

# **Award of liberalised spectrum in the 900MHz and other bands**

A report for ComReg

ComReg Document 10/71a

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# 1 Introduction

## 1.1 Background

1. In the third of its consultation papers on liberalising the future use of spectrum in the 900 MHz and 1800 MHz spectrum bands (issued in December 2009) ComReg outlined its plans for the award of usage rights for liberalised spectrum in the 900MHz band by way of an auction.<sup>1</sup> A report<sup>2</sup> by DotEcon advising on aspects of this award, including potential auction rules and recommendations on minimum prices, was published alongside ComReg's consultation document.
2. The mechanism proposed for the award of usage rights for liberalised 900MHz spectrum involved the use of a combinatorial auction to allow purchase of spectrum usage rights made available in two time slices. This dealt with the uneven availability of spectrum over time due to the differing expiry dates of existing GSM licences in the 900MHz band. The use of a combinatorial auction allowed riskless recombination of these time slices into a longer-lived licence as well as riskless aggregation of 2x5MHz blocks into 2x10MHz licences.
3. Having initially identified and examined four potential candidate auction formats, two combinatorial auction formats were considered suitable for this task: a sealed bid combinatorial auction (SBCA) and a combinatorial clock auction (CCA). Relative to the SBCA, the open rounds of a CCA would allow for price discovery, but might create a greater risk of bidders reducing demand (whether due to unilateral strategic considerations or through tacit collusion) in order to reduce the price paid. As concerns about this latter risk were particularly acute owing to the fine balance of supply and likely demand, leading to the potential for a 'natural' distribution of the available spectrum across the incumbents in line with their current relative strengths. For these reasons, an SBCA was proposed.
4. In the responses to ComReg consultation 09/99, respondents raised various concerns about the use of a sealed-bid auction rather than an open auction. In particular, some incumbent operators were worried about the risk that such a process might create for them of failing to win back spectrum and the consumer disruption that this might entail.
5. Since that report, there have been a number of significant developments. First, the passage of time has meant that a number of other spectrum awards have occurred and the benchmarks of spectrum value used to inform the reserve price recommendations in our previous report now need updating. There have also been significant macroeconomic developments over this period, with Irish GDP falling significantly; benchmarks also need to be updated to take into

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<sup>1</sup> See ComReg document 09/99.

<sup>2</sup> See ComReg document 09/99c.

account these changes. This has been addressed in our separate update report on benchmarking.

6. Second, due to current lack of demand for a new commercial DTT multiplex, a window of opportunity has been created for unexpectedly early release of digital dividend spectrum in the 800MHz band. The Minister for Communications, Energy and Natural Resources has announced that spectrum in the 800MHz band will be available following earlier than expected switch off of analogue TV broadcasting at the end of 2012.<sup>3</sup> In the light of this announcement, ComReg has asked us to consider how the proposed auction of 900MHz spectrum<sup>4</sup> could be modified to account for the various developments since our December 2009 report.

## 1.2 Structure of the report

7. This paper presents our revised advice on the award of spectrum usage rights in the 900MHz band in light of these developments.
8. First, we revisit the balance of considerations in choosing between a sealed bid combinatorial auction (SBCA) and a combinatorial clock auction (CCA) both in light of responses to ComReg consultation 09/99 and the availability of spectrum in the 800MHz band. We recommend that on balance a CCA format is now desirable, but that in order to address business continuity concerns raised in the responses to ComReg consultation 09/99 an appropriate activity rule must be used (what we call a 'relative cap'). This means that the CCA should follow similar rules to the recent 2.6GHz auction in Denmark, rather than the CCAs run to date in the UK.
9. Second, we consider the benefits and drawbacks of a 'big auction' combining 900MHz spectrum with spectrum in other bands including the 800MHz band. The proposed rules for a CCA are sufficiently broad that an additional band can be accommodated without significant revision of the rules. Overall, there are strong economic efficiency reasons for including closely substitutable spectrum in a unified award process.
10. We also consider the case for inclusion of 1800MHz spectrum in a single award process. There are still potential benefits to a common auction, but these are not as overwhelming as that of combining 800MHz and 900MHz.
11. Assuming a combined auction of 800MHz and 900MHz spectrum (and regardless of the inclusion or otherwise of 1800MHz spectrum), the report then considers the detailed rules for such an award.
12. A companion report considers minimum prices, first evaluating the case for a common minimum price for 800MHz and 900MHz spectrum and, second,

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<sup>3</sup> See ComReg document 10/59.

<sup>4</sup> The proposed auction rules for 900MHz spectrum are described in ComReg document 09/99.

assessing the case for revisiting the minimum price relative to calculated benchmarks in the context of increased supply of sub-1GHz spectrum and looser spectrum caps relative to the proposals in ComReg 09/99.

## 2 Auction format

13. As part of its report published alongside ComReg consultation 09/99, DotEcon's report (09/99c) considered the relative merits and drawbacks of the sealed bid combinatorial auction (SBCA) format and combinatorial clock auction (CCA) format. Our resulting recommendation was based on an evaluation of the relative benefit of reducing common value uncertainty using an open auction versus the greater risks of strategic behaviour to weaken competition in such a format.
14. In this section we revisit the relative merits and drawbacks of these two alternatives in light of responses to ComReg consultation 09/99. We defer considering whether the case for the CCA versus a SBCA is affected by moving to a combined award of spectrum in the 900MHz and 800MHz bands until Section 4. Our concern in this section is purely to revisit the relative merits of the two approaches for an award of 900MHz only.

### 2.1 Recommendation in light of consultation responses

#### 2.1.1 Common value uncertainty in our previous report

15. In our assessment of auction formats as described in our previous report, we concluded that, although bidders did face common value uncertainty, it was not of overwhelming importance for the award of 900MHz spectrum. The award of liberalised 900MHz licences enables an extension of 3G deployment from 2.1GHz to 900MHz, representing an evolutionary cost saving (albeit a significant one) for providing wide area coverage, rather than a revolutionary change in the services to be provided as when 3G licences were first offered. Therefore, the reasons that many countries used open auctions for the first wave of 2.1GHz assignments do not in our view apply here.
16. Moreover, the benefits to operators of operating 3G services below 1GHz might vary idiosyncratically according to each operator's plans for migration from legacy 2G services and deployment of 3G services to rural areas. Therefore, even to the extent that there was common value uncertainty, there might be idiosyncratic factors affecting each bidder's likely valuation. Given this, seems unlikely that one bidder could learn significantly about common factors affecting their own valuation by observing another bidder's valuation, as factors common to all operators could be masked by idiosyncratic factors.
17. In summary, in our previous report we recognised that individual bidders' valuations were uncertain and might be affected by common factors. However, this is a matter of degree. We found no compelling reason to suggest that there would be a strong interdependency between the valuations of bidders, so that observing information about the likely market-clearing price in an open auction would lead bidders to update their valuations significantly.

#### 2.1.2 Consultation responses

18. In their responses to ComReg consultation 09/99, some existing 900MHz operators have argued that there is considerable common value uncertainty.

For example, in its response, Vodafone cited the existence of common value uncertainty based on uncertainty regarding factors including:

- Future economic and technological conditions;
- Future trends in service demand, revenues and margins;
- Cost efficiencies likely to be achievable from use of 900 MHz spectrum rather than other spectrum bands; and
- Likely evolution of the key factors driving spectrum valuation beyond the first 3-4 years.<sup>5</sup>

Where such common value uncertainty is significant, the case for an auction format with open rounds - the CCA in this case - is strengthened.

19. We have no disagreement with Vodafone that these are all factors that give rise to common value uncertainty. Indeed, our previous report explicitly acknowledged that common value uncertainty is likely to be present, albeit masked by idiosyncrasies affecting each bidder's valuation. However, no evidence was presented in the consultation responses to change our view that common value uncertainty is not an overwhelming consideration in favour of an open auction. Rather, we need to consider the balance between the benefits of an open auction in terms of promoting price discovery and the risks of this format in terms of strategic behaviour that weakens competition.

### 2.1.3 Risk of weak competition

20. Our previous report noted that a drawback of any open auction is that it runs a greater risk that bidders might seek to act strategically to reduce demand to ensure that they pay relatively low prices for what they win. Further, the potential for this may be exacerbated where it is likely that the level of excess demand will be limited.
21. A potential issue with open auctions in general is that tacit collusion may be possible in which a sufficient number of bidders jointly reduce their demands to moderate the prices they pay. Competition over open rounds may facilitate such outcomes, as if bidders are intent on tacitly colluding the open rounds will provide them with the ability to observe whether their fellow colluders are behaving in line with or deviating from the implicit agreement. However, in such cases there would be an incentive for individual parties to deviate from the implicit agreement and compete for more spectrum. Because sealed bids are single round and there is no opportunity to observe whether other parties to a tacit agreement will behave in line with or deviate from the agreement, the potential for successful collusion is reduced.
22. However, in the proposed 900MHz auction, the concerns about weak competition are more acute than simply tacit collusion. Given the proposed

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<sup>5</sup> ComReg (March 2010), "Submissions to Consultation 09/99 - Liberalising the Future Use of the 900 MHz and 1800 MHz Spectrum Bands", ComReg Document 10/21R, p.173



spectrum caps of 2x10MHz, the balance between supply and likely demand is so fine that even *unilateral* strategic behaviour could undermine competition, let alone tacit collusion. In particular, with a spectrum cap of 2x10MHz and four incumbent mobile operators, without competition from entrants it necessarily follows that three incumbents would win 2x10MHz and one incumbent 2x5MHz. Therefore, it is possible that the only matter to be competed over is whether an incumbent gets 2x5MHz or 2x10MHz. In such a situation, all it would take is for one incumbent mobile operator to be willing to reduce its demand from 2x10MHz to 2x5MHz at a point below its incremental valuation for 2x10MHz in order to curtail competition artificially, leading to the auction closing prematurely and the bidder being awarded 2x5MHz relatively cheaply. This only requires a *unilateral* decision by one incumbent to reduce demand strategically; tacit collusion is not necessary in this case.

23. The incentives for such behaviour can be reduced in a number of ways. First, incentives for both unilateral strategic demand reduction and tacit collusion can be reduced by setting a relatively high minimum price, as ComReg has already stated its proposal to do. By reducing the difference between the minimum price and the valuations of bidders, the payoff to a bidder or bidders from acting strategically to soften competition is correspondingly reduced. We recommend this approach be maintained, subject to revisions of the estimated minimum price that we discuss separately.
24. Second, the use of a combinatorial format with a second price rule maximises the opportunity for bidders to compete for a larger package of spectrum without necessarily causing the price of a smaller package of spectrum (the fall-back option) to increase as a consequence of their bids. This is because the second price rule is based on the specific opportunity cost that each bidder imposes on others and there is no necessity that prices per lot are uniform across bidders. In particular, this means that if there is competition for 2x10MHz, this does not automatically lead to a higher price for a successful competitor who wins 2x5MHz unless the smaller package is also competed for. This is a useful feature of second price rules that dramatically reduces the incentives for strategic demand reduction. This is the case in *both* SBCAs and CCAs. The recent Danish 2.6GHz auction provides a good example of how in a CCA with a second price rule it is possible to sustain reasonable competition for the amount of spectrum won amongst a limited field of participants.<sup>6</sup>
25. Third, the use of a SBCA rather than a CCA reduces the risk of tacit collusion. It can also create uncertainty as to whether incumbents in the 900MHz band are being challenged by new entrants to the band or indeed to the Irish mobile market. In contrast, in an open auction (especially with the spectrum cap of 2x10MHz proposed in ComReg document 09/99) may be fairly easy to infer whether or not there is competition from entrants. For this reason we

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<sup>6</sup> While there was excess demand for only two paired lots at the beginning of the 2.6GHz auction in Denmark, the clock stage of the auction continued for 25 rounds, with three of the four participants paying prices several times the (relatively modest) reserve price for the spectrum usage rights they were awarded.

recommended in the previous report that any CCA be run with restricted transparency of other bidders bidding behaviour during the auction, revealing information about aggregate demand but not individual bids.<sup>7</sup>

26. The difficulties created by the fine balance of supply and likely demand would probably be much reduced by the inclusion of 800MHz spectrum as this opens up a much wider range of plausible outcomes. We discuss this issue in Section 4 when considering how the auction could be changed to include this new spectrum. Therefore, including 800MHz spectrum would in any case require a re-assessment of the balance between a CCA and SBCA even if other considerations were absent.

#### 2.1.4 Opportunity to re-bid and avoiding customer disruption

27. In response to ComReg consultation 09/99, Vodafone and O2 objected to ComReg's proposed SBCA format (Modified Option 1) on the basis that Vodafone itself, O2 or indeed both of these operators faced a risk that they would not be assigned any spectrum in the 900MHz award, and that were this to happen there would be unavoidable disruption to consumers. Further to this assertion, Vodafone presented detailed data as to the number of customers that would be affected were it not to secure at least 2x5MHz of 900MHz spectrum. Consequently, both operators favoured an open auction alternative.
28. At the crux of this argument is the fact that, as a single round process, the SBCA permits the possibility that if a sufficient number of other bidders would make sufficiently high bids that at least one of the existing 900MHz operators would not be allocated any spectrum usage rights in the 900MHz band; once this information was known, the defeated incumbent would not have the opportunity to raise its bids. Whilst incumbents might be expected to calibrate their bids to reflect the potential value of lost customers, and thus minimise the prospect of not securing sufficient spectrum usage rights, it is nevertheless not implausible that an incumbent could be highly uncertain about how to value 900MHz spectrum for business continuity reasons.
29. An advantage of the CCA format relative to the SCBA is that the CCA deals directly with the complaint on the part of these operators that in a SBCA they risk being out-bid (be a bid set at a value below that which reflects as incumbent's actual value of business continuity) for all of their current assignments of spectrum without having an opportunity to re-bid. Given the low probability of a situation where an incumbent would not bid at a level that reflected the value of its existing GSM customers, this issue was not considered in our previous report.
30. Notice that uncertainty about the value of retained spectrum for business continuity reasons is unlikely to constitute strong common value uncertainty in

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<sup>7</sup> Note that restricted transparency represents the restriction of visibility of other bidders bidding strategies as expressed through their individual bids. It does not imply restriction of visibility of the award process; our proposed auction format allows for a high level of transparency of the auction itself, and all results and calculations will be verifiable after the auction has been completed.

the conventional sense, as the value of retaining spectrum to provide legacy services is likely to be idiosyncratic across incumbents. Different operators will have different plans about how fast they wish to free up 900MHz spectrum and how long they wish to support legacy services. Therefore, any argument in favour of a CCA due to the uncertainty of valuing business continuity is not primarily related to common value uncertainty. Rather, it centres on providing bidders with the opportunity to re-bid due to the difficulty of refining estimates of the value of business continuity.

31. In a CCA, a bidder would have the facility open to it to secure whatever amount of spectrum it deemed essential by pursuing an appropriate bidding strategy. We illustrate in Annex A that in a CCA with a relative cap on supplementary bids, such a strategy is always available to a bidder. However, in order to provide this facility to bidders, it is important what form of activity rule is used.

#### 2.1.5 Overall assessment

32. Based on the responses to ComReg consultation 09/99, our overall assessment is as follows:
- a) We remain unconvinced that common value uncertainty is a predominant concern despite the arguments advanced by some respondents. In particular, no counterargument has been put to the position taken in our original report that the currently proposed award process would be far less influenced by common value uncertainty than previous awards such as 2.1GHz. It is not that common value uncertainty is absent from this award process, but that it is one of a number of considerations to be weighed. Therefore, we remain of the view that a balance needs to be struck between promoting price discovery and the risks of weak competition, particularly where this might be caused by tacit collusion or strategic demand reduction in a 900MHz-only auction;
  - b) We remain of the view that the risks of weak competition appear to be particularly high for a 900MHz-only award. No arguments or evidence presented in the consultation responses diminish this concern. Therefore, regardless of which format is chosen, the detailed rules need to reduce this risk as best as possible. Limited transparency in a CCA and relatively high minimum prices in either format reduce the likelihood of tacit collusion and strategic demand reduction. In either format a combinational auction with a second price rule will help in controlling incentives for unilateral strategic demand reduction by maximising the incentive for bidders to compete for more spectrum relative to less;
  - c) The problem of business continuity risks and the difficulty for an incumbent bidder in valuing the retention of spectrum to serve existing GSM customers would be better addressed by a CCA than a SBCA (provided the appropriate activity rule is used for the CCA). This issue was not considered in our previous report as we judged that there the probability of an incumbent not bidding to reflect a high value on

business continuity was insignificant. However, incumbents have taken a contrary view about this probability in their consultation responses.

33. Having taken these issues into account, the perceived balance of the CCA and the SBCA has shifted somewhat, as we believe that the issue of business continuity risks might be significant enough to tip our recommendation from a SBCA to a CCA for an award of spectrum usage rights in the 900MHz band. (This without considering the additional issues that arise if 800MHz spectrum is included in a common award, which we will turn to subsequently.) Our reasoning is as follows:
- The CCA format ensures that no existing operator is left without enough 900MHz spectrum to meet the needs of its existing customers without making an active, informed decision to do so based on prices in the auction;
  - The relative activity rule (explained in the following sub-section and recently used in the Danish 2.6GHz auction) provides existing operators with certainty as to how to win a minimum amount of spectrum in the auction provided that they are prepared to bid accordingly;
  - Relatively high minimum prices and limited transparency reduce the possibility of tacit collusion and strategic demand reduction;
  - The use of a combinatorial auction with a second price to a degree controls incentives for strategic demand reduction (i.e. bidding for less spectrum to get a better price) as it is possible to compete for larger packages without necessarily having to pay more for smaller packages if unsuccessful in securing a larger package.

## 2.2 Form of CCA proposed

### 2.2.1 Required features of the auction

34. We have described the general features of a CCA in our previous report. Therefore, we will not repeat the more technical details such as determination of winners and winning prices.
35. The specific features of the proposed CCA are that:
- There would be two non-substitutable categories of eligibility for the first and second time slice (i.e. it would not be possible to bid for more lots in one time category by bidding for fewer in the other); and
  - Rather than having caps on supplementary bids based on eligibility points<sup>8</sup>, caps on these bids would be determined by a 'relative' activity rule similar to that used in the recent 2.6GHz auction in Denmark (and described below). This activity rule is necessary to address the concerns about

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<sup>8</sup> For an explanation of 'eligibility points', see section 6.2.1 of ComReg document 09/99c.

business continuity by permitting strategies that can guarantee winning a minimum amount of spectrum provided existing operators are prepared to bid accordingly.

36. Further, two features that were part of the CCA proposed in 09/99 continue to be important and are assumed throughout the proposals presented here:
- Relatively high minimum prices; and
  - Limited transparency of bids during the auction.

### 2.2.2 Mechanics of the auction

#### Primary bid rounds

37. During the primary bid rounds, bids would be made for packages of lots in two time categories corresponding to the first and second time slices of prospective licences. At the beginning of each primary bid round the auctioneer would announce a price per lot for each category. Bidders simply state how many lots they would like in each time category at these prices.
38. Bidders cannot increase the number of lots they bid for in a time category from one primary bid round to the next. For the purposes of determining eligibility to make bids, the first and second time slices are treated as two independent categories across which eligibility to bid is not transferable. Therefore, it would not be possible for a bidder to reduce demand for one time slice and increase its demand for the other time slice from one primary bid round to the next.
39. As part of their applications, bidders would be required to state the number of lots in each time category they wish to be assigned at the reserve price. This will be taken as a binding bid and considered when determining winners in the same way as a bid made in a primary round. Deposit requirements would be determined by the initial bid at the reserve price; each category would have an associated deposit required per lot.
40. Where there is excess demand for lots in either or both time categories, the award process would progress to the auction stage following the lodgement of deposits by bidders in line with their respective applications. Bidders will only be informed of details regarding the status of their own application; they will not be informed of the identity of other applicants nor the reserve price bids, deposit levels or initial eligibility of other bidders.
41. In the first primary bid round, the choice facing bidders would be how many lots in each time category they wish to be assigned at the unit price for a lot in a category of the reserve price plus one price increment. (The value of this increment will depend on the amount of excess demand in each category and might be specified by a pre-announced rule. Alternatively, it may be left to the Auctioneer to set price increments within certain limits).
42. At the end of the round, bidders will be presented with the following information:
- The round prices in the last completed round;
  - The number of lots it bid on in each category in that round at these prices;

- The total demand for lots in each category at these lot prices, and the amount of excess demand where relevant; and
- Where there is excess demand in at least one lot category, the round price in each lot category in the following round (with the price increment being determined by the Auctioneer or through a rule given the level of excess demand in the category).

*At no point during the primary bid rounds will bidders be given information as to the bids placed by other bidders. Bidders only receive aggregated information.*

43. Where there is excess demand in at least one lot category, a second round will be scheduled. Where demand was not greater than supply of lots in a lot category in the first round, the price in the second round will remain unchanged; where there was excess demand in a lot category in the first round, the price of a lot in that category in the second round will increase. Primary bid rounds will continue in this way until demand for lots in each category is less than or equal to the number of lots available.

#### **Supplementary bids round**

44. Once the primary bid rounds have been completed, a supplementary bids round will then be run. The reason for this extra round is that bidders may not have bid for all the packages of interest to them up to that point. In addition, where a bidder has reduced its demand from one round to the next, the granularity of the bid increments may mean that it has not been able to bid the entirety of its valuation (i.e. the previous round price was below its valuation, but the next round price strictly above it). In such cases, the supplementary bids round gives an opportunity to raise bids.
45. It is important that the supplementary bids round does not undermine the integrity of the open rounds. In particular, we do not want bidders hanging back from making bids during the open rounds and then making them all in the supplementary round, otherwise we effectively have a sealed bid auction rather than an open auction. The formulation of activity rules for supplementary bids is critical to getting bid incentives correct for the primary rounds. Also, we cannot make it too easy for supplementary bids to upset the final outcome of the primary bid rounds (if there are unsold lots at this point) otherwise the benefits of the open format in reducing continuity risks for incumbents would be lost. For example, we do not want a situation where, having apparently secured at least one block in the first time slice in the final primary bid round, an incumbent then has an unavoidable risk of ultimately not getting any spectrum at all due to the supplementary round.
46. The standard eligibility-points based activity rule for supplementary bids used in the UK CCAs run to date<sup>9</sup> does not adequately address the issue of providing bidders with reasonable certainty about what they might win given the outcome of the clock stage. This rule was based on capping supplementary bids

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<sup>9</sup> These are the L-band and the 10-40GHz auctions.

to the maximum amount that could have bid in the last primary round when the bidder was able to bid for the package in question. Therefore, supplementary bids are subject to a absolute cap with these activity rules.

47. The problem with the absolute cap is that it encourages bidders to bid for the largest package of lots whose price does not exceed its valuation, instead of dropping back to smaller packages that offers a higher relative surplus at current prices. If a bidder did not stick with the largest possible package, it might find itself unable to bid its full value for a larger package in the supplementary bids round. (This problem also exists to some extent with an SMRA auction format, where bidders may have strategic incentives to exaggerate demand in the early to middle stages of an auction.) However, as the auction approaches a conclusion, the possibility that any round could be the last one should discipline bidders into bidding for their most wanted set of lots.
48. The incentives for bidders to target larger packages rather than their most valuable package at given prices may have negative implications for price discovery, as demand levels at any particular price may be above the efficient level. In turn, this could reduce the efficiency of an auction in a common value setting, as bidders are less likely to receive information that they might use to adjust their valuations and bids. The primary bid rounds may also continue for longer than is necessary to match demand and supply. It also means that it may be difficult for bidders to pursue strategies in which they try to guarantee winning a certain minimum amount of spectrum.
49. As an alternative to the eligibility-points rule, Ausubel et al (2006) proposed using a 'revealed preference' activity rule for multi-round combinatorial auctions.<sup>20</sup> Under this approach, bidders can bid for any package of lots, regardless of size, provided that the relative amounts that they bid for a package are consistent with their preferences as revealed by the bids they have made in previous rounds. This incentivises bidders to bid for the package that gives them the highest surplus at prevailing prices in each round, thus improving price discovery. In this case, all bids made in each primary bid round and in the supplementary bids round must be consistent with value preferences set in previous rounds.
50. However, the rigid revealed preference rule also has a serious flaw. Bidders may find themselves unable to adjust their preferences during the primary bid rounds in response to information about other bidders. Put differently, although price discovery is much improved, bidders may be unable to exploit this information. A potential solution to this flaw is to implement the revealed preference rule on a 'relaxed' basis, such that some inconsistency with preferences expressed in previous bids is tolerated. This is the approach that we adopt for the rules set out in this document.

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<sup>20</sup> L. Ausubel, P. Cramton, and P. Milgrom (2006), "The Clock-Proxy Auction: A Practical Combinatorial Auction Design," in P. Cramton, Y. Shoham, and R Steinberg (eds.), *Combinatorial Auctions*, MIT Press, Chapter 5, 115-138.

51. DotEcon and Ofcom developed a 'relative cap' activity rule for the CCA for use in the UK 2.6GHz auction before plans for this award were revised following the digital Britain report by the Independent Spectrum Broker.<sup>11</sup> It draws on both the eligibility points and revealed preference approaches.<sup>12</sup> This 'relative cap' activity rule has since been implemented in the 2.6GHz auction in Denmark.
52. Under this approach, a standard eligibility-points rule is used to determine activity and eligibility to bid in the primary rounds. In the supplementary round, the following rules would apply to bids made in this round:
- a) There is no limit on the supplementary bid that can be made for the package bid for in the final primary bid round (provided that the bidder is still bidding for some non-zero package).
  - b) The supplementary bid for *any other package A* is subject to a cap determined in the following way:
    1. First, determine the last primary bid round in which the bidder would have been eligible to bid for package *A*. Call this round *n*. This will either be the final round or some round in which the bidder dropped its eligibility to bid (by reducing the number of blocks bid for in one or both categories) and so gave up the opportunity to bid for package *A* in later rounds.
    2. Suppose that the bidder bid for package *B* in round *n*;
    3. The supplementary bid for package *A* cannot exceed the bid for package *B* (i.e. the supplementary bid for this package, if one is made, or otherwise the primary round bid) plus the price difference between packages *A* and *B* that applied in round *n* (i.e. the packages are priced at the round *n* prices).
53. This formulation appears complex, but the idea is quite simple. Having already been given the opportunity to decide between *A* and *B* back in round *n* and plumping for *B*, this reveals the premium that the bidder is prepared to pay for *B* relative to *A*. In making supplementary bids, the bidder cannot now dramatically increase its bid for *A* relative to that for *B* and overturn the preference it has already revealed.
54. Notice that the caps in effect chain back to the supplementary bid made for the final package (i.e. the package bid for in the final primary bid round). This means that if the supplementary bid on the final package is increased, then all other supplementary bids can be increased. It is only the *relative* amounts bid for different packages that are constrained.

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<sup>11</sup> <http://interactive.bis.gov.uk/digitalbritain/report/>

<sup>12</sup> More information about the use of a 'relative cap' activity rule auction is available at: [www.ofcom.org.uk/radiocomms/spectrumawards/awardspending/award\\_2010/](http://www.ofcom.org.uk/radiocomms/spectrumawards/awardspending/award_2010/). For a description of experiments undertaken by Peter Cramton to test this rule using DotEcon's WebBidder software, see Cramton, P, (2009), Spectrum Auction Design, Working Paper, University of Maryland.



55. After the supplementary bids round has ended, the entirety of bids from both primary rounds and the supplementary round will be taken together. Winners and winning prices (i.e. base prices in our terminology) will be determined in exactly the same manner as described in our original proposals.

#### Unsold lots and guaranteeing lots won

56. In the event that there are unsold lots in the final primary bid round (which is quite likely given what we suspect about the structure of bidders' demand), it is possible that the outcome of the final primary bid round might not be the eventual outcome of the auction. This is because it might be more efficient to recombine bids made in the auction in a way that makes better use of the total number of lots available.
57. However, provided that we use the relative activity rule described above, there is a simple strategy that bidders can adopt to ensure that their position in the final primary bid round is protected. In particular, bidders will know if there are any unallocated lots in the final primary bid round, as they are told aggregate demand in each category. If a bidder then increases its final primary bid by the value of any unsold lots at final round prices plus one Euro, it can be sure that it will not be displaced from the winning outcome regardless of the supplementary bids made by others. This is because the relative cap limits the *incremental* value that can be generated by awarding larger packages to other bidders to the final round prices.
58. Although the relative cap is a little complex, it does allow for much more straightforward bidding strategies. Further, we need to use this rule if we are to provide a means for bidders to be able to guarantee the outcome they achieve in the final primary bid round. This feature is essential for dealing with the issue of business continuity risks.

#### Assignment round

59. Following this determination of winners and base prices, a single assignment round would be scheduled. During this round, winners would have the opportunity (though not an obligation) to bid for specific locations within the given band plan. The constraints on assignment options for winners would be:
- To be considered, a bid made by a bidder must relate to the amount of spectrum awarded to that bidder, or a subset thereof;
  - Lot C and/or lot D in the first time slice are fixed as Meteor's in the case that Meteor did not win 2x10MHz in the auction in this time category; and
  - Within a time category, only band plans that allow all winners of 2x10MHz to have contiguous spectrum will be considered.
60. After the assignment round has ended and bids in this round have been processed, bidders will be informed of the specific frequencies awarded to them in each time category along with the frequencies awarded to all other winners, the prices paid by all winners for their spectrum assignment (which we refer to as additional prices) and the total price paid by each bidder for spectrum (the sum of base prices and additional prices).

### 3 800MHz spectrum

#### 3.1 Availability and band plan

61. The Minister for Communications, Energy and Natural Resources has announced that spectrum in the 800MHz band will be available following earlier than expected switch off of analogue TV broadcasting at the end of 2012.<sup>13</sup>
62. The 800MHz spectrum would be available from a common starting date of 2013. The 800 MHz band would be made available in compliance with the EC Decision<sup>14</sup> on the 800 MHz band. Relative to spectrum within the interior of the band, spectrum at the top and bottom of the band would not be subject to any additional restrictions due to neighbouring use other than compliance with the conditions set out in the EC Decision. Therefore, for the purposes of an award process, all of the 800MHz spectrum could be treated as homogeneous.
63. The preferred CEPT plan for the 790-862MHz sub-band envisages paired use of this spectrum, packaged as six blocks of 2x5MHz (791-821MHz paired with 832-862MHz) with fixed duplex separations and a centre gap of 11MHz. While CEPT has considered a number of other options including mixed use and unpaired use only, because of the relatively limited amount of spectrum in the 800MHz sub-band, mixed paired/unpaired use is not envisaged; the guard blocks that this would require between paired and unpaired users would be punitive as a proportion of the available spectrum and so unlikely to be economically efficient.<sup>15</sup>

#### 3.2 Substitutability with 900MHz

64. There are a number of factors that indicate that once legacy GSM issues in the 900MHz band have been phased out, spectrum in the 800MHz and 900MHz bands will be close substitutes from the perspective of mobile operators:
  - Spectrum in these bands have similar radio propagation characteristics and are well suited to providing wide-area coverage and in-building penetration;
  - The 800MHz band is fast becoming harmonised across the EU for the provision of electronic communications services, providing the necessary scale to ensure equipment availability;
  - It is proposed that all spectrum in the 800MHz and 900MHz bands is packaged into lots of the same size in Ireland i.e. 2x5MHz; and

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<sup>13</sup> See ComReg document 10/59.

<sup>14</sup> <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:117:0095:0101:EN:PDF>

<sup>15</sup> This is unlike the auction of 2.6GHz spectrum in the Netherlands that allowed a split of the band between paired and unpaired use to be determined by the auction.

- From 2015 (at the latest), all spectrum in the 800MHz and 900MHz bands will have similar technical restrictions.
65. The propagation characteristics, technical restrictions and packaging of spectrum in the 800MHz band are essentially the same as those of 900MHz spectrum. Therefore, spectrum in the 800MHz band may well be suited for award in a unified process given its ability to substitute for 900MHz spectrum in the long run. We consider this further in the next section, where we investigate the prospect of an auction of 800MHz and 900MHz spectrum in one integrated and simultaneous process.

## 4 The 'big auction' prospect

66. In this section, we first consider the generic merits and drawbacks of a 'big auction', that is, the auctioning of more than one spectrum band in one simultaneous process. We recommend such a combined process for the auctioning of 800MHz and 900MHz spectrum.
67. Following this discussion, we describe how multiple spectrum bands can be included in a CCA. We also consider the case for including 1800MHz spectrum in a combined auction of 800MHz and 900MHz spectrum.
68. Finally, we discuss the issue of whether the first time slice should be the same for both 800MHz and 900MHz or whether 900MHz spectrum should be made available sooner than early 2013.

### 4.1 Merits and drawbacks of a 'big auction'

#### 4.1.1 Valuation linkages across bands

69. Broadly speaking, spectrum in different frequency bands has become increasingly substitutable for mobile operators:
  - With the increasing adoption of a service- and technology-neutral approach to licensing by regulators, spectrum in different bands can be used to provide similar services;
  - With an increasing number of bands being harmonised for use for electronic communications across the EU (such as the 800MHz sub-band), equipment for providing similar services is slowly becoming available across multiple bands, albeit in a phased manner.
70. Operators face a large number of possible combinations of spectrum which can be used to provide services. They have choices over:
  - the overall quantity of spectrum licensed;
  - the relative amounts of low and high frequency spectrum held (which is relevant for cost effective deployment in rural areas and provision of capacity in urban areas);
  - relative holdings in specific frequency bands (where specific frequencies may matter due to differing timing of equipment availability in different bands and issues of transitioning from legacy services).
71. Although spectrum in different bands should be substitutable in the long run, in the short term there may be more complicated factors in play. Using low frequency and high frequency spectrum in combination may provide lower cost network coverage and capacity. Even at similar frequencies, operators may wish to hold spectrum across a number of bands to allow migration of services and customers. Holding spectrum in different bands reduces exposure to the risk of delayed availability of equipment (especially handsets) able to operate in a certain band. Therefore, we could have a situation in which spectrum in different bands could be complementary for some bidders.

72. Notice that it is entirely possible for spectrum in different bands to be *both* substitutes and complements at the same time. This is because the nature of demand depends on the amount of spectrum bought. A bidder might want some minimum holding of spectrum in each of a number of bands, but then be flexible about how its total spectrum requirement is met through holdings distributed across these bands.

#### 4.1.2 Inefficiency in sequential processes

73. We can expect that the choice between the different combinations of spectrum that an operator would ideally hold will be affected by the relative price of spectrum in different bands. Supply is generally tighter below 1GHz and operators are likely to be prepared to make trade-offs in the spectrum they hold depending on the cost of different bands. As such, the auctioning of multiple spectrum bands at the same time allows operators to consider the full mix of possible holdings in different bands and strike these trade-offs on the basis of price. This reduces risk for operators and promotes efficient allocation.
74. In contrast, running sequential processes could suffer from the problem that bidders in earlier award processes would not know what price spectrum usage rights in later processes might be sold for, or whether they would be likely to win any such rights in any later processes. Further, once spectrum usage rights have been won in one process, it is not then possible to alter this outcome in the course of bidding in a later process. Therefore, sequential processes are unable to explore the full range of trade-offs and are highly dependent on bidders' expectations about what might happen in later awards. The difficulties inherent in this means that we cannot be certain of an efficient allocation.
75. Where spectrum has been awarded in a sequence of auctions, such as with Swiss WLL licences in 2001, often very different prices are seen for closely similar lots. This is strong evidence of the inefficiency of the outcome, as similar lots should sell for similar prices. Dissimilar prices show that substitution on the basis of price has been largely impossible in a sequential award process.

#### 4.1.3 Flexible mix of spectrum across bands

76. Achieving an efficient outcome not only requires a unified award process, but it is also desirable to provide flexibility for bidders to seek different mixes of spectrum across bands. For the reasons discussed above, it is very difficult to forecast what mix of spectrum an operator might ideally want and different operators might well take different views for good reasons. Therefore, pre-packaging spectrum across bands in fixed proportions (e.g. 2 x 5MHz of 900MHz linked with 2 x 5MHz of 800MHz) is not appropriate.
77. In the currently proposed award process there is great uncertainty surrounding the nature of demand:
- The relative preference for 800MHz or 900MHz is not known and is likely to differ for entrants and incumbents in the 900MHz bands, and indeed amongst existing 900MHz operators;
  - The minimum requirements of a new entrant with no spectrum in any bands other than those included in the auction may be different to that of

existing mobile operators. For example, the three existing mobile operators in the 900MHz band also have spectrum in both the 1800MHz and 2.1GHz band at present;

- Amongst existing operators, minimum requirements will vary based on expiration of current licences, requirements to continue to serve GSM customers and ease of migration of GSM customers to receiving services provided by other spectrum holdings;
- There are numerous possible considerations (discussed above) that might lead to some bidders wanting spectrum at both 800MHz and 900MHz, but also having some flexibility at the margin.

In order to determine an efficient allocation of spectrum under these circumstances, it is important to use an auction mechanism that can explore the full range of possibilities in terms of distribution of spectrum. This then allows competition between bidders to reveal valuations and the auction mechanism to select an efficient outcome.

#### 4.1.4 Facilitation of entry

78. If spectrum in the 900MHz band were to be auctioned relatively soon and 800MHz were to be awarded later only when it becomes available, then there is a significant likelihood that there would be no 900MHz spectrum awarded to potential new entrants to the Irish mobile market. This assessment of likelihood is based on the close match of likely incumbent demand and supply – there is 2x35MHz of spectrum available in this band and there are four mobile operators with existing infrastructure and customers that have each expressed an interest in obtaining spectrum up to the cap of 2x10MHz.
79. If supply were to be increased by including 800MHz spectrum within an early award process, the possibility for a new entrant to win its minimum requirement of spectrum needed to commence operations would be increased. The facilitation of such a possibility would be beneficial for competition within the auction. A unified auction of 800MHz and 900MHz would provide a much enhanced opportunity for entrants (enhanced further if 1800MHz were also available, as we discuss later) whether or not entrants eventually avail themselves of the opportunity.

#### 4.1.5 Cementing of downstream market outcomes

80. A bidder winning a combination of lots in the first and second time slices in the 900MHz band will be assigned spectrum until 2030. This does not necessarily have any negative implications for market entry, as for reasons discussed above spectrum in the 800MHz band represents a credible alternative to an entrant for 900MHz spectrum. At present, however, the 800MHz and 900MHz bands together represent the entirety of the spectrum under 1GHz that has been harmonised for use for providing electronic communications services.
81. It might be argued that if both 800MHz and 900MHz spectrum is made available in a single process, then this might represent the last opportunity to get access to significant amounts of sub-1GHz spectrum prior to 2030, when licences would expire. However, even if this assessment is accurate, this is not a

good argument for staggering the award of 900MHz and 800MHz to keep a drip feed of sub-1GHz spectrum.

82. First, we have already seen above that sequential award of substitutable spectrum is likely to lead to inefficient outcomes. Second, delaying making 800MHz spectrum available is an unnecessary restriction of spectrum supply that simply delays new services and/or enhanced competition benefits to consumers. Third, if there are concerns about competition, then the appropriate response is to impose spectrum caps to constrain excessive concentration of spectrum and to maximise the potential for entry; entrants would likely be discouraged rather than encouraged by 800MHz and 900MHz spectrum being split across different processes.
83. In any case, given that 800MHz spectrum will become available in 2013 and ComReg will be keen to award this commercially valuable spectrum relatively soon after it becoming available, if ComReg were to split the processes, 800MHz would need to be awarded soon after award of 900MHz spectrum. Therefore, even if it were reasonable to try to ensure staggered release of sub-1GHz spectrum, in practice this would appear difficult to achieve.

#### 4.1.6 Complexity

84. Predictably, the introduction of further categories of lots that an auction of spectrum in multiple bands will complicate the situation for bidders. Indeed, in order to facilitate the types of trade-offs that bidders might wish to make (bidding on less spectrum in one band and more spectrum in another as the price of spectrum in one band become more expensive), such an award process would clearly need to allow switching of demand across different categories of lots that might be considered substitutes. Further, with more possible combinations of spectrum that a bidder might wish to win, the greater will be the complexity involved in choosing what to bid for during the auction to respect these relative preferences. This complexity is the downside to providing greater flexibility.

## 4.2 Features of any proposed 'big auction'

### 4.2.1 Temporal lots

85. In the 900MHz-only auction (both as proposed in ComReg document 09/99 and as subject to the modifications proposed here) we have assumed that there would be two distinct time periods:

- the time period up to the expiration of Meteor's licence in 2015; and
- the subsequent period until expiration in 2030.

If usage rights for 800MHz spectrum were added to the auction process, the question arises whether a similar time division should be adopted for 800MHz spectrum.

86. The main benefit of creating the same time slices for 800MHz spectrum would be that this would create flexibility for bidders to have different mixes of 800MHz and 900MHz spectrum in the two time slices. We do not know

whether bidders would avail of this flexibility, but there are good reasons why they may want to:

- the relative availability of 900MHz is reduced in the first time period due to Meteor's existing licence still being in force;
- operators with legacy requirements for 900MHz spectrum are likely to have different demands for the first and second time slices;
- expected equipment availability across the two bands may affect their relative value especially in the first time slice.

For these and other reasons the relative cost of 800MHz and 900MHz might differ across the two time slices.

87. The obvious example of the benefit of creating flexibility is that an existing operator may require at least some 900MHz spectrum for the first time period but may be largely indifferent between 800MHz or 900MHz in the second time period. As such, it may bid for 800MHz spectrum, 900MHz spectrum or a combination of spectrum in both bands based on the relative price of lots in each spectrum band for the second time slice (even if the possibility of substitution is much curtailed for the first time slice). It would probably be impossible to pursue such a strategy if the 800MHz and 900MHz bands did not have the same time slices, especially if a spectrum cap is in operation.
88. In order to get the benefits of a combined auction including substitutable spectrum, we recommend that 800MHz spectrum in a combined auction is offered in two distinct categories using the same time slices as the 900MHz band (i.e. pre- and post-2015).

#### 4.2.2 Band-specific lot categories

89. Even though spectrum in the 800MHz and 900MHz bands is likely to be closely substitutable in the long run, there are good reasons for valuation differences in the short run. Bidders may have preferences for one band over another or for some mix of spectrum across both bands. Therefore, to achieve efficient allocation we need to treat the bands as separate categories and allow their relative prices to vary above a set common minimum price (see below).
90. In an auction of spectrum in the 800MHz and 900MHz bands, therefore, there would be four distinct lot categories:
- 800MHz lots in the first time slice (6 lots);
  - 800MHz in the second time slice (6 lots);
  - 900MHz lots in the first time slice (5 lots);
  - 900MHz in the second time slice (7 lots).
91. Bidders would have a total amount of eligibility to bid in each time slice, and would not be able to increase bidding in one time slice as a result of reducing bidding activity in the other. However, within a time slice, a bidder would be able to switch its bidding between 800MHz and 900MHz lots subject to bidding eligibility for that time slice capping the number of bids it may make across the two bands. Given the similarities of 800MHz and 900MHz spectrum, we would



propose that eligibility is counted simply as the number of 2x5MHz lots bid for (i.e. equal weight is given to 800MHz and 900MHz categories). The number of bids made in each time slice could not be increased from one primary bid round to the next, but within a time slice bids could be switched between 800MHz and 900MHz bands. That is, in the first primary bid round, the choice facing bidders would be how many lots in each spectrum band in each time category they wish to be assigned (which must be 0, 1, 2, 3 or 4 given a 2x20MHz spectrum cap (see Section 4.3.3) and no limits on which band one can bid on within a time period) at the unit price for a lot in a category of the reserve price plus one price increment.

92. Given the ability to switch bids between 800MHz and 900MHz categories within a time slice, we would also propose that a common minimum price be set for spectrum in the 800MHz and 900MHz bands within a time slice. The level of these minimum prices is considered in DotEcon's updated benchmarking report published alongside this document. Given the similar propagation characteristics of 800MHz and 900MHz spectrum, it is likely that the value of spectrum in these bands is broadly similar. Indeed, the price per MHz per population achieved in the recent auction of liberalised 800MHz spectrum in Germany was similar to that set as minimum prices for the 900MHz auction in Ireland based on benchmarks of spectrum in the 900MHz band.
93. At the application stage, bidders would state their demand for spectrum in each of the 4 lot categories listed above based on these minimum prices and pay the sum of the corresponding deposits. Excess demand within each of these categories would be assessed based on demand stated in bidder applications. Where there is excess demand in any category, the award process will progress to the auction stage. Demand stated in bidder applications will be binding and will be treated as a bid at the reserve price for the purposes of determining winners. Prices in the first round of the auction will be the reserve price for categories where there was no excess demand at the application stage and reserve price plus one increment in categories where there was excess demand at the application stage.
94. In subsequent primary bid rounds, prices will be set independently for each lot category. The price of a lot in a category in a round will be based on the round price and excess demand in that category in the previous round. There should be limits on the maximum proportionate bid increment that the auctioneer can apply from one primary bid round to the next.
95. The supplementary bids round would take account of both demand for lots by time slice and relative prices per lot across different bands within a time slice in the setting of caps on supplementary bids. All caps would be set relative to a bidder's supplementary bid for the package it bid for in the final primary bid round (or, where a supplementary bid for this package is not made, based on round prices per lot in the last round in which a bidder was eligible to bid for the relevant package). An illustration of how supplementary bids would be calculated is provided in Annex B of this report.
96. The mechanics of the assignment round would be the same in the big auction as in the 900MHz-only auction, as discussed in 09/99c, but for the fact that there

are more categories and a correspondingly greater number of packages of lot locations for which a bidder might wish to express its relative preferences.

#### 4.2.3 1800MHz spectrum

97. Given the assumption of a 'big auction' including spectrum in both the 800MHz and 900MHz bands, the case for including other spectrum available for award needs to be reassessed. In particular, much of the spectrum in the 1800MHz band is unassigned at present, and spectrum in the band that is currently assigned will become available in late 2014 or mid 2015. Therefore, the case for including the 1800MHz band in the 'big auction' needs to be considered carefully.
98. While low frequency spectrum (that is, spectrum below 1GHz) and high frequency spectrum (spectrum significantly above 1GHz, upwards of 1700MHz for example) may not be very close substitutes due to their different radio propagation characteristics, these two different types of spectrum may well still be substitutes at the margin for delivering capacity. It is possible that with continued growth of demand for data, the substitutability of low and high frequency spectrum may be greater in the long run, as the advantages of low frequency spectrum in delivering wide area coverage may reduce if cell site counts need to grow for capacity reasons. Where there is availability of substitutable spectrum (or more generally spectrum with any valuation linkage) the economic efficiency of spectrum allocation will be enhanced by using a unified process, as we have already discussed above.
99. The presence of 1800MHz in a common award process is likely to have greatest impact on entrants. An entrant with no existing mobile spectrum has two problems. First, it needs sufficient spectrum to offer services comparable with incumbent competitors and it may find low frequency spectrum relatively more costly to obtain due to its greater scarcity and high value to incumbents. Second, it may benefit from a mix of high and low frequency spectrum to be able to both provide wide-area coverage and also provide capacity in urban areas. Therefore, an entrant might treat high and low frequency spectrum as complements (i.e. it benefits from a mix) but also substitutes at the margin (i.e. it might make do with more high frequency spectrum even if it ideally would prefer low frequency spectrum).
100. Maximising opportunity for entrants does not, of course, mean that entry will occur. However, even if entry does not occur, it may still be beneficial to make it desirable for entrants to participate. This is because even the threat of competition from entrants in a CCA with limited transparency is likely to undermine gaming behaviour such as tacit collusion and strategic demand reduction.
101. The main potential concern of including 1800MHz spectrum in the auction is that demand may be weak for 1800MHz spectrum. If this were the case, it creates the possibility that spectrum in this band might be inefficiently awarded (that is, bid on and awarded to bidders not because they have a valuable business case requiring this spectrum but because it is cheap). Under this scenario, the public interest might be better served by ComReg retaining this spectrum for award at a later date when demand is firmer. This is a

consequence of the fact that spectrum licences are of considerable duration and this spectrum award has an opportunity cost; allocating spectrum to users now means that the allocation of this spectrum to other alternative users is precluded for at least 15 years.<sup>16</sup> This risk can be reduced, however, by setting the reserve price for 1800MHz spectrum licences at a level that discourages the frivolous purchase of 1800MHz spectrum licences.

102. Therefore, we believe that there may be some merit in considering the inclusion of 1800MHz within a 'big auction' of 800MHz and 900MHz spectrum. This may lead to greater economic efficiency (for the similar reasons that make 'big auctions' desirable, given above). Concerns about hoarding or frivolous demand could be addressed by setting an appropriate level of minimum price.
103. If the 1800MHz band were not to be included in a 'big auction', ComReg could still take steps to reduce the uncertainty that bidders in the 'big auction' have regarding this spectrum. While ComReg may not be willing to set expectations regarding the price of 1800MHz when it becomes available, it could make clear some of the details surrounding its envisaged availability e.g. the earliest time from which it might be available for assignment (both the spectrum currently assigned until late 2014 or mid 2015 and the spectrum currently unassigned) and the spectrum packaging that will be in place when this spectrum is awarded (e.g. 2x5MHz lots).

### 4.3 Issues surrounding a 'big auction'

#### 4.3.1 Timing issue

104. Spectrum in the 800MHz and 900MHz bands will become available at different times. Availability of spectrum in the 900MHz band is on a staggered basis:
- Two 2x5MHz blocks of spectrum are available now;
  - A further three 2x5MHz blocks will become available in May 2011; and
  - The two remaining 2x5MHz blocks will become available in 2015 as Meteor's existing licence expires.

However, owing to the two time slots envisaged for a 900MHz award process and the ability of Meteor, the holder of the only spectrum licence expiring in 2015, to bid for liberalised spectrum in the first time slice if it so chooses, all 900MHz spectrum could potentially be licensed on a liberalised basis from May

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<sup>16</sup> This assumes a 15-year licence duration for licences for spectrum in the 1800MHz band. This is an estimate based on ComReg consultations and responses by respondents relating to this issue and is not definitive or binding in any way.

2011.<sup>17</sup> In contrast, all spectrum in the 800MHz band is expected to become available only in early 2013.

105. Given our recommendation to have two time slices in the 800MHz band also, the issue arises whether the first time period for 800MHz should mirror that of 900MHz. That is, two options are available for the packaging of 800MHz spectrum in a 'big auction' with 900MHz spectrum, where both options assume that the envisaged auction is held as soon as is practically possible:
- **Option 1:** Auction spectrum from when it is available. In this case, the first time slice for 900MHz spectrum would cover the period from May 2011 to 2015, and the first time slice for 800MHz spectrum would cover the 2013-2015 period.
  - **Option 2:** Auction spectrum from a common start date. In this case, the first time slice for both 800MHz and 900MHz spectrum would cover the 2013-2015 period.
106. Notice that both of these options permit bidders to acquire different mixes of 800MHz and 900MHz across the two slices, as there is a common date for both bands for the crossover from the first time slice to the second time slice. The difference between the two options is solely the differing starting date for the two bands in the first time slice.
107. The main advantage of Option 2 relative to Option 1 is that it avoids the risk of distortions within the auction mechanisms as a result of the lengths of the licences in the first time period being very different with lots in the two bands failing to be reasonable substitutes of roughly similar value. For example, equal eligibility weighting and minimum prices across the bands may be unreasonable if the 900MHz first time slice is twice the length of the 800MHz time slice in the first time period.
108. Further, Option 2 has the potential to create a more level playing field amongst entrants and incumbents than Option 1. Specifically, there is a high likelihood that competition for 900MHz in the first period will be strong based on the requirements of existing operators to continue their GSM operations. This consideration is less important in the second period as existing operators can maintain or increase their total demand for sub-1GHz spectrum but spread this demand across the 800MHz and 900MHz bands. However, consider then the case of a potential entrant competing against incumbents under these circumstances. It is unlikely that a potential entrant is going to want 800MHz spectrum in the first time slice and 900MHz spectrum in the second time slice. Therefore, the desirable options for a potential entrant are 800MHz spectrum for the second or both time slices, or 900MHz spectrum for the second or both time slices. Given this, there is the potential for existing operators to compete

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<sup>17</sup> In practice, the use of some of this spectrum on a liberalised basis could not occur until after migrating to different frequency assignments and, in the case of at least one 2x5MHz lot per existing 900MHz operator, until its existing GSM operations are reduced from using 2x7.2MHz in this band to 2x5MHz. This issue is discussed further below.

aggressively for spectrum in the 900MHz band in the first time slice, driving up the price and encouraging any potential entrants to opt for 800MHz rather than 900MHz spectrum. In this way, existing operators would be able to keep a new entrant out of the market easily until at least 2013.

109. The essence of this argument is that this is a critical time in the development of the market, with liberalised sub-1GHz spectrum delivering wide-spread high-speed, low-cost services hopefully just round the corner. The concern is that 900MHz incumbents may have the ability to leverage their need for immediate access to 900MHz spectrum to provide legacy GSM services to get a head-start vis-à-vis network deployment and marketing of services on any operator trying to use 800MHz to compete in future data services (whether this is an entrant, H3GI or Meteor in the event that it does not use the option for earlier liberalisation). It is certainly possible that an 18-month lead time for a number of operators over others in providing low cost 3G services in Ireland would affect the structure of the resulting market substantially.
110. However, delaying the availability of such high-speed, low-cost services by preventing any operator from deploying 3G services in 900MHz spectrum in the interests of a common start date could lead to substantial foregone benefits for consumers. Indeed, the main disadvantage of Option 2 relative to Option 1 is the delay of availability of liberalised spectrum under 1GHz. Therefore, the magnitude of these two opposite effects needs to be considered in order to make a relative assessment of the better option in the case of Ireland.
111. In its consultation process to date, ComReg has taken the view that in principle only new licences for this spectrum will be liberalised. Under Option 1, therefore, two 2x5MHz blocks of liberalised 900MHz spectrum could notionally be awarded immediately upon conclusion of an auction process; a further three 2x5MHz lots could be awarded from May 2011. If Meteor were to bid and win back spectrum in the first time slice, a further two 2x5MHz blocks of liberalised spectrum would be awarded from May 2011. In practice, this means that the entire 900MHz band could be liberalised by the middle of 2011. This is in comparison to full liberalisation of the 900MHz band at the beginning of 2013, which is a small but significant delay.
112. However, the magnitude of this effect may in practice not be that large, as only some blocks at 900MHz are in practice likely to be available for early liberalisation due to the requirement to run legacy GSM services for some time. Given the information provided by operators as to their requirements for spectrum to continue GSM operations (2x5MHz), their current spectrum allocation is not large enough to operate 3G services and continue to provide services to GSM customers. Submissions of respondents to ComReg's consultation process have confirmed both that a minimum of 2x5MHz will be required to continue serving legacy GSM customers and maintain quality of service standards for a number of years still and that 2x5MHz is sufficient to fulfill this requirement.
113. Moreover, any incumbent wanting to deploy 3G and 2G simultaneously would face some delay in reducing the amount of 900MHz spectrum in use by GSM. In this context, ComReg has made available to DotEcon an engineering study by RedM/Vilicom commissioned by ComReg to consider a number of issues

surrounding the transition of the 900MHz band from GSM to liberalised use, including the time likely required by existing 900MHz operators to reduce the amount of spectrum used for serving GSM 900 customers from 2x7.2MHz to 2x5MHz. The study estimated that in the worst case, it would take operators two years to do this. While this would in practice vary across operators, nevertheless, if this estimate is broadly accurate, existing 900MHz operators would not be able to use their current assignments of 900MHz spectrum or indeed a larger assignment of 2x10MHz for the provision of 3G services for the time period in question i.e. 18 months.

114. Our interpretation of these findings is that during a period in which operators continued provision of existing GSM services, but were squeezing these down to use less spectrum, it would be difficult to offer 3G services at the same time without holding sufficient 900MHz spectrum. Put simply, squeezing legacy services down to use less spectrum seems likely to come first and only then when this has been achieved will 3G services be offered in the freed-up spectrum. If this is the case, there is a much-reduced cost to not liberalising 900MHz spectrum assigned to existing operators for this period. The primary disadvantage of delaying the award of liberalised 900MHz spectrum to coincide with the award of spectrum in the 800MHz band is therefore limited to the delayed award of the two 2x5MHz spectrum blocks, blocks A and B, that are available now.
115. A potential disadvantage of Option 2 is that the staged migration of operators to different frequencies in the light of the auction outcome is precluded. It is highly likely that at least one of the existing operators in the 900MHz band will have to move to a different set of frequencies within this band after the auction. Where all spectrum in the band is allocated from 2013, a situation is precluded where one operator begins moving after the auction, say in mid-2011. However, as part of the RedM/Vilicom study, it was estimated that the time and cost of a complete migration of existing 900MHz operators to different frequencies was small. Further, this is a maximum cost, as the actual migration of operators in this band will likely be more limited than full migration of all operators, and the burden of time and cost to do this would be correspondingly less than the estimate provided.
116. However, it is possible that under Option 2 a number of measures could be taken to benefit from the auction outcome being known prior to licences starting in 2013. For example, some of the benefit of staged migration (if frequencies change) under Option 1 can be achieved by allowing 900MHz licensees to start any transitioning prior to 2013, as is proposed by ComReg. Also, the allocation for 800MHz from 2013 would be known, so it would be possible to allow roll-out of infrastructure with test and trialing prior to services being offered. Such measures would mitigate much of the delay cost associated with Option 2.
117. Overall, it does not appear that the consequences to the delay to services from Option 2 are particularly troublesome. Option 1 runs some risks of distortions to competition both within the auction and in downstream services markets. Therefore, on balance Option 2 appears more attractive. However, even small delays to the availability of services are likely to have large welfare costs, so it is

critical to this conclusion that it is not the case that Option 1 could be expected to deliver new services significantly faster.

#### 4.3.2 Meteor situation

118. In the proposals in our previous report – where the 900MHz band is auctioned in isolation with a cap on spectrum holdings by any one operator of 2x10MHz - the situation surrounding Meteor's licence was clear. Either Meteor would win spectrum in the first time slice in the auction, in which case they would be given a liberalised licence for this period, or they would not in which case they would maintain this spectrum over the course of the first time slice on an unliberalised basis. In both cases, given where Meteor is located in the band, no combination of spectrum allocation amongst other winners would necessitate migration of Meteor to other frequencies.<sup>18</sup> It would always be possible to assign generic lots to specific frequencies to give each winner a contiguous frequency range.
119. This helpful situation does not carry over to a 'big auction' including 800MHz and 900MHz spectrum where a much larger total cap on spectrum under 1GHz in the first time slice might be implemented. For example, were a bidder to win 2x20MHz of 900MHz spectrum in the first time slice, there would be no assignment option that would not necessitate Meteor migrating to different frequencies. There are a number of possible solutions, including:
- Making any bid for four or more 2x5MHz blocks at 900MHz in the first time slice conditional on the basis that there would *not* be a contiguous assignment of frequencies, unlike any bid of three blocks or fewer; or
  - Imposing an additional spectrum cap on 900MHz spectrum in the first time slice to avoid this possibility. In order to avoid this problem, a cap on spectrum in this band for the relevant period would have to be at most 2x15MHz.

The first solution is preferable as it is less restrictive and unlikely to have any effect on the auction outcome.

#### 4.3.3 Spectrum caps

120. Given the substitutability of 800MHz and 900MHz spectrum in the long run, we consider that a cap on total spectrum under 1GHz is appropriate (as opposed to band specific caps). In total, inclusion of the 800MHz band will make 2x65MHz of spectrum available. It would be inappropriate to maintain the previously proposed cap of 2x10MHz given the much greater amount of spectrum available.
121. The level of a spectrum cap should be set in order to balance the benefits of protecting competition against the cost of doing so. That is, on one side, a spectrum cap should preclude outcomes that would result in the totality of a

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<sup>18</sup> It might however require Meteor re-tuning one channel in order to be at least 200kHz from the edge of a liberalised licence.

type of spectrum resource, in this case low frequency spectrum for mobile use, being held by such a small number of operators that competition would undoubtedly be harmed. On the other side, a spectrum cap should be limited to precluding *only* those outcomes that are viewed to unequivocally damage competition.

122. We believe that a cap of 2x15MHz per bidder would be too tight to balance these goals; while award of spectrum by an entrant to the mobile market should of course be facilitated, a spectrum cap of 2x15MHz would ensure that spectrum would be available to a mobile entrant by not allowing the four incumbent mobile operators the opportunity to purchase all the spectrum usage rights available. Therefore, there seems very little justification for a cap of that small an amount of spectrum, as it would be tantamount to reserving spectrum for an entrant.
123. In contrast, it is debatable whether a spectrum cap of 2x25MHz is simply too large to contemplate given asymmetries amongst spectrum winners that would be possible. As an extreme example, there would be a possibility that two bidders would win 2x25MHz each. In this scenario, even where both of these were existing mobile operators, this would likely mean that the two other existing operators had only 2x15MHz between them, or indeed that one operator had 2x15MHz and the other secured no spectrum under 1GHz. Given the cost efficiencies linked to the provision of 3G services using sub-1GHz spectrum, it is likely that such a result would substantially damage the ability of such an operator to compete effectively in the market for 3G services over the coming years. This is in addition to the disruption that might result from an existing 900MHz operator not obtaining rights to spectrum usage in this band for serving existing GSM customers. While this is a low probability outcome its potential effect on competition is sufficiently large that ComReg may wish to preclude this possibility.
124. Where the possibilities allowed under a 2x25MHz are considered too extreme to allow, tightest spectrum cap that does not unnecessarily limit auction outcomes is 2x20MHz. This level of spectrum cap would permit reasonable competition amongst the incumbents and does not raise concerns about creating incentives for tacit collusion or strategic demand reduction. Conversely, by guaranteeing an outcome with a minimum of three winners (where there is demand by this number of bidders), it prohibits the kind of extreme allocation possibilities that will likely lead to dampened competition in downstream markets for services.

#### 4.3.4 Licence conditions

125. Given that spectrum in the 800MHz and 900MHz bands will be in different categories, it is not necessary that resulting licences for spectrum in these bands be the same. However, in order to maximise the opportunity for substitution between bands and for holding larger blocks of spectrum within one band, there would be a benefit in ensuring that licence conditions are as far as possible homogeneous across 800MHz and 900MHz bands to avoid distorting the choice to purchase spectrum in either band. For example, attaching onerous coverage obligations to 800MHz but not to 900MHz spectrum would limit substitution and thereby constrain the set of likely outcomes for no obvious benefit.



126. In practice, however, there may be licence conditions associated with incumbent 900MHz operators continued use of spectrum (e.g. quality standards for legacy GSM voice services). If possible, it may be beneficial to avoid linking the fulfilment of such obligations to specific bands; that is, allowing such operators to fulfil such requirements using any combination of their spectrum holdings (as recommended in our previous report). This would limit the effect of these obligations on the choice between 800MHz and 900MHz spectrum in the auction.

## Annex A: Illustration of the relative activity rule (single lot category)

127. In the following example, we illustrate how caps on supplementary bids are formed. We also highlight the strategy that a bidder could use for winning the package bid on by the bidder in the final primary bid round works. In the following scenario, there is excess supply (i.e. unallocated lots) in the final primary bid round.
128. For simplicity, we assume that there is a single category with 7 lots (and so ignore the category relating to the first time slice and any other spectrum that might be available in other lot categories). Note that this numerical example is intended for illustrative purposes only. It does not express estimates as to the valuations of bidders, or indeed the likely divergence of valuations for spectrum across bidders. Comments about bidding strategies are not intended to provide any recommendation as to the strategies that bidders should adopt given these rules.
129. The following table provides the valuations for the five bidders in our example.

**Table 1: Example valuations**

Bidder	Number of lots	Valuations (€)
Adam	2	12.1m
Adam	1	8m
Ben	2	10m
Carl	2	10m
David	2	6.3m
Emily	2	7.8m
Emily	1	2m

130. Suppose the price per lot was €3m in the third primary bid round and all five bidders (Adam, Ben, Carl, David and Emily) bid for 2 lots. In the fourth primary bid round, the price per lot was set at €4m. Only Adam, Ben and Carl bid for 2 lots and there is, therefore, one unsold lot in the final primary bid round.
131. Because David and Emily dropped demand to zero in the fourth round, their cap in the supplementary round will be determined by the price in the fourth primary bid round. The relative caps for their relevant supplementary bids are provided in the following table. These are absolute caps, as although they are

set relative to a bidder's final package, for these bidders their final package is necessarily priced at zero as they dropped out of the primary bid rounds before the end.

**Table 2: Example supplementary caps**

Bidder	Number of lots	Cap
David	2	€8m
Emily	2	€8m
Emily	1	€4m

132. Adam, Ben and Carl kept bidding for a package of two lots in what turned out to be the final primary bid round. Their supplementary bids for a package of two lots are therefore uncapped as these were the packages they were bidding on in the final primary bid round.
133. Adam also has a valuation for a package of one lot. His supplementary bid for this package would be capped relative to his supplementary bid for two lots (or his final primary bid round bid for two lots if he does not submit a supplementary bid for a package of two lots). The relative cap is determined by the difference in quantities between the two packages (i.e. one less lot in this case) valued at the final primary bid round prices. Therefore, if Adam submits a supplementary bid of €X for a package of two lots, his supplementary bid for a package of one lot would be capped at  $\text{€}X - \text{€}4\text{m}$  which is the supplementary bid (€X) for a package of two lots and the price difference between a package of two lots and a package of one lot at final round prices (-€4m). If he does not submit a supplementary bid for a package of two lots, his supplementary bid for one lot would be capped relative to his final round bid for a package of two lots. Specifically, it would be capped at €4m, which is the final primary round bid for a package of two lots (€8m) less the price difference between a package of two lots and one of one lot at final primary bid round prices (€4m).
134. If all bidders submit supplementary bids according to their true valuations for all packages in the supplementary bids round, the winning combination of bids that will maximise the sum of winning bids is to allocate one lot to Adam and two lots to Ben, Carl and Emily. Hence, Adam does not win two lots as his bid for one lot allows for a more efficient allocation overall given all bids placed by all bidders.
135. Having bid on two lots in the final primary bid round, if Adam wished to ensure that he would be awarded two lots in the lot allocation based on primary bid round and supplementary bids round bids, he should bid the sum of his final primary bid round bid (€8m) plus the value of unsold lots at the final primary bid round price (one at €4m) plus €1 (to avoid ties). Therefore, if Adam were to

make a bid of €12,000,001 for a package of two lots in the supplementary bids round whilst not bidding for one lot, he would ensure that he would be awarded two lots in the winning allocation regardless of other bids made by any other bidders. He would not necessarily pay this amount, but rather only the opportunity cost, which will not exceed this amount.

136. This 'knock-out bid' strategy works because Emily and David have a cap on their supplementary bids based on their bidding behaviour in the last primary bid round. Neither Emily nor David could place a supplementary bid high enough to stop Adam winning two lots if Adam were to increase his bid in the final primary bid round by the value of the unsold lots in the final primary bid round and refrain from bidding for other packages.

## Annex B: Illustration of the relative activity cap (multiple lot categories)

137. In the following example, we illustrate how caps on an individual's supplementary bids are formed in the case where there are two lot categories, A and B. There is one eligibility point per lot and eligibility to bid can be transferred across lot categories. This example is kept as simple as possible to highlight exactly how these caps are generated.
138. Consider the table of round prices and bids in four primary bid rounds for bidder Alex. Note that it does not matter whether this reduction in demand commences in the early or late primary bid rounds – the important information for determining caps on supplementary bids is the round price in each category of lots in the rounds in which bidders reduce their eligibility. Therefore, the relative caps on supplementary bids are entirely determined by the primary bids made in rounds in which eligibility was dropped by Alex, not any other primary bid round.
139. The relative cap activity rule imposes caps relative to the final primary bid. Where the final primary bid is for a non-zero package (i.e. the bidder did not drop out completely in an earlier primary bid round) then the supplementary bid for the final primary package (FPP) is unlimited. If the final primary package is zero (i.e. no lots in either category), then the bid must also be zero, which in effect imposes absolute caps on all bids for other packages through the application of the relative cap rule (relative to the zero package in this case).
140. We will look at two cases below. The first considers round X+3 being the final primary bid round, in which case Alex has already entirely dropped out of the primary round bidding. The second case supposes that round X+2 is the final primary bid round (ignore round X+3 in the table for these purposes) and so Alex was still bidding for a non-zero package as the primary bid rounds closed.

Table 3: Example rounds prices and demand of an individual bidder

Round	Round price for Category A	Demand by Alex for lots in Category A	Round price for Category B	Demand by Alex for lots in Category B
X	100	0	100	2
X+1	100	2	110	0
X+2	105	1	115	0
X+3	110	0	120	0

**Case 1: Round X+3 is the final primary bid round**

141. The package bid for in round X+2 is the final primary package. Alex has dropped to the zero package in the final primary bid round. Obviously the “bid” for a zero package is necessarily zero and cannot be raised.
142. The relative caps are calculated using the same rule as Case 2, but because the final primary package is zero in this case, the result is that bids on other packages are subject to absolute caps.
143. Take for example the package (2,0). Alex was last eligible to bid for this package in round X+2. Therefore, his supplementary bid for (2,0) is limited to the bid for the final primary package (i.e. zero) plus the price difference between the value of the (2,0) and (0,0) packages at round X+2 prices. In this example, Alex’s bid for (2,0) is capped at the round X+2 price.

**Table 4: Caps on supplementary bids based on eligibility points**

Package (Category A lots, Category B lots)	Last round with eligibility to bid for this package	Price of package in this round = cap on package
(0, 2)	X+2	230
(2, 0)	X+2	210
(1, 0)	X+3	110

**Case 2: Round X+2 is the final primary bid round**

144. Assume, then, following in the scenario presented in Table 3, the auction closed in round X+2. Therefore, the FPP is made up of one lot of Category A spectrum only. There is no limit on the supplementary bid that may be made for this package.
145. Table 5 shows how the relative caps on supplementary bids are calculated given a bid of, say, 150 for the final primary package of 1 A and no B lots. Both of these packages have eligibility of 2, so the last round in which Alex would have been eligible to bid for them is round X+2.

Table 5: Caps on supplementary bids linked to final primary package

Package (Category A lots, Category B lots)	Calculation of cap on supplementary bid given a bid of 150 for the FPP	Cap on supplementary bid
(0, 2)	Value of cap on FPP + [2*(price of Category B lots in round X+2) - 1* price of Category A lots in round X+2]	$150 + [2*115 - 1*105]$ =275
(2, 0)	Value of cap on FPP + [2*(price of Category A lots in round X+2) - 1* price of Category A lots in round X+2]	$150 + [2*105 - 1*105]$ =255

