, to prevent abuse of this facility. Ofcom is currently minded to allow a maximum of two such extensions during the clock stage[9] (and none in the best and final offers stage), each of up to 20 minutes.

Termination conditions

2.36 The clock stage terminates when there is no excess demand for any available lots. Ofcom will also have the discretion to terminate the clock stage earlier than this, for example if there is only a limited amount of excess demand remaining and Ofcom judges that it would be more appropriate to move immediately to the best and final offers stage.

[9] Although Ofcom would likely retain the discretion to increase this number during the auction if considered desirable

Section 3

Comparison of the candidate auction formats

Introduction

3.1 Section 7 of the consultation document considered a number of factors which could be relevant to the choice of design of the auction for the award of the available spectrum 1452 – 1492 MHz. These and further relevant factors were also considered in Annex 8 of the consultation document, the Impact Assessment, which compared the merits of the different auction designs considered.

3.2 This Section of the document summarises the two candidate auction formats from the consultation document. It then seeks to identify factors which could be relevant to the decision on which auction format to use for the award of the available spectrum and compare each of the auction formats being considered against these.

Summary of candidate auction formats from the consultation document

SMRA with augmented switching rules

3.3 Ofcom, in the consultation document, concluded that the auction format for the award of the available spectrum should be a simultaneous, multi-round format with specific lots. With this conclusion, Ofcom then considered the issue of whether to design an auction with or without package bidding options.

3.4 An auction format without package bidding options would be a SMRA with augmented switching rules. The augmented switching rules enhance flexibility for those bidders that are seeking combinations of individual lots. Under such switching rules, bidders that are current high bidders on a lot may *withdraw their demand* but only if they *make a new bid on another lot* on which they are not the current high bidder. This makes switching between lots significantly more fluid (compared to where there are no such switching rules) as withdrawals are not penalised provided that there are corresponding new bids.

3.5 The addition of such switching rules reduces bidder exposure to substitution and aggregation risks. This is because it becomes much easier for a bidder wishing to aggregate lots to move between blocks in response to relative price movements. The inclusion of such switching rules should therefore produce a more efficient outcome than a standard SMRA. However, in the absence of package bidding, this auction format cannot entirely eliminate aggregation risks. In this auction, these risks may impact particularly on those bidders seeking to aggregate lots for applications requiring larger amounts of spectrum.

SMRA with limited package bidding

3.6 An auction format that would more directly address aggregation issues would be a SMRA with limited package bidding. This format is a combinatorial SMRA, but with only a limited set of packages available. In the consultation document, Ofcom proposed that if this auction format were to be used in the award of available spectrum, it would propose allowing bidders to make package bids for groups of

three adjacent lots (equating to 5.1 MHz), which Ofcom called 'triples', as well as for single lots of 1.7 MHz. To illustrate this, Ofcom presented an example bid form in Figure 21 of the consultation document, which is reproduced below as Figure 1.

Figure 1 – Illustrative example of a bid form for SMRA with limited combinatorial bidding

Lot	High bidder	Type of bid	Current Price	Bids for single lots	Bids for triples	
A	Tom	Triple	£ xxx	£ xxx ^		
B	Tom	Triple	£ xxx	£ xxx ^	ABC	£ xxx ^
C	Tom	Triple	£ xxx	£ xxx ^	BCD	£ xxx ^
D	Dick	Single	£ xxx	£ xxx ^	CDE	£ xxx ^
E	Dick	Single	£ xxx	£ xxx ^	DEF	£ xxx ^
F	Peter	Triple	£ xxx	£ xxx ^	EFG	£ xxx ^
G	Peter	Triple	£ xxx	£ xxx ^	FGH	£ xxx ^
H	Peter	Triple	£ xxx	£ xxx ^	GHI	£ xxx ^
I	Emma	Triple	£ xxx	£ xxx ^	HIJ	£ xxx ^
J	Emma	Triple	£ xxx	£ xxx ^	IJK	£ xxx ^
K	Emma	Triple	£ xxx	£ xxx ^	JKL	£ xxx ^
L	Emma	Triple	£ xxx	£ xxx ^	KLM	£ xxx ^
M	Emma	Triple	£ xxx	£ xxx ^	LMN	£ xxx ^
N	Emma	Triple	£ xxx	£ xxx ^	MNO	£ xxx ^
O	Ofcom	None	£ xxx	£ xxx ^	NOP	£ xxx ^
P	Dick	Single	£ xxx	£ xxx ^		
Q	Jo	Single	£ xxx	£ xxx ^		

Source: DotEcon

3.7 Figure 1 indicates the bid-options available to bidders (whereby A-P relate to single 1.7 MHz lots in the lower 27.5 MHz whereas lot Q stands for the upper 12.5 MHz spectrum block). This limited set of packages greatly reduces the complexity of the auction relative to a full combinatorial SMRA.

3.8 This format reduces the aggregation risk for applications needing 5 MHz lots or other combinations of spectrum in excess of 5 MHz, relative to the SMRA with enhanced switching. However, (unlike a full combinatorial auction) this format does not address fully aggregation risks for bidders seeking amounts of spectrum greater than 5 MHz or discontinuous combinations of frequencies. In the consultation document, Ofcom considered that remaining aggregation risks should be at a manageable level, given that having contiguous spectrum in quantities larger than 5 MHz seems to be less critical to prospective business cases for use of the available spectrum.

3.9 The main drawback of this auction format is that it may be more challenging to implement than a SMRA with augmented switching rules, although actual bidding should be reasonably straightforward for bidders. The implementation challenges stem from the need to introduce a mathematical algorithm to determine the highest bids for each lot at the end of each round and the need for there to be more complex rules on determining the price levels for individual lots in each round, given the possibility that high bids on some lots may be for triples. However, on the other hand, one simplification in this auction format is that it is not necessary to implement rules on bid switching and withdrawals, as the introduction of package bidding diminishes the risk of stranded licences.

Comparison of candidate auction formats

Bid shading

3.10 Bid shading is when a bidder bids less than its full valuation of the spectrum. A bidder may adopt such a strategy where it is expected to "pay as bid". If a bidder were to bid its full valuation and it was required to pay as bid then it would not retain any surplus of the economic value of the spectrum for itself. The only way a bidder could retain economic value would be to shade its bid and bid less than its full valuation. If an auction design introduces incentives to shade bids, then this can lead to inefficient allocations.

SMRA with augmented switching rules

3.11 Bid shading is likely in a SMRA with augmented switching rules. This is particularly true where there is a risk of stranded lots (see below). With such a risk, bidders bid more cautiously than they would otherwise do in attempt to avoid being stranded with unwanted lots.

SMRA with limited package bidding

3.12 Bid shading is also possible with this auction format. This is particularly so where bidders are seeking packages of lots that do not equate with the pre-specified package of 5.1 MHz. This is for the same reason as with a SMRA with augmented switching rules and the risk that bidders will be stranded with unwanted lots.

Combinatorial clock

3.13 This auction format should reduce any incentive for a bidder to shade its bids compared to the other candidate formats. This is because the calculation of the price that winning bidders pay will minimise payments, subject to the condition that no losing bidder or combination of bidders (including combinations of losing and winning bidders) would, on the basis of their bids, be willing to pay more (see paragraph 2.21). Because of these constraints, the allocation of spectrum from the best and final offers stage reduces the incentive of bidders to manipulate their bids. It may be that some incentive to shade bids will remain, but this incentive is likely to be weak.

Aggregation risk/ stranded lots

3.14 Aggregation risks arise where a bidder is seeking to secure multiple lots. Where lots are offered individually, bidders seeking multiple lots will be required to make multiple bids. This introduces a risk that bidders will be successful on a subset of their bids, for which they have little or no value i.e. bidders risk being left with stranded lots.

SMRA with augmented switching rules

3.15 While augmented switching rules can mitigate aggregation risks, there remains a risk of stranded lots with this auction format. The ability of bidders to switch away from lots as prices increase mean that bidders seeking packages of lots risk being stranded with a subset of the lots on which they were bidding when the auction ends.

SMRA with limited package bidding

3.16 By pre-packaging lots, this auction format reduces aggregation risks for bidders, removing them completely for those bidders seeking 5.1 MHz of spectrum. However, risks remain for those bidders seeking different sized packages.

Combinatorial clock

3.17 All package bids are mutually exclusive. This means that bidders will only face the possibility of winning packages that they have explicitly bid for and as such, as long as bidders bid truthfully, there is no aggregation risk for bidders or risk of being stranded with unwanted lots.

Threshold problem

3.18 The threshold problem arises when there are groups of bidders that are demanding few lots and these bidders are unable to displace bidders who are bidding for a package of multiple lots. There may be a free-rider problem in that if one or more small bidders raise their bids this may be enough for all small bidders to benefit by displacing the larger package bidder. This means that a small bidder will have an incentive not to raise its bid, even though it may have a higher value on the lots it wants to win[10].

SMRA with augmented switching rules

3.19 The threshold problem does not arise with this auction format because there are no package bidders.

SMRA with limited package bidding

3.20 The threshold problem could be prominent in this auction format, particularly if there is demand for single lots from some bidders and these bidders are seeking to outbid those bidders seeking 5.1 MHz packages.

Combinatorial clock

3.21 Clock auctions can help small bidders to co-ordinate their bids where there is a threshold problem. However, to the extent there is demand for small packages of lots (including single lots), the threshold problem will to some extent remain.

[10] This incentive materialises because a small bidder will stands to gain if it can free-ride on another small bidder which is increasing its bid. If the other small bidder increases its bid sufficiently, the combined small bidder bids will exceed the bid of the larger package bidder and the small bidders will win the spectrum on which they were bidding.

Complexity for bidders

3.22 The choice of auction format could introduce complexity for bidders. To the extent that the auction format is so complicated that bidders are unable to learn from the progress of the auction or bid their preferences, then this could introduce inefficiencies and risk a sub-optimal allocation of the available spectrum.

SMRA with augmented switching rules

3.23 This auction format would be complex for bidders. While the mechanics of bidding are quite simple and this is a variation on the widely used SMRA format, bidders will need to manage the process of switching bids across multiple lots and reconcile their own demand with that of other bidders. Further, there may be scope for strategic behaviour by bidders, which could distort outcomes (although activity rules can go someway to mitigate this risk).

SMRA with limited package bidding

3.24 This auction format should be relatively straightforward for bidders. Bidders will interact with a relatively straightforward bidding tool and will be able to express demand for specific lots, shifting demand in response to changes in relative prices. However, as prices will be calculated using an algorithm, the calculation of these prices may not be transparent.

Combinatorial clock

3.25 The clock stage would be relatively straightforward for bidders, who would be able to bid on a mutually exclusive basis on packages of lots in each round of the clock stage. Moreover, whilst bidders may need to submit best and final offers for a number of packages, the challenge of doing this should be reduced by the price discovery which the clock stage should provide.

Unsold lots

3.26 Unsold lots can arise when bidders switch their demand from one lot to another lot or from one package of lots to another package (or if permitted a complete withdrawal of demand). Such a sudden step change in demand may have the effect that at the closing auction price, demand for lots is less than supply, leaving the auctioneer with unsold licenses. This may not be efficient as there may be a bidder who had previously dropped out of the auction who would have been willing to buy the unsold lots, albeit at a lower price.

SMRA with augmented switching rules

3.27 As there is an aggregation risk and a risk of stranded lots with this auction format, there will also be a risk of unsold lots. However, this risk can be reduced by the design of the switching rules, although reducing the risk of unsold lots will increase the risk of stranded lots as the risk would be shifted from the auctioneer to the bidders.

SMRA with limited package bidding

3.28 There would remain some risk of unsold lots with this auction format.

Combinatorial clock

3.29 There is unlikely to be unsold lots with this auction format as all bids are mutually exclusive and bids from the clock stage carry through to the best and final offers stage. The risk of unsold lots will be greater where there is a lack of competition.

Strategic demand reduction

3.30 Strategic demand reduction can arise where lots are closely substitutable so that their prices are closely linked, and bidders want multiple lots. In particular, reducing the number of lots bought can reduce the price paid on all lots won. A bidder may be better off buying fewer lots at a lower price than more lots at a higher price.

SMRA with augmented switching rules

3.31 The risk of strategic demand reduction exists with this auction format, although because prices will not necessarily be uniform across lots, then there is a reduction in the incentive for bidders to strategically reduce demand, so may not be that relevant.

SMRA with limited package bidding

3.32 There is also a risk of strategic demand reduction with this auction format, although again because prices will not necessarily be uniform across lots there is a reduction in the incentive for bidders to strategically reduce demand, so may not be that relevant.

Combinatorial clock

3.33 Again, because prices are not required to be uniform across lots in this auction design, strategic demand reduction is unlikely to be of concern with this auction format.

Section 4

Next steps

4.1 This consultation, published on the 15 February 2007, lasts for an 8 week period. The closing date for responses is 12 April 2007. The consultation is shorter than Ofcom's standard 10 week period as Ofcom has already conducted a detailed consultation on the award of spectrum in the 1452 – 1492 MHz frequency band including auction design. See Annex 1 for details of how to respond to this consultation.

4.2 Ofcom will carry out a stakeholder event in to explain further the issues that have been raised in this discussion document. Invitations to this event will be sent out in due course, and details will be posted on the Ofcom website at http://www.ofcom.org.uk/radiocomms/spectrumawards/awardspending/award_1452/.

4.3 Ofcom expects to release a statement detailing its final proposals for this spectrum award, together with draft regulations and an Information Memorandum, in the summer of 2007.

4.4 An award would then be planned to take place in the autumn of 2007.

4.5 This timetable is subject to a number of external factors beyond Ofcom's control, in particular international issues as indicated in Ofcom's "Update on international developments and the timetable for the 1452 – 1492 MHz award" in October 2006[11], and so may be amended during the course of the award process.

4.6 Please note that you can register to receive free mail Updates alerting you to the publications of relevant Ofcom documents. For more details please see: http://www.ofcom.org.uk/static/subscribe/select_list.htm

[11] http://www.ofcom.org.uk/radiocomms/spectrumawards/awardspending/award_1452/intupdate/

Annex 1

Responding to this consultation

How to respond

A1.1 Ofcom invites written views and comments on the issues raised in this document, to be made **by 5pm on 12 April 2007**.

A1.2 Ofcom strongly prefers to receive responses using the online web form at http://www.ofcom.org.uk/consult/condocs/1452design/howtorespond/form, as this helps us to process the responses quickly and efficiently. We would also be grateful if you could assist us by completing a response (see Annex 3), to indicate whether or not there are confidentiality issues. This response coversheet is incorporated into the online web form questionnaire.

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

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

Anirban Roy
Floor 3
Spectrum Markets Team
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA

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

A1.6 It would be helpful if your response could include direct answers to the questions asked in this document, which is listed at Annex 4. It would also help if you can explain why you hold your views.

Further information

A1.7 If you want to discuss the issues and questions raised in this discussion document, or need advice on the appropriate form of response, please contact Anirban Roy on 020 7783 4677.

Confidentiality

A1.8 We believe it is important for everyone interested in an issue to see the views expressed by consultation respondents. We will therefore usually publish all responses on our website, www.ofcom.org.uk, ideally on receipt (when respondents confirm on their response coversheet that this is acceptable).

A1.9 All comments will be treated as non-confidential unless respondents specify that part or all of the response is confidential and should not be disclosed. Please place any confidential parts of a response in a separate annex so that non-confidential parts may be published along with the respondent's identity.

A1.10 Ofcom reserves its power to disclose any information it receives where this is required to facilitate the carrying out of its statutory functions.

A1.11 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use in order to meet its legal requirements. Ofcom's approach on intellectual property rights is explained further on its website at http://www.ofcom.org.uk/about/accoun/disclaimer/

Ofcom's consultation processes

A1.12 Ofcom seeks to ensure that responding to a consultation is easy as possible. For more information please see our consultation principles in Annex 2.

A1.13 If you have any comments or suggestions on how Ofcom conducts its consultations, please call our consultation helpdesk on 020 7981 3003 or e-mail us at consult@ofcom.org.uk . We would particularly welcome thoughts on how Ofcom could more effectively seek the views of those groups or individuals, such as small businesses or particular types of residential consumers, who are less likely to give their opinions through a formal consultation.

A1.14 If you would like to discuss these issues or Ofcom's consultation processes more generally you can alternatively contact Vicki Nash, Director Scotland, who is Ofcom's consultation champion:

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

Tel: 0141 229 7401
Fax: 0141 229 7433

Email vicki.nash@ofcom.org.uk

Annex 2

Ofcom's consultation principles

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

Before the consultation

A2.2 Where possible, we will hold informal talks with people and organisations before announcing a big consultation to find out whether we are thinking in the right direction. If we do not have enough time to do this, we will hold an open meeting to explain our proposals shortly after announcing the consultation.

During the consultation

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

A2.4 We will make the consultation document as short and simple as possible with a summary of no more than two pages. We will try to make it as easy as possible to give us a written response. If the consultation is complicated, we may provide a shortened version for smaller organisations or individuals who would otherwise not be able to spare the time to share their views.

A2.5 We will normally allow ten weeks for responses to consultations on issues of general interest. This consultation is shorter than Ofcom's standard 10 week period as Ofcom has already conducted a detailed consultation on the award of spectrum in the 1452 – 1492 MHz frequency band, including auction design

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

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

After the consultation

A2.8 We will look at each response carefully and with an open mind. We will give reasons for our decisions and will give an account of how the views of those concerned helped shape those decisions.

Annex 3

Consultation response cover sheet

A3.1 In the interests of transparency, we will publish all consultation responses in full on our website, www.ofcom.org.uk, unless a respondent specifies that all or part of their response is confidential. We will also refer to the contents of a response when explaining our decision, without disclosing the specific information that you wish to remain confidential.

A3.2 We have produced a coversheet for responses (see below) and would be very grateful if you could send one with your response (this is incorporated into the online web form if you respond in this way). This will speed up our processing of responses, and help to maintain confidentiality by allowing you to state very clearly what you don't want to be published. We will keep your completed coversheets confidential.

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

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

A3.5 Please put any confidential parts of your response in a separate annex to your response, so that they are clearly identified. This can include information such as your personal background and experience. If you want your name, address, other contact details, or job title to remain confidential, please provide them in your coversheet only so that we don't have to edit your response.

Cover sheet for response to an Ofcom consultation

BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

What do you want Ofcom to keep confidential?

Nothing	☐	Name/contact details/job title	☐
Whole response	☐	Organisation	☐
Part of the response	☐	If there is no separate annex, which parts?	

DECLARATION

I confirm that the correspondence supplied with this cover sheet is a formal consultation response. It can be published in full on Ofcom's website, unless otherwise specified on this cover sheet, and I authorise Ofcom to make use of the information in this response to meet its legal requirements. If I have sent my response by email, Ofcom can disregard any standard e-mail text about not disclosing email contents and attachments.

Ofcom seeks to publish responses on receipt. If your response is non-confidential (in whole or in part), and you would prefer us to publish your response only once the consultation has ended, please tick here. ☐

Name Signed (if hard copy)

Annex 4

Consultation question

A4.1 Ofcom would welcome comments or views on any aspect of this discussion document by 15 March 2007. In particular

Do stakeholders agree that Ofcom should award the 1452-1492 MHz band using a combinatorial clock auction format or have any other comments on the contents of this document?

Annex 5

Candidate auction formats included in the consultation document

Introduction

A5.1 This annex reproduces Annex 9 from the original consultation document, which described the main features of the two auction formats considered in that document. All references are to that document.

Introduction

A5.2 Section 6 of this [consultation] document sets out several possible options for the packaging of the 1452 – 1492 MHz spectrum band. In short, the available 40 MHz of spectrum can be awarded as one spectrum block, or alternatively it can be divided into multiple lots of 1.7MHz, multiple lots of 5.1 MHz, or lots of varied sizes. The packaging solution that will eventually be taken forward for this award impacts on the specific auction design format and rules to be adopted.

A5.3 For illustration purposes in this annex only, we assume an award whereby the spectrum is packaged as follows:

Sub band:	**Illustrative packaging solution**
Lower 27.5 MHz (1452 – 1479.5 MHz)	Lots A-P: 16 lots of 1.7 MHz
Upper 12.5 MHz (1479.5 – 1492 MHz)	Lot Q: 1 lot of 12.5 MHz

A5.4 The auction format and rules required for other packaging solutions would be very similar to the ones described here.

A5.5 Section 7 of this [consultation] document sets out Ofcom's arguments for proposing to use an SMRA (Simultaneous Multiple Round Auction) format, given an award involving multiple spectrum lots. SMRAs have been widely deployed by spectrum managers to award multiple lots; for example, the UK 3G, BFWA and PFWA auctions all used SMRA formats. There is great scope for varying the detailed auction rules to meet the specific challenges created by individual awards.For this award, Ofcom has identified two leading candidate SMRA formats for awarding the available lots:

- **SMRA with enhanced switching**: an SMRA with rules that facilitate switching between lots; or
- **SMRA with limited combinatorial bidding**: an SMRA with the ability to make combinatorial bids for triples of lots.

A5.6 In the following subsections, we describe the main features of the two auction formats.

SMRA with enhanced switching

A5.7 This format is an adaptation of the standard SMRA developed and used by the United States FCC for multi-unit spectrum auctions, and subsequently adopted by spectrum managers in other countries, such as the United Kingdom. It is particularly suitable where a band is divided into a large number of lots by frequency, as it reduces risks that bidders fail to win contiguous spectrum lots where they need such spectrum. The format was used successfully in Norway in 2004 to award 150 lots of spectrum (6 regions each with 25 lots of 3.5MHz) in the 3.5GHz band.

A5.8 The key adaptation from a standard SMRA is the introduction of enhanced 'switching' rules to increase flexibility for bidders seeking contiguous lots. This reduces bidder exposure to substitution and aggregation risks, and should therefore produce a more efficient outcome than the standard SMRA. However, in the absence of package bidding, it cannot entirely eliminate aggregation risks. In this auction, these risks may impact particularly on those bidders seeking to aggregate lots into blocks of 5MHz or more.

Making bids

A5.9 Bidding proceeds in multiple rounds and finishes simultaneously for all lots.

A5.10 Figure 1 shows an example of a simple bid form. Bids are made for single lots. There are no restrictions on what bids can be made other than available eligibility.

A5.11 The amounts bid per lot are non-discretionary. To make a bid for a lot, bidders simply check a box next to that lot to confirm that they accept the new bid amount. Bidders that have the current high bid on a lot may increase their bid if they wish.

Figure 1: Illustrative example of bid form for SMRA with enhanced switching

Lot	High bidder	Current Price	New Bid Amount	BID	WD
A	Tom	£ xxx	£ ppp	☐	☐
B	Tom	£ xxx	£ xxx	☐	☐
C	Tom	£ xxx	£ xxx	☐	☐
D	Dick	£ xxx	£ xxx	☐	☐
E	Dick	£ xxx	£ xxx	☐	☐
F	Ofcom	£ xxx	£ xxx	☐	☐
G	Ofcom	£ xxx	£ xxx	☐	☐
H	Ofcom	£ xxx	£ xxx	☐	☐
I	Emma	£ xxx	£ xxx	☐	☐
J	Emma	£ xxx	£ xxx	☐	☐
K	Emma	£ xxx	£ xxx	☐	☐
L	Emma	£ xxx	£ xxx	☐	☐
M	Emma	£ xxx	£ xxx	☐	☐
N	Emma	£ xxx	£ xxx	☐	☐
O	Peter	£ xxx	£ xxx	☐	☐
P	Jo	£ xxx	£ xxx	☐	☐
Q	Jo	£ xxx	£ xxx	☐	☐

Notes: Simple check box bidding – bidders simply check the box to make a bid for a specific lot at the new bid amount. WD = Withdraw; this option would only be available on a lot-by-lot basis to the current high bidders on that lot.
Source: DotEcon

Eligibility and activity requirements

A5.12 Bidders have an ***eligibility*** that limits the number of lots on which they can bid. Each lot has an associated number of ***eligibility points***. Prior to the auction, bidders

submit a deposit linked to the number of eligibility points that they require given the maximum number of lots that they wish to bid for. This determines their eligibility in round 1 of the auction.

A5.13 In subsequent rounds, each bidder's eligibility is determined by their bidding activity in the previous round. In order to maintain eligibility from one round to the next, bidders must exceed a certain minimum level of ***activity***, a so-called ***activity requirement***. This mechanism prevents bidders 'hiding' their demand until late in the auction.

A5.14 A bidder's level of activity in each round is determined by the sum of:

- the eligibility points associated with the lots on which they were the current highest bidder at the start of the round (excluding any such bids that are withdrawn); plus
- the eligibility points associated any other lots on which they placed new bids during the round.

A5.15 Thus, a bidder that is the current highest bidder on a lot is not obliged to bid on that lot in the next round in order to maintain eligibility.

A5.16 Ofcom may set the activity requirement at 100% of eligibility throughout the auction. Alternatively, it may start with a lower level of activity requirement (e.g. 60% of eligibility), with the auction moving through ***stages*** where the activity requirement is tightened until it reaches 100%. The later approach is more complex but may offer some advantage in terms of facilitating switching and substitution behaviour.

A5.17 Detailed discussion of the eligibility rules can be found under 'auction rules common to both formats' further down in this annex, as these rules are fairly standard to both the candidate auction formats.

Winner determination

A5.18 At the end of each round, provisional winning bids are chosen by taking the highest bid received for each lot. If two or more bidders submitted a new bid on the same lot in the last round, then the high bidder is determined from between them using a process of random selection.

A5.19 The bidder that submitted the highest bid on a lot in the previous round is the ***current highest bidder***.

Making withdrawals and switching

A5.20 Bidders that are current high bidders on a lot may withdraw their demand in the next round but only if they make a new bid on another lot on which they are not the current high bidder. This makes switching between lots significantly more fluid than under standard FCC-style SMRA rules as withdrawals are not penalised provided that there are corresponding new bids. This should improve efficiency as it is much easier for a bidder wishing to aggregate contiguous demand to move between blocks in response to relative price movements.

A5.21 These rules would apply to lots A-P (the 1.7 MHz lots in the lower 27.5 MHz spectrum band), but may or may not be extended to lot Q (the 12.5 MHz lot).

A5.22 In the event that a bidder withdraws its demand from a lot and there are no new bids on that lot in the same round, there are two possible approaches that Ofcom could take. Either:

- the lot reverts to Ofcom at the current price; or
- the lot reverts to previous bids (if there are any), which are reactivated[12], at the amount of those bids.

A5.23 Ofcom has not decided yet which of these approaches it would use. The latter approach, which was used for the Norwegian 3.5GHz auction, is more complex to implement, requiring additional rules in relation to the reactivation of bids where bidders had previously lost eligibility. The former approach is simpler but would create a small risk that one or more lots may go unsold unnecessarily.

A5.24 In either case, in the event that a lot reverted to Ofcom, the auctioneer would reserve the right to reduce the current price in the next and subsequent rounds. However, once a bidder has bid for a specific lot, it would only be permitted to bid again on that lot at a price higher than its previous bid, removing any incentive to withdraw to achieve lower prices.

Current prices and bid increments

A5.25 Initially, the prices of lots A-P (the 1.7 MHz lots in 1452 – 1479.5 MHz spectrum band) would be the same and set equal to an amount determined by Ofcom. Lot Q (the 12.5 MHz lot in the 1479.5 – 1492 MHz spectrum band) would have a higher initial price, reflecting its larger spectrum endowment. We consider the issue of the level of reserve prices under 'auction rules common to both formats' further down.

A5.26 In round 1, the bid amount for each lot is the current price. The bid amount for a lot would remain at this level in successive rounds until a bid is received for that lot.

A5.27 Once a bid has been received for a lot, the new bid amount in the next round is the current price plus a fixed bid increment determined by the auctioneer.

A5.28 The bid increment may be a fixed amount or a fixed percentage of the current price. The auctioneer would have discretion to alter the amount of the bid increment from round-to-round, but would always announce any change in advance of the round in which the change is implemented. Ofcom envisages that, in any particular round, the same fixed or percentage increment would be applied across lots A-P (the 1.7 MHz lots), but a different increment may be applied to lot Q (the 12.5 MHz lot).

End of auction

A5.29 The auction ends when there is a round in which there are no new bids or withdrawals. Lots are awarded to those bidders that were the current highest bidders in the final round at the price determined by their last bids.

[12] Ofcom would only reactive previous bids which had lapsed because a bidder had subsequently dropped its activity. Bids that had lapsed because a bidder had shifted activity to another lot would not be considered.

SMRA with limited combinatorial bidding

A5.30 This format is also an adaptation of the standard SMRA, but with the significant innovation that bidders may bid for packages of three contiguous lots, as well as for single lots. It is particularly suitable where a band is divided by frequency into multiple, contiguous lots, and some bidders face predictable patterns of aggregation risks (i.e. in this case, the need to amalgamate blocks of 5 MHz spectrum). The format has not been used before, although the rules described below have some similarity to those proposed by the FCC for the US 700 MHz band.[13] This auction format would, however, be significantly less complicated than the FCC auction, as the lots are national rather than regional, and Ofcom proposes to limit the scope for combinatorial bidding to triples of lots.

A5.31 The introduction of combinatorial bidding should significantly increase flexibility for bidders seeking contiguous lots. This should substantially mitigate bidder exposure to substitution and aggregation risks, and may therefore produce a more efficient outcome than the other candidate auction format. Furthermore, with the introduction of combinatorial bidding, it is no longer necessary to use rules on bid withdrawals to facilitate switching between lots, thus simplifying the choices that bidders need to make on a round-by-round basis.

Making bids

A5.32 Bidding proceeds in multiple rounds and finishes simultaneously for all lots.

A5.33 Bids are made for packages, consisting of either single lots (of which there are 17) or contiguous triples of lots excluding lot Q (of which there are 14). Contiguous triples amount to about 5.1 MHz of spectrum in total. Other package bids are not permitted, so the bidding options are substantially more limited than in a full combinatorial auction.

A5.34 Figure 2 shows an example of a simple bid form. There are no restrictions on what bids can be made other than available eligibility. For instance, a bidder could bid both on a triple and a single lot contained within that triple or for two overlapping triples. Bids are non-exclusive, so that more than one of a bidder's bids can win, provided they do not include the same lots.

[13] This auction was postponed for regulatory reasons, so the auction rules were never implemented.

Figure 2: Illustrative example of bid form for SMRA with limited combinatorial bidding

Lot	High bidder	Type of bid	Current Price	Bids for single lots	Bids for triples	
A	Tom	Triple	£ xxx	£ xxx ^		
B	Tom	Triple	£ xxx	£ xxx ^	ABC	£ xxx ^
C	Tom	Triple	£ xxx	£ xxx ^	BCD	£ xxx ^
D	Dick	Single	£ xxx	£ xxx ^	CDE	£ xxx ^
E	Dick	Single	£ xxx	£ xxx ^	DEF	£ xxx ^
F	Peter	Triple	£ xxx	£ xxx ^	EFG	£ xxx ^
G	Peter	Triple	£ xxx	£ xxx ^	FGH	£ xxx ^
H	Peter	Triple	£ xxx	£ xxx ^	GHI	£ xxx ^
I	Emma	Triple	£ xxx	£ xxx ^	HIJ	£ xxx ^
J	Emma	Triple	£ xxx	£ xxx ^	IJK	£ xxx ^
K	Emma	Triple	£ xxx	£ xxx ^	JKL	£ xxx ^
L	Emma	Triple	£ xxx	£ xxx ^	KLM	£ xxx ^
M	Emma	Triple	£ xxx	£ xxx ^	LMN	£ xxx ^
N	Emma	Triple	£ xxx	£ xxx ^	MNO	£ xxx ^
O	Ofcom	None	£ xxx	£ xxx ^	NOP	£ xxx ^
P	Dick	Single	£ xxx	£ xxx ^		
Q	Jo	Single	£ xxx	£ xxx ^		

Notes: Simple menu bidding – to make a bid for a single or triple, bidders select from a drop down menu containing a limited number of bid amount options.

Source: DotEcon

Eligibility and activity requirements

A5.35 The rules on eligibility and activity requirements are essentially the same as for the other candidate auction format.

A5.36 For the purposes of determining activity levels, a bidder is considered to be active on a lot in a round if it:

- had the current high bid on that lot after completion of the previous round; or

- submitted a new bid on that lot in the round.

A5.37 The total level of activity for each bidder is calculated by summing the eligibility points associated with the lots on which they are active. Note that even if a bidder has submitted multiple bids featuring the same lots, each lot is only considered once for the purpose of calculating activity levels.

Winner determination

A5.38 At the end of each round, provisional winning bids are chosen by maximising the aggregate value of accepted bids subject to each lot only being allocated at most once. There is no restriction on the number of provisionally winning bids accepted from any single bidder.

A5.39 If there is more than one combination of valid bids that has the same highest aggregate value, then a process of random selection would be used to determine which combination is successful.

Current prices and bid increments

A5.40 As with the other candidate auction formats, the initial prices of lots A-P would be set equal, with lot Q having a higher initial price. We consider the issue of the level of reserve prices further down in 'auction rules common to both formats'. The initial price of a package is the sum of the prices of lots within them (i.e. triples are initially three times the price of singles).

A5.41 In round 1, the minimum bid for each package is the initial price.

A5.42 After the first round, Ofcom would compute shadow prices of individual lots implied by the bids so far received. These are prices such that:

- winning bids are equal to the sum of shadow prices of the lots within the package;

- (as far as possible) losing bids are less than that sum of shadow prices of the lots within the package.

A5.43 By construction, where a single bid is a current high bid, the shadow price is equal to the amount of the current high bid. Where a triple bid is a current high bid, the determination of shadow prices for individual lots is more complex. It would be determined by application of an algorithm that would distribute the amount of the winning triple bid across the component lots.

A5.44 From round 2 onwards, the minimum bid for each package (including both singles and triples) would be:

- the initial price for the package at the start of auction (only relevant if no bids have been received for any of the lots within the package); or

- the sum of the shadow prices for the component lots of the package that has the current high bid, plus a bid increment.

A5.45 The bid increment may be a fixed amount or a fixed percentage of the shadow price. The auctioneer would have discretion to alter the amount of the bid increment from round-to-round, but would always announce any change in advance of the round in

which the change is implemented. To avoid complicated amounts, the resulting minimum bid would be rounded off, for example to whole £10,000s. Ofcom envisages that, in any particular round, the same fixed or percentage increment would be applied across lots A-P (the 1.7 MHz lots in the lower 27.5 MHz), but a different increment may be applied to lot Q (the 12.5 MHz lot).

A5.46 Ofcom also intends to set maximum bids and to restrict bid options to limited number of levels between the minimum and maximum. The purpose of restricting bids in this way is to prevent errors by bidders (i.e. excessive bids) and restrict the scope for strategic behaviour (such as jump bidding or signalling) which might distort the auction. The appropriate level of the maximum bid for particular packages has not yet been determined.

End of auction

A5.47 If there are two consecutive rounds in which there are no changes in the winning bids, the auction would enter a ***provisional final round***. This process is designed to hasten the end of the auction if there are bidders who remain eligible to bid (i.e. are active) but have not been current high bidders in two consecutive rounds. The auction would end after the provisional final round unless there is a new winning bid. If a new winning bid did emerge, then the auction would revert to normal rounds.

A5.48 Lots are awarded to those bidders that were the current highest bidders in the final round at the price determined by their last bids.