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Inclusion of the 1800MHz band in a joint award of spectrum in the 800MHz and 900MHz bands

A report for ComReg

ComReg Document 10/105a

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Content

Tables & Figures

1 Introduction

1. In its first consultation on the future use of 900MHz and 1800MHz spectrum in Ireland published in July 2008 (08/57), ComReg took the view that the pathway towards the use of Long-Term Evolution (LTE) to provide advanced data services in the 1800MHz band was unclear and that existing licensees were not fully utilising their current assignments in this band. Therefore, ComReg proposed that there was no imminent need to hold an award process for additional spectrum available in the 1800MHz band. In line with this position on 1800MHz and because of the earlier expiry of current licences in the 900MHz band, plans were advanced and consulted upon for the award of 900MHz spectrum licences in Ireland (ComReg documents 09/14 and 09/99). Throughout this process, ComReg has maintained its view that it would tackle the issue of an award of 1800MHz spectrum when this was merited or in 2013 at the latest.

2. Subsequent to the two consultations in 2009, ComReg has updated its proposals for an award to include 800MHz spectrum in ComReg consultation 10/71. This takes into account the issues raised by stakeholders in the previous consultations and other developments. The most important development in this context is the emergence of greater certainty regarding the availability of 800MHz spectrum for award. Given the expected timescale for 800MHz spectrum becoming available and the fact that this spectrum is likely to be considered by bidders as a substitute to 900MHz spectrum in the long run, ComReg's current proposal is to award spectrum in both bands simultaneously in an integrated auction process.

3. In the latest consultation (ComReg 10/71) it was highlighted that demand for 1800MHz spectrum may have significant interrelationships with demand for 800MHz and 900MHz spectrum. Spectrum in the 1800MHz band is a potential complement to sub-1GHz spectrum for some bidders (especially an entrant) and may indeed act as a substitute to lower frequency spectrum at the margin in providing incremental capacity. In its latest consultation (10/71) ComReg has sought the views of stakeholders on the potential integration of 1800MHz spectrum in the proposed sub-1GHz auction. In the accompanying report (10/71a) DotEcon analyses the general merits and drawbacks of a 'big auction', i.e. auctioning several frequency bands in one simultaneous award process. Section 4 of the DotEcon report discusses the merits and downsides of a big auction including 800MHz, 900MHz and 1800MHz spectrum. In particular, the issues arising with such a joint award are analysed and a number of options are proposed on how to resolve them. Overall, the report recommends the inclusion of 1800MHz spectrum in a joint award process with 800MHz and 900MHz spectrum as this may lead to greater economic efficiency.

4. Given the expiry of O2 and Vodafone's existing 900MHz licences in May 2011, there is a consequent requirement to implement an award process for spectrum (including that becoming available in the 900MHz band) in a timely fashion. To this end, ComReg has requested that DotEcon advise on a number of aspects of the potential award of 1800MHz spectrum were it to be included as part of a joint award of spectrum in the 800MHz and 900MHz bands. Specifically, we have been asked to consider:

- The modifications to the award process currently proposed needed to include 1800MHz spectrum;
- The appropriate spectrum caps in light of this award of spectrum in multiple bands;
- The modification of the eligibility point system required to reflect the multi-band nature of the award;
- The appropriate minimum prices for spectrum in the 1800MHz band given the minimum prices proposed for sub-1GHz spectrum; and
- Appropriate licence conditions for licences awarded in this band.

5. We consider each of these issues in this report. First, we consider the appropriate spectrum packaging for the 1800MHz band in Section 2. We provide an overview to the main auction features in Section 3. Section 4 then considers the appropriate early liberalisation options for the existing 1800MHz operators and Section 5 investigates an appropriate spectrum cap. Section 6 discusses one of the main modifications to the auction design of introducing an eligibility point system. Section 7 considers an appropriate minimum price and Section 8 coverage obligations for 1800MHz spectrum given current proposals for licence conditions for sub-1GHz spectrum.

6. This report makes frequent reference to the current proposals for an auction of 800MHz and 900MHz spectrum. Therefore, this document should be read in combination with ComReg's most recent consultation on a sub-1GHz award process (10/71) and our accompanying report (10/71a) as well as previous consultation on the liberalisation of 900MHz and 1800MHz (09/99) and our accompanying report 09/99c.

2 Spectrum packaging in the 1800MHz band

2.1 Frequency packaging in the 1800MHz band

7. As part of consultation 08/57, ComReg sought stakeholder views on a block size of 2x5MHz for any spectrum offered in the 1800MHz band. The majority of respondents supported this, and those that did not highlighted the need for a minimum award of 2x10MHz in order to ensure efficient deployment of LTE and to ensure that a new entrant in this band could compete effectively. Based on responses ComReg provisionally set a block size of 2x5MHz for any award of this band.

8. While some time has passed since ComReg took this view, it does not appear that circumstances have changed in a way that suggests that an alternative block size might be more appropriate. Technologies likely to be deployed in the 1800MHz band are compatible with a 2x5MHz block size.

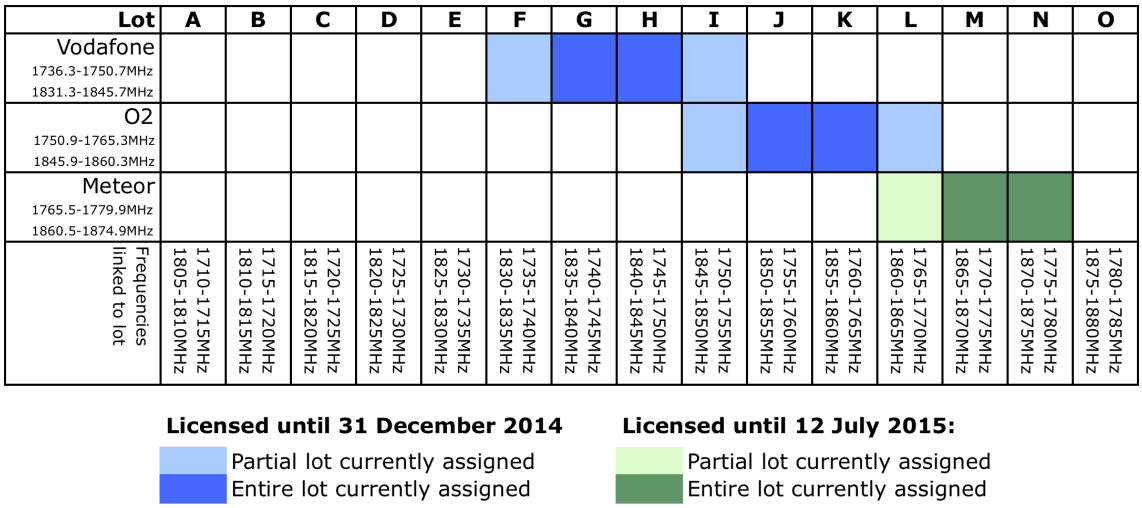
9. Lots of 2x5MHz could be aggregated within a combinatorial auction into larger contiguous blocks. This lot size allows maximum flexibility in terms of the amount of spectrum that a bidder can bid for in the 1800MHz band and in terms of opportunities for switching between different bands included in the proposed auction. Therefore, given the proposed auction format, the case for larger block sizes (e.g. 2x10MHz) is weak.

10. There also seems to be general support for packaging of sub-1GHz spectrum into generic 2x5MHz lots (09/99c), so that 2x5MHz packaging of the 1800MHz band would be consistent with the recent proposals for the sub-1GHz band.

2.2 Existing operators in the 1800MHz band

11. The 1800MHz band consists of 2x75MHz of spectrum, 1710–1785MHz paired with 1805–1880MHz. At present, there are three spectrum assignments of 2x14.4MHz each in this band. Given their respective locations within the band, 2x26.4MHz of the 2x31.8MHz of 1800MHz spectrum that is currently unassigned is in one contiguous block (see Figure 1).

Figure 1: 1800MHz band



12. Vodafone and O2's licences expire on the same date at the end of 2014 (31/12/2014) while Meteor's licence expires approximate 6 months later (on the 12/7/2015). Table 1 below lists these licence details.

Table 1: Spectrum assignments and licence expiry in the 1800MHz band

Licensee Name	Spectrum Assignment	Licence Expiry Date
Vodafone	1736.3-1750.7MHz 1831.3-1845.7MHz	31 December 2014
O2	1750.9-1765.3MHz 1845.9-1860.3MHz	31 December 2014
Meteor	1765.5–1779.9MHz 1860.5–1874.9MHz	12 July 2015

13. The similar, but non-identical, expiry dates of the incumbents' licences present complications for packaging spectrum in the 1800MHz band into appropriate time slices as well as for early liberalisation options in the band, which we discuss in turn.

2.3 Temporal packaging ("time slices")

14. There are two options for packaging 1800MHz spectrum into time slices depending on whether we take into account the differing expiry dates of the incumbents licences or not:

- **Two time slices** covering:
  - 1 January 2013 – 12 July 2015; and
  - 13 July 2015 – 12 July 2030.

- **Three time slices** covering:
  - 1 January 2013 – 31 December 2014;
  - 1 January 2015 – 12 July 2015; and
  - 13 July 2015 – 12 July 2030.

15. In both cases the final time slice for the 1800MHz band coincides with the final time slices proposed for the 800MHz and 900MHz bands respectively. Therefore, there is the opportunity to switch between bands fluidly.

16. In the 3-time slice option, the first time slice for the 800MHz and 900MHz bands (i.e. up to July 2015) would be sub-divided into two time slices for the 1800MHz band due to the differing expiry dates of existing 1800MHz licences.

17. The 3-time slice option closely mirrors the 2-time slice approach that ComReg has already proposed in the 900MHz band. Spectrum licences are broken down into the finest divisions required to match the various differing expiry dates of incumbent licences. However, we are concerned that such an approach is practically undesirable in relation to the 1800MHz band for a number of reasons.

18. First, the 3-time slice option is much more complex than the 2-time slice option. In order for lots in the 1800MHz band to be substitutable with lots in the 800MHz and 900MHz bands, three corresponding time slice periods will be required across all bands. This significantly increases the different combinations of bids that bidders can bid on, and therefore increases the complexity for bidders in deciding how to bid.

19. A further drawback of the 3-time slice option is that with the addition of a third time category, a risk arises that an operator may have to change frequencies in advance of the second time slice (1 January – 12 July 2015) and again in advance of the third time slice (from 13 July 2015 onwards). This is because assignment options within the band may be limited until the third time slice if incumbent operators retained existing spectrum holdings. While bidders can of course bid to avoid this, there is no guarantee that this can be avoided for all bidders.[1] The cost of moving twice may discourage a new entrant to the band from bidding not just on the last time slice but also the first and second time slices.

20. For these reasons, we believe that the 2-time slice option is desirable. However, this then raises transitional issues, but these are fairly modest compared with the benefits of using the simpler approach.

[1] Under the "full assignment round" approach proposed in this report, this risk of having to re-tune can be reduced. Further, under our proposed constraint on assignment options, the only case in which it then would be necessary to re-tune frequencies twice is when at least one bidder wins different amounts of spectrum in two time slices. Both of these proposals and their implications are discussed in detail further below.

21. For the remainder of this report we assume a 2-time slice option to be adopted with time slices as outlined above (1/1/2013-12/7/2015 and 13/7/2015-18/6/2030).

2.3.1 Transitional issues

22. One issue to be resolved with adding 1800MHz spectrum to the proposed sub-1GHz auction is the terms set for the transitional periods that would exist: first, from the end of the auction until the beginning of 2013 and, second, from the beginning of 2013 until the respective 1800MHz licences of existing operators expire.

23. Where a new 1800MHz band plan were to be generated by the assignment round of the auction, the same licence terms relating to transitional matters would apply to 1800MHz spectrum as proposed for spectrum in the 800MHz and 900MHz bands:

- The migration of operators to their location in the band for the first time slice (that is, by the beginning of 2013);
- To facilitate earliest service-provision, ComReg is proposing to issue to all winners of liberalised spectrum:
    - 'preparatory licences' under the Wireless Telegraphy Act[2] that would enable recipients to install networks and associated equipment in the 800 MHz and 900 MHz bands (but would not allow any wireless telegraphy transmissions) and that would commence from shortly after the conclusion of the licence award process and operate until the commencement date of new liberalised-use licences;
    - in addition, during this period ComReg will consider and grant wherever possible 'test licences' to facilitate the testing of these networks and equipment[3].
- Transitional issues between the first and second time slice (i.e. where an operator were to bid for and win different spectrum frequencies for the first and second time slice, they would be doing so on the understanding that the licensee of a particular set of frequencies in the second time slice will have the right to exclusively use these frequencies from the beginning of the second time slice to the end of that time slice).

24. In the event that Vodafone and/or O2 did not avail of early liberalisation options (discussed in the next subsection), their existing licences would

[2] Section 5 (1) of the Wireless Telegraphy Act 1926, allows for a licence to be issued ' to keep and have possession of apparatus for wireless telegraphy' subject to 'such conditions and restrictions' as 'shall be prescribed in regard thereto by regulations' which would be made under Section 6 of same Act. Hence a licence could be issued which would allow for the lawful possession of apparatus for wireless telegraphy but which would include restrictions on use until 800 MHz and 900 MHz spectrum availability.

[3] See Test and Trial Ireland, www.testandtrial.ie

terminate approximately 6 months before the start of any new licence available in the second time slice. The specifics of any such arrangements are not considered here.

3 Auction rules for early liberalisation

3.1 Background

25. The main features of the current proposals for a sub-1GHz auction are:

- Holding a multiple round auction process to allow price discovery;
- Using a combinatorial clock auction format to allow bidders to bid for packages of spectrum (including across multiple bands);
- Allowing bidders only limited transparency regarding the bidding behaviour of other bidders in the auction;
- Using a supplementary bids round to allow bidders to bid for all packages of interest to them and to do so without fixed bid increments, allowing bidders to express their exact valuations;
- Adopting activity rules in the supplementary bids round that implement relative caps based on the preferences expressed by bidders during the clock rounds; and
- Using a second price rule ('pay the opportunity cost of what you win') for spectrum won by individual bidders.

26. These features of the proposed sub-1GHz award meet ComReg's statutory objectives[4]. In modifying this auction design to incorporate spectrum in the 1800MHz band, these features should be maintained. Fortunately, it is possible to include the 1800MHz band whilst preserving much of the structure of the original proposals. This means that ComReg's statutory objectives can continue to be met with only moderate changes to the auction design.

27. In section 2 of 10/71a we described the main features of the proposed CCA format which includes:

- A main stage comprising:
  - A clock stage comprising multiple clock rounds; and
  - A single round during which supplementary bids can be made by bidders in the clock stage.

  Bidding in the main stage will be for generic lots. The main stage will determine the amount of spectrum won in each band.
- An assignment stage comprising a single assignment. The assignment round will determine the specific frequencies to be assigned in each band in each time period to winners in the main stage.

[4] See Chapter 3 of 10/71 discussing ComReg's functions and obligations in relation to spectrum.

28. In the remainder of this section we provide an overview of bidding in the case where early liberalisation is permitted for existing 1800MHz operators.

3.2 General principles for liberalising spectrum

29. In both the 900MHz and 1800MHz bands, existing licensees will have the option of acquiring liberalised usage rights for the remaining term of their existing licences. Notice that early liberalisation is only relevant for the first time slice, as all relevant existing licences will have expired by the second time slice. In this sub-section, we discuss the mechanism for incorporating this early liberalisation option in the auction.

30. Two broad principles need to be respected by the auction mechanism:

    a) ***Linking release of existing and re-award of liberalised spectrum***. Existing licensees should not face any risk of losing spectrum that they already have. It would be unreasonable to expect existing licensees to give up their current licences without knowing that they could obtain liberalised spectrum to replace the released spectrum. This means that the release of existing spectrum needs to be contingent on winning at least that amount of spectrum back again. In particular, the auction mechanism cannot use a two-step process in which bidders first decide whether or not to return existing licences and then at a later stage bid for liberalised spectrum. This would create an unacceptable risk that a bidder could lose its current spectrum without gaining new spectrum, with consequent effects on business continuity. Rather, a link must be made between releasing existing licences and winning new ones.

    b) ***Liberalisation at opportunity cost***. Existing licensees should not be given an unfair advantage in winning liberalised spectrum by virtue of holding their current licences. In particular, it is imperative that a current licensee pay the opportunity cost of awarding liberalised spectrum, otherwise there will be other, higher value users who will have been inefficiently excluded. The other parties could, in these circumstances, complain that the existing licensee had been awarded spectrum at less than its true market value (in that they were prepared to pay more for it) and that, in effect, the existing licensee has received a subsidy for its liberalised spectrum.

31. These two principles are compatible. In particular, it does not create an unfair advantage to existing licensees to have certainty that they will not lose existing spectrum if they opt to liberalise it provided that they also pay the opportunity cost of being awarded these liberalised licences. Existing licensees will need to make bids to liberalise spectrum they already hold. If these bids are not sufficiently high, then the licensee will not be re-awarded liberalised spectrum to replace its existing licence; as then there are other potential users of this liberalised spectrum that would be prepared to pay more and thus impose higher opportunity costs for that spectrum.

3.3 Bidding procedures and early liberalisation

32. An existing licensee would have complete flexibility to decide whether to seek to liberalise some or all of their existing licences. They would have options to:

    a) Bid for additional liberalised spectrum in a band where it had an existing licence and retaining its existing, unliberalised licence;

    b) Relinquish the entirety of the remaining term of its existing licence and winning back spectrum in the same band on a liberalised basis;

    c) Release some, but not all, of the spectrum contained in its licence. In this case it would retain the residual spectrum on an unliberalised basis for the remaining term of the licence and could win additional liberalised spectrum alongside this.

33. In all cases, a bidder would be subject to the provisions of the spectrum caps – both overall and for sub-1GHz spectrum. Existing spectrum held in the 900MHz and 1800MHz bands would count towards these caps even if not liberalised.

34. A bidder would be able to make a linked bid to purchase new liberalised spectrum and to release existing spectrum. In deciding how much spectrum to release, an existing licensee would need to release spectrum in a manner compatible with the released spectrum being reallocated using 2x5MHz blocks. This means that:

    a) In the 1800MHz band, an existing licensee holding 2x14.4MHz would have the option of releasing one or two blocks of 2x5MHz and/or one partially occupied block;

    b) In the 900MHz band, Meteor would have the option to release a block of 2x5MHz and/or a partially occupied block.

35. Bidders would specify the number of wholly and partially occupied 2x5MHz blocks they wished to release. However, they would not specify the frequencies to be released, as existing licensees would in any case be required to enter any unliberalised spectrum they retained into the assignment round to allow an efficient assignment of frequencies to occur. Therefore, even if spectrum is retained on an unliberalised basis, this might not necessarily be at the current frequencies.

36. For example, in the 1800MHz band, an existing licensee could make a linked offer to:

    a) Release a partially occupied 2x5MHz block;

    b) Release a wholly occupied 2x5MHz block;

c) Retain a wholly occupied 2x5MHz block on an unliberalised basis;[5] and

d) Buy three 2x5MHz blocks on a liberalised basis.

37. These components of the offer are linked, so existing unliberalised spectrum would not need to be released unless the corresponding purchase of liberalised spectrum also occurred. Therefore, in the example bid above, there is no risk that the bidder could end up with less spectrum in the 1800MHz band than it started with; either the bid is successful, in which case it has more spectrum than previously, or unsuccessful, in which case it would retain its existing spectrum on an unliberalised basis.

38. Where an existing licensee liberalises some or all of its existing spectrum, it would receive a rebate for the unliberalised spectrum rights that it is simultaneously relinquishing. The value of this rebate will depend on:

a) Initial purchase price of the licence;

b) The band (900MHz or 1800MHz); and

c) The amount of spectrum being released.

39. For the purposes of the clock rounds, excess demand would be assessed on the basis of the demand to purchase spectrum and the available supply, taking account of the spectrum made available as a result of release by existing licensees. Notice that in the case of the 1800MHz band, where the current proposals for early liberalisation in the 900MHz band where applied to this band also, where 2x5MHz blocks are currently occupied by two existing licensees, it would be necessary for both of these to release that spectrum for the block to become available for award as a liberalised 2x5MHz block.

40. For the purposes of applying the activity rules, only demand for liberalised spectrum would be taken into account. In particular, offers to liberalise existing spectrum holdings would be treated in the same way as demand for liberalised spectrum. This is necessary to ensure that bidders with existing licences in the relevant bands are treated in exactly the same way as bidders without existing licences. For the avoidance of doubt, the spectrum cap will apply to all spectrum held in the relevant bands as a result of a bid, whether existing unliberalised spectrum or newly awarded liberalised spectrum.

41. Supplementary bids[6] would also include the possibility for existing licensees to make linked release offers in the manner described above. Notice that bidders would typically be able to make a number of bids, for example:

[5] More detailed rules on retaining a partial block of un-liberalised spectrum will be provided at the Information Memorandum stage.

[6] A detailed description of the general mechanics of the supplementary bids round can be found in Section 2.2.2 of 10/71a.

a) a bid to liberalise all existing spectrum held;

b) a bid to both liberalise existing spectrum and to acquire additional spectrum;

c) a bid to acquire liberalised spectrum without releasing existing spectrum.

By making a collection of such bids, bidders have complete flexibility to express their preferences for retaining existing spectrum on an unliberalised basis depending on the cost of acquiring replacement liberalised licences.

3.4 Determination of winners and winning prices

42. When determining the winning bids, the linked nature of buy and release offers (described above) will be respected. A bid – compromised an offer to buy spectrum licences at a price and a contingent offer to release existing spectrum – will be treated as a non-divisible unit.

43. The algorithm for determining winner bidders will respect this link, but only accept release offers from existing licensees in the event that re-awarding liberalised spectrum will not exclude some other bidder from winning that spectrum who might be prepared to pay more. The algorithm is based on the idea of looking across possible scenarios for release of spectrum.

44. First, all the possible scenarios for the release of existing spectrum by existing licensees in the 900MHz and 1800MHz will be identified from the bids received. By a release scenario, we mean a complete specification of the number of blocks released by each bidder and whether these are wholly or partially occupied blocks.

45. There are likely to be a number of such possible scenarios given the bids received. For example, a bidder might make one bid that offers to release spectrum and another bid that does not. In this case, there will be scenarios in which that bidder releases spectrum and other scenarios in which it does not.

46. These scenarios identify all possible hypothetical patterns of release of existing spectrum given the bids received. Each scenario completely specifies what spectrum existing licensees release and retain. Purely for illustrative purposes, one particular scenario might specify that:

a) Meteor releases all its 900MHz spectrum, but no 1800MHz spectrum

b) Vodafone releases two wholly occupied blocks of 1800MHz spectrum;

c) O2 does not release any spectrum at all.

47. For each scenario we go through the following steps:

a) Determine the available spectrum for award on a liberalised basis (which will depend on the scenario) in the first time slice. For any wholly occupied 2x5MHz blocks that are released, these will be available for award. In the case of partially occupied 2x5MHz blocks in the 1800MHz, it is necessary for *both* existing licensees

occupying this block to release before the block can be awarded as liberalised spectrum.

b) We determine the bids that are *compatible with the scenario*. These are bids of each that offer to release *at least* the amount specified in the scenario for that bidder. For example, if the scenario presumed that Meteor released a single block at 900MHz, then we would only consider Meteor's bids that involved releasing at least this much spectrum. All bids of any bidder who is not an existing licensee will be compatible with any release scenario.

c) Given the compatible bids, we determine the combination of bids, taking one bid from each bidder, of greatest total value subject to the total demand for spectrum in each band and for each time slice not exceeding the total lots available for award in that scenario. This will include the possibility that the bidder is not awarded any lots at all. (Notice that the amount of spectrum available for award will vary across scenarios.)

d) Any scenario in which a bidder offering to release lots does not win one of its compatible bids is excluded as infeasible.

48. Finally, amongst all feasible scenarios, we select the one with the greatest total value of winning bids. In the event of any tie across scenarios, the tied scenario with the greatest number of MHz of spectrum being released by incumbent bidders will be selected. If a tie amongst scenarios still remains, this will be resolved by random selection. This will be called the "winning scenario"[7].

49. This procedure ensures that if a release offer is accepted from a bidder, then its linked offer to buy lots is also accepted. This is achieved by only considering compatible bids at step b) above. Therefore, buying liberalised spectrum and released existing spectrum are treated as linked.

50. The procedure also ensures that if an existing licensee releases existing spectrum and receives liberalised spectrum in its place, then this will only occur provided that there is no other bidder excluded who might be prepared to pay more for that spectrum. This is achieved by requiring that offers to buy licences are winning bids in their own right, even if any link to the release of spectrum is ignored. Step c) of the procedure ensures this feature is present.

51. Winning prices will be determined using the procedure described in our previous report 09/99c, taking the total supply of spectrum as determined by the pattern of release by existing licensee specified in the winning scenario and including all compatible bids. This means that where the spectrum held by existing licensees is liberalised, the licensee will need to

[7] Ties are unlikely to occur in the actual auction in practice as they require two feasible scenarios to have exactly the same value, which depends on the (sum of) individual bids including those made in the supplementary bids round where bids can be expressed in denominations of €1.

pay the opportunity cost of that spectrum (i.e. the value to any other bidders excluded from that spectrum).

52. For any bidders returning existing licences – in whole or in part – an appropriate rebate could be applied to the winning licence. Whether and how such a rebate would be applied is, however, not considered further here.

4 Early liberalisation options in the 1800MHz band

53. In this section we consider the early liberalisation options for the 1800MHz band given the current incumbent spectrum holdings within the band.

4.1 Current recommendations on time slice and early liberalisation options and contiguity in assignment stage

54. There are currently three incumbents with spectrum holdings in the 900MHz band. Vodafone and O2's licences expire in May 2011 and Meteor's licence expires in July 2015. There is also some spectrum in this band that is currently not allocated. (For details see Section 2.1 of our report 09/99c, the band plan in Figure 2, and the key facts on licensing in Table 2.)

Figure 2: 900MHz band

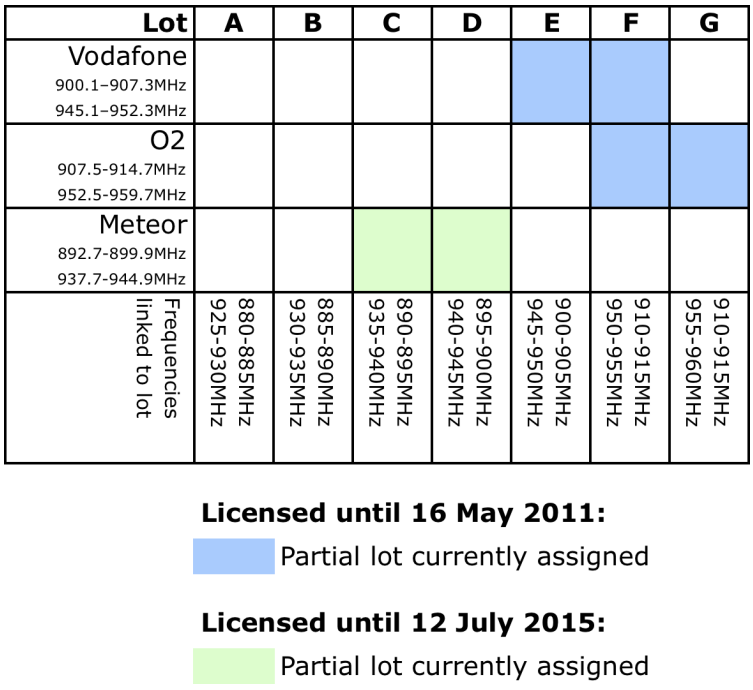


Table 2: Spectrum assignments and licence expiry in the 900MHz band

Licensee Name	Spectrum Assignment	Licence Expiry Date
Vodafone	900.1–907.3MHz 945.1–952.3MHz	16 May 2011
O2	907.5-914.7MHz 952.5-959.7MHz	16 May 2011
Meteor	892.7-899.9MHz 937.7-944.9MHz	12 July 2015

55. The impending expiry of existing licences, in particular that of Vodafone and O2, require a timely award process for the 900MHz band. To that

end, ComReg originally proposed awarding 900MHz spectrum in two time slices from May 2011 until July 2015 and July 2015 until July 2030 (Section 8.2 of 09/99).

56. In the same proposal (in 09/99), Meteor, whose licence expires in July 2015, would have the option to obtain liberalised 900MHz spectrum earlier than this. In particular, section 8.2.2 of 09/99c proposed that Meteor's early liberalisation options include:

- Not to liberalise any of its existing 900MHz frequencies early - its licence would remain unchanged (but it would potentially have to relocate its assignment by 200kHz); or
- Liberalise early a sub-set of existing 900MHz frequencies (i.e. one 2x5MHz block) – Meteor would then have two options in the assignment stage, either (i) entering the rest of its existing unliberalised frequencies along with its liberalised block in the assignment stage and be guaranteed contiguous frequencies but not guaranteed to retain its existing position in the 900MHz band; or (ii) keep their unliberalised frequencies in their existing location within the band and bid in the assignment round for placement of its liberalised block with no guarantee of contiguous spectrum between liberalised and unliberalised holdings.
- Liberalise all of its existing frequencies – in this case it would have no guarantee of retaining its existing frequencies but would be guaranteed that all spectrum assigned to it would be in a single contiguous block.

57. The original spectrum cap proposals in 09/99 of 2x10MHz in the 900MHz band implied that, despite Meteor's existing frequencies in the 900MHz band, all winners in the 900MHz band in the first time slice could be guaranteed that spectrum won in this lot category would be awarded in a single contiguous block.

58. In 2010, ComReg noted in 10/71 that there were a series of factors that provided greater certainty over the availability of spectrum in the 800MHz band in 2013[8]. In light of these developments, ComReg explored the benefits and implications of a joint award process for 800MHz and

[8] The introduction of 10/71 notes in particular: *"While preparing the response to Document 09/99, ComReg became aware of potentially significant changes concerning broadcasting services in Ireland. Firstly, the Minister for Communications, Energy and Natural Resources ('the Minister'), announced that ASO will occur during Quarter 4 of 2012 (in conjunction with analogue switchover in Northern Ireland). Secondly, on 5 August 2010, the Broadcasting Authority of Ireland ('BAI') published a statement regarding the conclusion of its commercial DTT multiplex licensing process. In particular, the BAI stated that it will not be feasible to introduce commercial DTT as originally intended and certainly not in advance of ASO. Accordingly, there will not be any digital broadcasting requirement for the use of the 800 MHz spectrum in advance of ASO."*

It is also expected that the European Commission ("EC") will shortly publish its Radio Spectrum Policy Programme which in the call for responses6 "invites the European Parliament and Council to consider that co-ordinated availability of the 800 MHz band for electronic communication services ("ECS") other than broadcasting should be achieved by all EU Member States by 2015"

900MHz band in its latest 10/71 consultation. In particular, considering the potential substitutability between 800MHz and 900MHz in the long run on account of the two bands' similar radio frequency characteristics, ComReg proposed to align the availability of liberalised spectrum in the 900MHz and 800MHz bands so as make the lots of the two bands to be directly substitutable in the auction. To this end, ComReg proposed modifying the first time slice for the 900MHz band to run from 2013 until July 2015 to align with the availability of the 800MHz band. As part of these proposals ComReg also proposed the issue of a new "interim" licence to Vodafone and O2 as a transitional arrangement between the proposed auction in 2011 until 2013 when the licences from the first time slice commence. In Section 3.2.6 of 10/71 ComReg concludes that the benefits of a joint award of 800MHz and 900MHz spectrum outweigh the potential disadvantages of such interim arrangements.

59. The inclusion of the 800MHz band in a joint award also led to proposals for a 2x20MHz sub-1GHz spectrum cap (Section 4.3.3 of 10/71a). In considering the appropriateness of this sub-1GHz cap, we also considered the implications of Meteor's current position in the 900MHz band in Section 4.3.2 of 10/71a. In particular, a 2x20MHz sub-1GHz cap implies the possibility that a winner of 2x20MHz in the 900MHz band would not receive spectrum in a single contiguous block depending on the decision of Meteor as to which part of its existing frequencies to liberalise and which blocks to retain. If Meteor were to retain all of its existing frequencies (taking up blocks C and D in Figure 2) or to partially liberalise but to retain block D, a winner of 2x20MHz could not be accommodated in a contiguous block. Only if Meteor chooses to liberalise all of its existing spectrum or to retain only block C, a winner of 2x20MHz would receive contiguous spectrum.[9]

60. On the whole, however, these potential problems were quite limited, with the problem of contiguous assignment only arising for a winner of 2x20MHz in the first time slice and then only if Meteor decided not to liberalise. Risks of a lack of contiguity relate only to the first time slice – contiguity would be ensured in the second time slice by only offering winners of spectrum in the band assignment options that would be in line with the award of contiguous spectrum to all winners. Given that there are three existing operators in the 900MHz band at present and these operators will have GSM legacy issues to deal with within the first time slice, while outcomes where the band is assigned mainly to one or two operators may be possible in the second time slice when these legacy issues may have been addressed to a large degree, the probability that such an outcome would result in the first time slice is small.

[9] There are two other cases in which contiguous assignments for winners in the 900MHz band cannot be guaranteed: if there are two winners of 2x15MHz spectrum and Meteor retains block C; or if there are three winners of 2x10MHz and Meteor retains block D. In both cases Meteor would need to be one of these winners and it seems unlikely that it would put a high value on retaining the problematic block and not receiving its new frequencies contiguously next to or around this block. Therefore these two cases are much less problematic than the case of one winner of 2x20MHz 900MHz spectrum.

61. If we apply this same mechanism in the 1800MHz band, however, the decision of existing licensees on early liberalisation and consequent retention of particular frequency holdings by these existing operators could have more severe implications for spectral efficiency in the 1800MHz band. For instance, consider a scenario in which only Vodafone opts for early liberalisation of its existing 1800MHz frequencies. If the current 900MHz proposal for early liberalisation were to be applied to 1800MHz frequencies, if it were to bid to liberalise only a subset of its frequencies, say for example 2 blocks (see Figure 1) and chose to retain existing frequencies in block G. Imagine then that Vodafone bids in the assignment round for blocks E and F and is assigned these specific blocks in this round. The spectrum in the 1800MHz band available for award to other operators as a result of Vodafone's early liberalisation decision would then be highly fragmented – it would be broken up into 3 portions, including 2 single block portions (block H and block O). Further, given that there are three operators in the 1800MHz band with spectrum holdings in the first time slice and consequent ability to affect the location of spectrum available for award in this band, the probability that non-contiguous assignments would result from this type of approach to spectrum assignment in the 1800MHz band is substantial.

62. In summary, therefore, while in the case of the 900MHz band, the current proposals would have a low risk of fragmentation of frequency assignments as a result of Meteor retaining all or part of its existing holdings unliberalised for the first time slice, it is likely that fragmentation would result from a applying this same approach to early liberalisation in the 1800MHz band.

63. In addition, where the assignment options for one or more bidders are likely to be fragmented and such bidders place high value on contiguous spectrum, a risk arises that the auction outcome will be inefficient. This is because where a bidder places a much lower value on a non-contiguous assignment than on a contiguous assignment, it would need to stop bidding in the clock rounds once it reaches its valuation for a non-contiguous assignment. Therefore, if this value difference is significant, there is a material possibility that such a bidder would not be awarded a contiguous assignment of frequencies even if it placed the highest value of all bidders on this on account of not having the opportunity to express its full value for the contiguous assignment.

64. In the following sub-section, we consider two alternatives to the extension of current proposals for early liberalisation of 900MHz spectrum to the 1800MHz band:

- An 'all or nothing' approach to early liberalisation; and
- A 'full assignment round' approach

65. We consider whether such options would improve the efficiency of eventual allocations and what other consequences the adoption of such alternatives might have in the 1800MHz band. Where an alternative seems satisfactory, we also consider if these alternative proposals for 1800MHz spectrum would fit well within the circumstances of the 900MHz band.

4.2 Alternative early liberalisation options for 1800MHz spectrum

4.2.1 'All or nothing' approach

66. Under this alternative, existing 1800MHz operators would not be permitted to liberalise a subset of existing frequencies. They could only opt to liberalise their entire existing licence, in which case this spectrum would need to be competed for and its frequency allocation determined in the assignment stage.

67. Lots available during the assignment stage of the auction would be specific and constitute the currently unallocated lots (blocks A, B, C, D, E and O in Figure 1) and the lots of any incumbents that opt to liberalise early.[10] That is, where all three existing operators choose to liberalise their 1800MHz spectrum early, spectrum from the entire 1800MHz band will be available in the first time slice for assignment.

68. On the contrary, where incumbent operators do not opt to liberalise their 1800MHz spectrum early, only a portion of the 1800MHz band will be available for possible assignment, that is, the entire band less the entire existing allocation to operators that have not chosen to liberalise their spectrum in the first time slice.

69. While this approach appears to remove many fragmented outcomes from the list of potential auction outcomes, it does not remove all of these alternatives. As such, it represents an incomplete solution to fragmentation and auction outcome inefficiency still risks fragmented outcomes. Further, this approach has other drawbacks that make this an unsatisfactory approach to early liberalisation.

70. In essence, whether a bidder would be able to ensure contiguous spectrum in the assignment round will be effected by the decision of other bidders whether or not to liberalised their existing 1800MHz spectrum. This creates a drawback that even where a bidder is required to commit all or none of its existing 1800MHz holdings in the first time slice to the assignment round, owing to the exact frequencies held by these bidders (that is, across parts of 2x5MHz blocks), it would not be possible to ensure that bidders get contiguous assignments. Specifically, an existing 1800MHz operator not liberalising spectrum early (either because it does not opt to do so or is unsuccessful in the clock phase of the auction) may prevent other winners from winning contiguous spectrum and indeed full spectrum blocks, as its existing frequencies will fragment the available spectrum for award.

71. In particular, as both O2 and Meteor's existing frequencies occupy blocks I and L in Figure 1, for blocks I and L to be available for award, both O2

[10] Note that where this spectrum were to be awarded with liberalised rights of use, given that adjacent spectrum may continue to be used for GSM, usage would have to be subjected to the technical conditions of operating UMTS or other technologies adjacent to GSM as specified in the relevant EC Decision (2009/766/EC).

and Meteor would have to opt for early liberalisation for these blocks to be eligible for award in full. Therefore, in the case where only one of these operators were to liberalise its spectrum holdings and the entire band was awarded in the main stage, not only would at least one bidder end up with a fragmented assignment, their assignment would also not be in full blocks of 2x5MHz.[11]

4.2.2 'Full assignment round' approach

72. Under this alternative, all spectrum in the band would be included in the assignment round including existing licences whether or not holders of these licences chose to liberalise early. That is, frequencies linked to existing 1800MHz spectrum licences from 2013 onwards would be determined within the auction, regardless of whether or not this spectrum is liberalised.

73. This approach has a number of significant advantages. First, in the case where the entire band is available for award then the CCA format proposed will *always* ensure that the spectrum won by bidders is awarded in a single contiguous block. This is done by limiting the assignment options of each winner to those that allow the award of contiguous spectrum to all winners. (Note that the award of contiguous spectrum will be ensured under all approaches for the second time slice as the entire 1800MHz band is available for this time period.)

74. Second, following from this assurance of spectrum contiguity, this approach alleviates the possibility of an inefficient auction outcome resulting from value differences of bidders for contiguous and non-contiguous spectrum assignments.

75. Relative to the early liberalisation option proposed for 900MHz spectrum in 09/99, the main drawback of this option is that imposes the requirement on existing operators that opt not to liberalise existing 1800MHz spectrum holdings in the first time slice to bid to maintain its current location within the band during the assignment stage. However, note that such a bidder could simply choose to enter zero bids in the assignment stage, in which case the bidder will receive the same amount of spectrum it currently holds, but will be expressing no preference over the frequencies that it will be assigned.

76. Under each of these alternatives, based on the bids of other bidders this bidder may have to move to another part of the band. This option therefore imposes the cost of moving to another location in the band or the cost of bidding to stay in its current location. (Given that different locations within the band should be roughly the same value, it seems unlikely that a bidder would bid much more than the cost of re-location just to stay in its current frequencies.)

[11] Note that this problem would not arise in the case of partial liberalisation of existing holdings, as where a bidder were to liberalise only part of its assignment, the spectrum frequencies that it would retain would be prescribed by the auctioneer to ensure that this would not happen.

77. There are a number of reasons to consider, however, that the magnitude of this downside is small:

- Technical analysis of the costs of relocation indicate that the monetary cost of such relocation is small[12] relative to the total costs of running a mobile network;
- Given that the spectrum assignments of all existing 1800MHz operators are spread over multiple 2x5MHz blocks including in all cases partial blocks, and given that the relevant EC Decision[13] requires a 2.8MHz separation between GSM and UMTS systems, at some point, all of the incumbent operators will need to incur the cost of relocating its frequencies if they were to win some 1800MHz spectrum in the second time slice, whether this is prior to the beginning of the first time slice or prior to the beginning of the second time slice; and
- The package bidding inherent in the CCA will allow for bidders to make bids for the same frequencies in the two time periods. Given the reasonable assumption that all bidders will want to minimise the number of times they need to relocate, where a bidder were to make such package bids it would be likely that such a bidder would be awarded the same frequencies in both time periods. Further, we propose to introduce a constraint on assignment options that will further reduce the possible requirements to relocate frequencies within each band as a result of the assignment round (discussed in the following sub-section).

78. Given this last factor, while this option imposes a cost of moving to existing 1800MHz operators that opt not to liberalise any spectrum early, this cost is offset by the cost of moving frequencies that is avoided prior to the second time slice. This then is essentially the re-timing of the incurrence of relocation costs from shortly before 2015 to shortly before 2013. As such, this imposition is considered to be moderate and, in any case, comparably small in comparison with the benefits associated with this option.

79. Therefore, on balance we believe that the 'full assignment round' approach is the best option available for the assignment of frequencies to bidders for the period from the beginning of 2013.

80. We then turn our attention to considering the suitability of this approach in the 900MHz band. As in the case of the 1800MHz band, the inclusion of all spectrum in an assignment round would have the benefit of increasing

[12] In its Joint Report for ComReg ("Retuning and Relocating GSM1800 Spectrum Assignments in Ireland", October 2010), Vilicom/Red-M concluded that the engineering costs for a 'typically' sized Irish network would be of the order of €240,000. Further, if the 1800MHz relocation project were to follow closely after an identical project to relocate the same operator's 900MHz network, then it should be possible to reduce the costs associated with the reduced project to around €130,000.

[13] Commission Decision on the harmonisation of the 900MHz and 1800MHz frequency bands for terrestrial systems capable of providing pan-European electronic communications services in the Community (2009/766/EC).

the number of potential auction outcomes that could result where all bidders are assigned contiguous spectrum and avoids any auction outcome inefficiency resulting from value differences for contiguous and non-contiguous spectrum. While these benefits will likely be smaller than those associated with those generated in the 1800MHz band, they are nonetheless material. The downside of potentially imposing a cost on Meteor of moving earlier than it might otherwise have done, as mentioned above, would be a re-timing of this cost as opposed to the pure imposition of such a cost. This cost would in any case be small[14]. In addition, there is a benefit to imposing consistent treatment across spectrum bands.

81. On the whole, we would recommend adopting the 'full assignment round' approach for both the 900MHz and 1800MHz bands.

4.3 Assignment constraints to ensure continuous assignments

82. Clearly, relocation between time slices cannot be avoided if bidders win different numbers of lots in the two time slices. Similarly, relocation cannot be restricted to contracting or expanding around the location of frequencies in the first time slice, as this may cause band fragmentation. For example, if in the first time slice Bidders 1, 2 and 3 win 2x10MHz each and Bidder 4 wins 2x5MHz. In the second time slice Bidders 1, 2 and 3 win 2x5MHz each while Bidder 4 wins 2x20MHz. The spectrum freed up by Bidders1, 2 and 3 in the second time slice cannot be re-assigned to Bidder 4 contiguously without re-locating at least one bidder's spectrum completely (rather than expanding or contracting it around its position in the first time slice).

83. However, although the requirement on at least one bidder to relocate its frequencies between the first and second time slice cannot be removed completely, it would be desirable to reduce the probability and the extent of necessary relocation between time slices.

84. It is possible to decrease this probability of a spectrum assignment where the number of times bidders will have to relocate from one time slice to the next. There are however two overarching points that should be borne in mind in assessing the imposition of any such constraints:

- The number of bidders that will need to relocate will in any case be affected by the winnings of each bidder within a band in the first and second time slices. This stems from the fact that where bidders win different amounts of spectrum across time slices, relocation or re-tuning on the part of at least one operator is inevitable.
- With the imposition of such constraints, the number of potential locations of bidders within the band and, correspondingly, the number locations within the band for which bidders may express a preference, will be reduced. Therefore, one must assess the possibilities that will be precluded by imposing such constraints and

[14] See footnote 15.

impose them only where the benefits to precluding such outcomes outweigh their potential costs.

85. We have considered a number of possible ways to increase this probability, and only one such constraint appears to offer the benefit of increasing the probability of bidders of not having to relocate between the first and second time slice without unduly limiting assignment options. We propose to impose the constraint on assignment options that where a bidder is awarded the same number of blocks in a band in the first time slice and the second time slice, assignment options within the band would be limited so that this bidder would be assigned the same frequencies within the band for the first and second time slice. Therefore, under this proposal, a bidder can bid in a way that ensures that where it is awarded spectrum in a band in both time slices, it is guaranteed continuous spectrum.

86. In the following paragraphs, we first consider the implications of our proposed constraint to reduce the probability of bidders that win spectrum in the first and second time slice within a band having to relocate or re-tune their frequencies from one period to the other. We then consider another constraint that may further reduce the extent of relocation (in terms of numbers of lots re-assigned from one time slice to the other) and show by way of example that this increased probability of continuity over time slices for bidders comes at the cost of further restricting the assignment options for such bidders. In particular, this constraint can limit the assignment options for bidders that win the same amount of spectrum in the first and second time slices. The overall effect of this further restriction is therefore ambiguous and discriminates against some bidders over others. We therefore conclude that the case for adding such a further restriction to the basic constraint proposed above is weak.

87. Note that in our assessment we assume the cost to an operator of re-locating or re-tuning its frequencies within a band is constant, i.e. shifting frequencies by a few channels would cost the same as moving to a completely different location in the band.[15] In particular, bidders that win different amounts of spectrum in the two time slices need to relocate or re-tune their equipment anyway, so that it should not make a difference whether their frequencies change only slightly (i.e. contract or expand in their position) or if they are relocated completely within the band. We then relax this assumption in considering our potential additional constraint.

88. Our proposed constraint on assignment options would impose that winners of the same amount of spectrum in the first and second time slices are guaranteed the same frequencies for each time period:

[15] In a report for ComReg (10/71c), Vilicom/Red-M estimate that the cost of Meteor re-tuning its frequencies by 200kHz, the smallest movement of frequencies that might possibly be contemplated, would be about €300,000 and in response Meteor estimated that such a move would cost less than this. In a further report for ComReg, Vilicom/Red-M estimate that the cost of re-locating a 'typically' sized Irish network of 2x15MHz within the 1800MHz band of €240,000. Therefore, it is reasonable to assume that the cost of moving is fixed, regardless of the magnitude of the move.

- In the case where all bidders were to win the same number of lots in a band in the first and second time slices, all assignment options would result in spectrum assignments that would be the same for the first and second time periods for all spectrum winners.
- In the case where one or more bidders were to win the same number of lots and other bidders were to win different numbers of lots across time slices, it is still possible that bidders with the same number of lots in the two time slices will have assignment options that are at the end of the band and in the middle of the band.

89. This constraint offers the benefit of guaranteeing assignment of the same frequencies wherever possible without unduly limiting the frequencies within the band that such bidders would be awarded.

90. We illustrate these points below using as an example the 900MHz band. While similar examples can be found for the 1800MHz band, they are more complex to present because of the larger number of 1800MHz lots. Our examples consider the case where the whole band is available in the assignment round, i.e. under the full assignment round approach or in the cases where Meteor chooses to release all of its existing spectrum holdings.

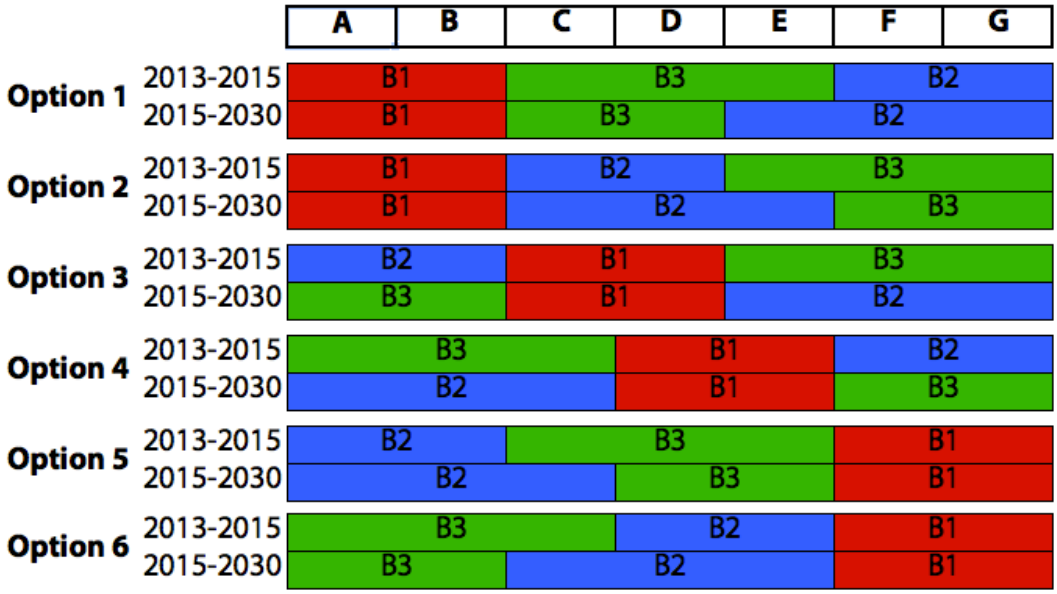
91. We consider the case where there are three winners in the band, Bidders 1, 2 and 3, in each time slice. The number of lots allocated to each bidder in each time slice at the end of the main stage is presented in Table 3 below:

Table 3: Spectrum allocated to bidders in the main stage

	Number of lots allocated to this bidder in the first time slice	Number of lots allocated to this bidder in the first time slice
Bidder 1	2	2
Bidder 2	2	3
Bidder 3	3	2

92. Where we impose the above proposed constraint, Bidder 1 would be guaranteed contiguous spectrum across the two time slices. This would mean that the assignment options within this band are as follows:

Figure 3: Assignment options given the allocation in the main stage



93. As can be seen from Figure 3, the available assignment options include assignment of spectrum to each bidder at each end of the band and in the middle of the band, and for Bidder 2 and Bidder 3, options for full relocation and for partial relocation where one or the other might be preferred.

94. Further, this proposed constraint produces assignment options that minimise the number of bidders that would be required to relocate or re-tune frequencies between the first and second time slices. That is, in the example above, two bidders have been assigned different numbers of lots in the first and second time slice. As the cost of moving frequencies is considered somewhat fixed, we can define a bidder that has to relocate as a bidder with different frequencies across time slices. Therefore, given the winnings of bidders in the main stage, the minimum number of bidders that would have to relocate is two, and Figure 3 presents all assignment options where only two operators are required to re-tune between time slices.

95. As aforementioned, it is possible to apply further conditions to that proposed above. One such condition that might be considered if it were perceived that bidders winning different amounts of spectrum would have a preference to re-tune part of their assignments over relocating of their full assignments is to constrain the assignment options such that the number of 'transition blocks', i.e. blocks which are assigned to different bidders in the two different time slices, should be minimised. This further restricts the assignment options based on the spectrum allocation described in Table 3:

- Assignment options 1,2, 5 and 6 have one transition block and assignment options 3 and 4 have 5 transition blocks. Therefore, under this additional constraint, only options 1,2,5 and 6 would be offered as feasible assignments in the assignment round.

- Options 3 and 4 that are not offered as feasible assignment options under this constraint are the only options that allow Bidder 1 to express a preference for being assigned frequencies in the middle of the band. Therefore, a consequence of this constraint given the allocation of spectrum at the main stage in this example is that Bidder 1 will be constrained to assignment options at the edge of the band. This is not the case for Bidders 2 and 3 in this example, who have assignment options at each end and in the middle of the band.

96. Note that with our proposed constraint above (limiting assignment options to those that guarantee winners of the same amount of spectrum in both time slices the same frequencies in both time slices) yields the same number of bidders required to relocate (two – bidders 2 and 3 in the example above) as the case if this further condition to minimise 'transition blocks' discussed is applied. Therefore, the latter is only worth considering if the cost to an operator of relocating its frequencies within a band is not constant, that is, there are significant additional cost savings of partial compared to full re-assignments.

97. In relation to the above example, the condition to minimise 'transition blocks' should only be applied if the perceived additional benefit to bidders from partial compared to full re-assignment (Bidders 2 and 3) out weighs the cost of reducing assignment options for other winners (Bidder 1).

98. Further, where there are more winners in this band or where there are more lots to be assigned as in the 1800MHz band, assignment options may be even more limited as compared to that illustrated in the example above by the addition of this particular constraint.

99. Given that there is no evidence that preferences for partial re-assignment over full re-assignment are strong, the benefit of imposing this additional constraint is limited. Further, the assignment options that are precluded by the addition of this constraint may have value to bidders that would not have the opportunity to express this preference. Importantly, where bidders do have moderate preferences for partial rather than full re-assignment of frequencies across time slices they will be able to express their preference for assignment options resulting in only partial re-assignment of frequencies in the assignment round. Therefore, based on the limited benefit and offsetting cost of imposing this additional constraint, we do not believe that this imposition offers unambiguous benefits, and recommend that only the original constraint considered is adopted.

5 Spectrum caps

100. ComReg has general objectives of ensuring efficient management and use of spectrum and promoting competition. In addition, ComReg should also be proportionate in its measures taken. These considerations mean that measures should constrain the bidding freedom of operators only to the degree necessary to ensure that ComReg's objectives are met and not go beyond this.

101. In setting constraints on bidders that meet these objectives, we must be mindful of the following issues:

- The avoidance of spectrum hoarding by incumbents;
- The avoidance of extremely asymmetric outcomes where the amount of spectrum awarded to a small number of operators severely hinders the commercial viability of its competitors;
- The avoidance of a situation where entry to the market is blocked by incumbents for anticompetitive motives;
- We do not want to unnecessarily preclude outcomes where significant amounts of spectrum are awarded to a relatively small number of operators where this might be efficient and meet the stated objectives;
- We do not necessarily want to prescribe only symmetric outcomes (i.e. all winners having similar amounts of spectrum) indirectly through the setting of spectrum caps at a level that would ensure this, as asymmetric outcomes may be compatible with a diversity of operators engaging in effective downstream competition provided the asymmetry is not too extreme; and
- We do not want to set spectrum caps at a level that results in spectrum going unsold where at least one bidder had a value for the unsold spectrum at the reserve price (and the minimum price associated with this).
- The spectrum caps are meant to serve as measures related to this auction to provide short-run protection of downstream competition rather than long-term caps on operator spectrum holdings.

102. It is clear from the outset that these objectives are often conflicting, and the assessment of any proposed cap would involve consideration of how it trades off these various objectives.

103. The previous ComReg consultations 09/99 and 10/71 contained the following proposals on spectrum cap for the sub-1GHz bands:

- 09/99 proposed a general cap of 2x10MHz (applying to both existing holdings and any spectrum won in a foreseeable award process) and a provision for relaxing the spectrum cap to 2x15MHz in case of unallocated spectrum were proposed in 09/99c Section 3.2 and 8.3 respectively.

- 10/71 proposed taking into consideration the substitutability of 800MHz and 900MHz in the long run and the increased amount of spectrum available and as a result a sub-1GHz cap of 2x20MHz was proposed in Section 4.3.3 of 10/71a.

104. These proposed caps would cover all existing spectrum holdings in the bands to be auctioned as well as new spectrum purchased. Therefore Meteor – given its existing licence in the 900MHz band – may only bid for an additional two blocks of sub-1GHz spectrum under the 2x20MHz sub-1GHz cap current proposed. We note that the spectrum cap proposed for 1800MHz in this section should also follow the same principle – that existing (unliberalised) spectrum holdings in the 1800MHz band will count towards the proposed cap in the first time slice.

105. Throughout this section, we assume a cap of 2x20MHz on the amount of sub-1GHz spectrum that any one bidder will be allowed to bid on during the auction as proposed in the latest consultation 10/71. We then investigate the form and level of any other constraints that might be implemented on the bids made in addition to this cap.

5.1 Efficiency considerations regarding spectrum caps

106. Both imposing spectrum caps and setting aside spectrum for entrants can be used to ensure that entrants are guaranteed to be able to acquire spectrum and that incumbents are unable to block entry (and thus restrict competition in the downstream market) by acquiring so much spectrum (at least in crucial bands) that the amount available for entrants is insufficient to support a viable business proposition. Spectrum caps that prevent existing operators from together acquiring more than a given amount of spectrum (i.e. a collective cap) have a similar effect as setting aside the remaining spectrum for entrants, as this remainder is effectively uncontested by existing operators.

107. However, where a spectrum cap is set at a level tight enough that it effectively creates entry in the market, there may be a danger that an entrant may not have an efficient business model to compete effectively downstream against existing incumbents over the long run and will eventually exit the market. Furthermore, such a reservation may attract speculative entry from parties wanting to sell on their holding of spectrum (which may be possible through selling the corporate entity holding the licence even if the licence itself it is not transferrable).

108. In addition, spectrum caps that effectively reserve spectrum for entrants (i.e. are so tight that maximum permitted demand from just the incumbents is in total less than the available spectrum) creates the risk of spectrum going unsold inefficiently:

- Spectrum may go unsold in the case that interest from entrants is limited to below the amount that is effectively reserved for them;
- Similarly, spectrum may go unsold in the event that entrants place bids only for larger packages (if entrants require a minimum amount of spectrum that is greater than the amount of spectrum effectively reserved for them), but their bids are not sufficiently high as to displace incumbents from the additional spectrum they may require.

109. Therefore, where spectrum caps are implemented, a balance has to be struck between the setting of caps at a level that ensures spectrum availability for entrants and the risk of spectrum going unsold where demand from existing operators is such that it would otherwise be allocated. These two factors are unavoidably always in conflict.

110. Spectrum caps have the additional effect of limiting the amount of spectrum that an individual bidder can acquire, thus also preventing highly asymmetric outcomes in which one incumbent, for example, acquired a disproportionately large amount of spectrum. For this reason, spectrum caps are more constraining than alternative measures to promote competition (for example, setting aside a fixed amount of spectrum for entrants, or only allowing outcomes with at least 4 winners of at least 2x10MHz of spectrum each), as they will preclude outcomes that result in a small number of bidders being awarded most of or all of the spectrum available.

111. This may or may not be efficient, and the relevant concern is whether there may be competition issues not only with respect to potential entrants (that is, the foreclosure of entry through the allocation of all relevant spectrum to existing mobile operators in Ireland) but also amongst incumbent operators (where one or more existing operators would be unable to compete effectively based on the spectrum allocated to other existing operators). As outlined in the previous sub-section, ComReg needs to be mindful of both of these possibilities, and as such spectrum caps are a significant measure in ensuring that competition is effective in the downstream market for services and that ComReg meets its objectives in the proposed award.

5.2 Band-specific caps versus multi-band caps

112. The award of spectrum in the 800MHz and 900MHz bands relies on a spectrum cap of 2x20MHz being applied on sub-1GHz spectrum to ensure that a potential entrant would be able to access this spectrum. The issue we now focus on is whether a spectrum cap should limit the ability of bidders to acquire 1800MHz spectrum. However,

113. Such constraint could be applied either as:

- a standalone cap on the amount of spectrum bidders could acquire on the 1800MHz band; or
- an overall cap on the total amount of spectrum bidders could acquire in the three bands (800MHz, 900MHz and 1800MHz), which could either replace the sub-1GHz cap or be applied in addition to the sub-1GHz cap.

114. An important consideration in deciding whether the spectrum cap should be applied as a standalone or an overall cap is the extent to which spectrum in these three bands may be regarded as substitutes, either in general or in providing incremental capacity for a bidder who also acquires sub-1GHz spectrum:

- If frequencies in multiple bands are substitutable from the perspective of bidders, then the cap should apply across bands. Using a number of band-specific caps instead of (or in addition to)

the multi-band cap would unduly restrict the range of potential outcomes, and would not improve the opportunities for entrants.

- If frequencies are complementary across bands, then band specific caps are needed in order to promote entry. Otherwise, entry may be deterred by the prospect of incumbents making use of the flexibility they are given through a multi-band cap in order to acquire so much spectrum in one band that the remaining amount is insufficient for an entrant.

- The most difficult case is where frequencies are both complementary and substitutable, i.e. the case where an operator, in order to run a viable business, may require a total amount of spectrum across a number of bands, but at the same time a minimum amount of spectrum in each band, and where this may vary between incumbents and entrants. In this case, a combination of band-specific caps and multi-band caps may be required.

115. In the short run, spectrum in the 800MHz and 900MHz band may have differing values to different users. In particular, equipment for 900MHz is already deployed while equipment for 800MHz is not widely available yet. Furthermore there is still some regulatory uncertainty remaining with regard to (global) harmonisation of the 800MHz band, which is not present for the 900MHz band. However, these concerns do not appear to be significant as a sufficient degree of harmonisation and equipment availability can be reasonably expected in the near future. In the long run, as technologies become less linked to specific frequencies, both bands have similar radio propagation characteristics and therefore should be substitutes (as discussed in section 3.2 of our previous report (10/71a) accompanying the latest consultation of 800MHz, 900MHz and 1800MHz spectrum release (10/71)). Therefore the 800MHz and 900MHz bands would seem to fall in the first group. This is the rationale for using a sub-1GHz cap that limits the total amount of spectrum that bidders can acquire in both bands as a whole.

116. However, sub-1GHz and 1800MHz spectrum in practice may be both complementary (in the sense that spectrum in the 1800MHz band can be used to provide additional capacity in busier spots), and substitutable (in that additional capacity could be provided using spectrum in either of these two bands, and in that an operator could deploy a network using spectrum in only one of these bands). It is also possible that with continued growth of demand for mobile data services, the substitutability of sub-1GHz and higher frequency spectrum may increase in the long run, as the advantages of low frequency spectrum in delivering wide area coverage are modest if the number of cell sites needs to grow for capacity reasons. This supports a global cap approach across all bands.

117. Despite these complications, the two different types of spectrum may well still be substitutes at the margin for delivering capacity. Therefore, even if a bidder prefers low frequency spectrum to high frequency spectrum, this bidder might be prepared to switch from sub-1GHz spectrum to high frequency spectrum in response to a sufficiently great price differential between low and high frequency lots.

118. Due to the scope for substitutability between low and high frequency spectrum, it would seem appropriate to define a spectrum cap in relation to the total amount of spectrum for which a bidder may bid. However, this would not address on its own the concern of lowering barriers to entry in the sub-1GHz bands, which are relevant due to the particular importance of sub-1GHz spectrum, its relative scarcity and the complementarity of low and high frequency spectrum. For this reason, the overall cap should be used in addition to the sub-1GHz cap.

5.3 Imperfect substitutability and overall cap

119. Despite the fact that an operator may be able to substitute spectrum in the sub-1GHz and the 1800MHz bands at the margin, there are significant differences between the sub-1GHz and the 1800MHz bands. Therefore, even if spectrum in different bands is to some extent substitutable for bidders, we must consider the degree of substitutability between spectrum blocks in different bands, and whether this should affect how an overall spectrum cap applied to a number of bands should be defined.

120. It is possible that due to inferior propagation characteristics of 1800MHz spectrum, a bidder may require a greater amount of 1800MHz spectrum to make up for not obtaining sub-1GHz spectrum and still have an attractive business proposition. In fact, this is reflected in the weighted eligibility points system that we have proposed. Therefore, in some cases, it might be appropriate to define a weighted overall spectrum cap, where sub-1GHz has a greater impact in limiting the total amount of spectrum that the bidder can bid for.

121. In addition, there may be a genuine reason for acquiring a significant amount of contiguous spectrum in the 1800MHz band, especially where an operator does not have access to sub-1GHz spectrum. This could potentially allow existing operators or new entrants to develop and deploy new services that might require considerable bandwidth. Even if such services might not be developed at present, an operator might wish to acquire a substantial amount of spectrum as an option for developing new services, or as a backup for potential capacity requirements in the future. Given that there is a considerable supply of spectrum in this band, there are no good reasons in principle for precluding outcomes resulting from such motivations.

122. For these reasons, we consider the possibility that the overall spectrum cap could be defined in a flexible manner that takes account of the amount of sub-1GHz spectrum that a bidder bids for. One solution for implementing a flexible cap could be to use the weights for the calculation of spectrum cap restrictions that are related to the eligibility weights used for the activity constraints, e.g. increasing the overall spectrum cap by 2x10MHz where a bidder bids for 2x5MHz less than the maximum amount of sub-1GHz spectrum, increasing the overall spectrum cap by 2x20MHz where a bidder bids for 2x10MHz less than the maximum amount of sub-1GHz spectrum, etc. An alternative approach would be to have a step function for the spectrum cap restriction that would depend on the amount of sub-1GHz spectrum a bidder bids for, e.g. where a bidder bids for 2x10MHz of sub-1GHz spectrum or less it is restricted in the amount of 1800MHz spectrum bid for. We discuss these alternative methods below when considering the appropriate level for the spectrum cap.

123. Whether a flexible overall spectrum cap is suitable depends on a number of factors, including the current and future availability of spectrum and the proposed level for an overall spectrum cap. The advantage of a flexible spectrum cap is that it would allow bidders to trade off between more valuable sub-1GHz spectrum and a greater quantity of 1800MHz spectrum, thus potentially providing an incentive for bidders to bid moderately for sub-1GHz spectrum and accommodate entry in this band in order to acquire a greater amount of 1800MHz spectrum for capacity. This might promote an efficient outcome where operators bid for a balanced combination of sub-1GHz required for coverage and legacy GSM services, and 1800MHZ spectrum for capacity, thus potentially allowing for a greater number of operators in the downstream market.

124. However, care must be taken when setting these incentives, as where the relative weights used for sub-1GHz and 1800MHz spectrum do not reflect the exact relative value of the spectrum in these two bands, this could lead to the distortion of bidder preferences for spectrum for reasons that relate only to the auction design. For example, where the ratio of value turned out to be less than 2:1, say 1.5: 1 between sub-1GHz and 1800MHz spectrum, such a spectrum cap may result in operators inefficiently favouring 1800MHz for deploying their networks, and sub-1GHz being inefficiently under-utilised. In addition, depending on the absolute level of the spectrum cap when bidders do not bid for sub-1GHz spectrum, this might provide the option for some bidders to acquire too much spectrum in the 1800MHz band.

125. Given uncertainty about the terms of any trade-off between sub-1GHz and 1800MHz spectrum, it is important that any proposal does not depend too critically on a presumed trade-off. For this reason, we ultimately propose a fairly liberal overall cap rather than using a more complex weighting system.

5.4 Inclusion of current spectrum holdings when setting caps

126. We note that in referring to “current spectrum holdings” we include all licences – either existing or new – within the bands being auctioned, but do not include spectrum held in any other bands. In particular, for the first time slice, incumbents’ holdings in existing bands to be auctioned (900MHz and 1800MHz) would count towards the spectrum cap imposed. For instance for Meteor, given its existing frequencies in the 900MHz band, it may only bid for an additional two blocks of sub-1GHz spectrum in the first time slice given the proposed 2x20MHz sub-1GHz cap.

127. Given the imminent liberalisation of spectrum use in multiple bands previously designated for mobile use, operators will soon be able to deploy their networks using spectrum across a number of alternative bands in Ireland. Therefore, the ability of an operator to compete in a market is determined to a certain degree by the overall amount of spectrum the operator holds across all bands. Large asymmetries in the total amount of spectrum held by different operators might limit effective competition at the service level.

128. Taking account of existing spectrum holdings in bands other than those to be auctioned when applying a spectrum cap limits the ability of those bidders who already hold large amounts of spectrum to strengthen

incumbency advantages and asymmetries as a result of the spectrum they win in the award. Therefore, taking account of current spectrum holdings when setting spectrum caps can help reduce barriers to entry.

129. However, there are a number of reasons why the case for including existing spectrum holdings in bands other than the 900MHz and 1800MHz in the calculation of the spectrum caps for the upcoming award is weak:

- First, existing long term spectrum holdings represent only a moderate proportion of the total amount of spectrum that will be available in the short and medium term (that is, by 2015 at the latest) for the provision of electronic communications services (spectrum that may be available in the 800MHz, 900MHz and 1800MHz bands at a minimum).
- Second, existing spectrum holdings not included in the auction that may count towards a spectrum cap, that is, holdings in the 2.1GHz band, are fairly symmetric amongst all existing operators. No single operator has substantially less spectrum in these bands than the others.
- Third, where the spectrum cap imposed is high enough to allow a new entrant to acquire sufficient spectrum to be able to compete effectively against incumbents, the inclusion of existing spectrum holdings of incumbents in setting a cap on the amount of spectrum the incumbents can buy in the auction should not be material in terms of affecting the competitive landscape of the mobile market.

Therefore, we do not expect current spectrum holdings to determine the long-run structure of the market after the award.

130. Taking account of current spectrum holdings outside the award bands when setting spectrum caps for the current award process would allow an entrant to acquire more spectrum than incumbent operators. That is, for an entrant without 2.1GHz spectrum, it can acquire 2x15MHz more spectrum than existing incumbents in the relevant frequency band category (that is, depending on whether a standalone or overall cap is imposed). However, given the amount of spectrum that is available in this award, current spectrum holdings in the 2.1GHz band are not likely to provide a material advantage to incumbent operators. Therefore, it does not seem reasonable to include this existing spectrum within the overall cap.

131. We anticipate the overall spectrum cap to be set at a level at which it does not limit legitimate business opportunities, but only prevents outcomes where operators may acquire large amounts of spectrum (which they may not even intend to use) in order to block entry or distort downstream competition. Therefore, while it may be prudent to include existing spectrum holdings in subsequent spectrum award processes, the spectrum caps for the present award can be set without reference to current spectrum holdings of bidders provided that the level of the overall spectrum cap is not set too tightly.

5.5 Level of an overall spectrum cap

132. In this section we consider the appropriate level for a spectrum cap in the 1800MHz band, both in isolation and when combined with sub-1GHz spectrum. This also allows us to consider the possibility of introducing flexibility for the overall spectrum cap in relation to the amount of sub-1GHz spectrum that a bidder might acquire.

133. We first consider the case of a bidder only bidding for 1800MHz spectrum, and not for any sub-1GHz spectrum. Such a bidder may require a significant amount of spectrum in order to provide an attractive alternative service to the services provided by operators who use sub-1GHz spectrum. For example, this might allow a new entrant to provide a differentiated service focused on high bandwidth to urban areas. A new entrant with such a business case might want to acquire an asymmetrically large amount of spectrum in the 1800MHz band compared to other bidders. But unlike the situation with sub-1GHz spectrum, an asymmetric spectrum allocation in the 1800MHz band seems unlikely to pose a significant threat to competition, as any entrant with a large amount of 1800MHz spectrum would still have to compete with incumbents who are assigned sub-1GHz frequencies. Indeed, differentiated offering might even be pro-competitive.

134. However, an outcome where a single bidder (whether an incumbent or an entrant) acquires the whole 1800MHz band may limit competition in the long term due to the asymmetry this situation would create in terms of the ability of operators to provide additional capacity, especially in the event that availability of further spectrum above 1GHz is significantly delayed. Therefore, it seems reasonable to limit the amount of spectrum that a single bidder may acquire in the 1800MHz band to 2x50MHz. This would allow for 2x25MHz to be awarded to other bidders, who would be expected to also bid for sub-1GHz spectrum. At the same time, 2x50MHz seems sufficient for an operator to provide a differentiated high bandwidth service if competition for spectrum allowed this.

135. We now consider the case for bidders who also bid on sub-1GHz spectrum. In particular, now look at the case where three bidders win the maximum 2x20MHz of sub-1GHz spectrum permitted. Consider the following alternative limits on the amount of 1800MHz spectrum that these bidders could be allowed to bid for:

- **2x20MHz** – This would ensure that the three sub-1GHz spectrum winners would not be able to acquire the totality of the spectrum in the 1800MHz band. Therefore, this would effectively reserve 2x15MHz for a fourth bidder. However, in the event that there were no additional bidders in this band, some of the spectrum would be unassigned. In addition, such a tight spectrum cap would impose a rather symmetric outcome even where four operators were to bid for this 1800MHz spectrum, as only 2x5MHz would be contested between these four bidders. Therefore, 2x20MHz in the 1800MHz band would seem to be too tight a cap.

- **2x25MHz** – This would ensure that at least three operators would be able to win 1800MHz spectrum. Therefore, in the event that only the three sub-1GHz winners were to bid for 1800MHz spectrum, this

would allow for the three bidders to be awarded the maximum amount of spectrum permitted. Although this would ensure that there is a possibility for all lots to be awarded even in the absence of a fourth bidder, it might be too restrictive in that it would automatically prescribe a symmetrical outcome (and possibly limit competition for spectrum). Therefore, 2x25MHz on 1800MHz may still be too tight a cap.

- **2x30MHz** – The most concentrated outcome that would be feasible with this level for the spectrum cap would be two operators with 2x30MHz each and one operator with 2x15MHz. Therefore, this outcome would still ensure that at least three bidders would be able to acquire spectrum in this band. In addition, even where the third operator would only acquire 2x15MHz, this provides enough bandwidth to effectively deploy 3G services using this spectrum. Where only the three sub-1GHz winners would bid for 1800MHz spectrum, these bidders could still compete for 2x15MHz of 1800MHz spectrum, which could then be allocated efficiently amongst these bidders. In addition, it would seem reasonable to presume that 2x20MHz of sub-1GHz plus 2x30MHz of 1800MHz spectrum would be sufficient for an operator to deploy a legitimate business proposition; therefore this cap would not appear to be too tight.

- **2x35MHz** – The most concentrated outcome that would be possible in this case is one where two of the three sub-1GHz winners could win 2x35MHz each in the 1800MHz band, with only 2x5MHz left for a third bidder, which might be insufficient for deploying services on a standalone basis. This may allow for sub-1GHz winners to block a third bidder or 1800MHz. This would not address concerns that incumbents could block entry and could limit competition in the downstream market. Therefore, a cap set at this level would seem to be too loose.

Taking this into consideration, an 1800MHz cap of 2x30MHz would seem to be the appropriate level for the spectrum cap on 1800MHz that should apply to a winner of 2x20MHz of sub-1GHz spectrum.

136. Given the above considerations, we can combine these cases (i.e. a 2x50MHz cap on 1800MHz for someone not bidding for sub-1GHz spectrum and a 30MHz cap for someone bidding for the maximum amount of 2x20MHz of sub-1GHz spectrum) in to a cap of 2x50MHz on the overall spectrum each bidder may bid for, where bidders could bid for 2x50MHz of 1800MHz spectrum on a standalone basis, or a combination of sub-1GHz and 1800MHz spectrum such that the total bandwidth does not exceed 2x50MHz.

137. The discussion above suggests with a one to one trade off between sub-1GHz and 1800MHz spectrum in that in acquiring the maximum 2x20MHz of sub-1GHz spectrum limits the bidder to acquiring 2x30MHz of 1800MHz spectrum. However, we discuss that 1800MHz may be less valuable than sub-1GHz spectrum (and indeed we reflected this in the relative eligibility point system in Section 6.3). This begs the question whether a weight should be applied to the different bands for

implementing an overall spectrum cap. If we were to apply such a weighting, this would have to involve either:

- A relaxation of the overall 2x50MHz cap; and/or
- A bidder with the maximum 2x20MHz sub-1GHz spectrum receiving less than 2x30MHz 1800MHz spectrum.

138. Neither of these outcomes seem a more attractive possibility than a simple un-weighted cap. In particular, restricting winners of the maximum 2x20MHz of sub-1GHz to less than 2x30MHz of 1800MHz, does not seem justified by the need to protect competition downstream and might well have an adverse effect on the competition for 1800MHz in the auction.

139. In addition, a weighting scheme could also create an inefficient incentive to bid for sub-1GHz spectrum early in the auction as this maintains the option to switch to a large amount of 1800MHz spectrum. This may create the wrong incentives for bidders when deciding the combination of sub-1GHz and 1800MHz spectrum they wish to bid for.

140. Given the considerations above, an overall cap of 2x50MHz in addition to the 2x20MHz cap on sub-1GHz spectrum appears to be the most appropriate solution.

5.6 Summary and conclusion

141. Hoarding is only an issue for incumbents, not for entrants, as only incumbents may want to protect their current business.

142. However, a symmetric cap for incumbents and entrants is preferable, because the auction includes a lot of spectrum and the whole market is contested.

143. The spectrum cap should not include existing 2.1GHz spectrum holdings, which are unlikely to have any impact on the ability of a successful bidder to subsequently compete in the downstream market.

144. We should not prescribe symmetric spectrum holdings in individual bands, or set caps that are too tight so that spectrum is not contested; the purpose of using an auction is to allow competition to determine the amount of spectrum to be awarded to each bidder.

145. The extreme case of one bidder (even an entrant) acquiring the whole 1800MHz band is not a short term threat to competition, but may be a long term concern due to the asymmetry it creates in spectrum holdings if availability of further spectrum above 1GHz is significantly delayed.

146. We should allow for the possibility for a bidder bidding only on 1800MHz spectrum to acquire a sufficiently large amount of spectrum as to effectively compete with operators that have sub-1GHz spectrum – a bidder not bidding for sub-1GHz spectrum should be allowed to bid for up to 2x50MHz in the 1800MHz band.

147. The polar opposite case is where a bidder bids for the maximum of 2x20MHz allowed in the sub-1GHz band. This would allow for at least two other bidders winning sub-1GHz spectrum. Such an operator might require up to 2x30MHz of 1800MHz spectrum for additional capacity in highly populated areas. This would allow for some competition at the

margin even in the event that we only had three sub-1GHz spectrum winners bidding for 1800MHz spectrum.

148. Allowing for intermediate cases, it would seem that an overall cap of 2x50MHz in addition to the 2x20MHz cap on sub-1GHz spectrum seems reasonable. This would allow operators to trade-off sub-1GHz spectrum and 1800MHz spectrum.

6 Substitutability of sub-1GHz and 1800MHz spectrum

149. In order to obtain the full benefits of including 1800MHz spectrum in the same auction as spectrum in the 800MHz and 900MHz bands, we would need to allow substitutability between spectrum in these different bands. In this section, we first consider why we wish to facilitate substitutability across lots in different bands. We then consider the difficulty that arises where lots in spectrum bands with different value are included in the same auction on equal terms. We propose an eligibility point system that allows substitutability across spectrum bands within a time slice, but also takes account of the values differences we believe to exist between spectrum in the 1800MHz band and sub-1GHz spectrum.

150. In particular, we note that we do not need the proposed *"exchange rate"* between 1800MHz and sub-1GHz spectrum to be an exact reflection of the relative value of different bands, only a tolerable approximation to neutralise the worst excesses of any incentive of a bidder to misuse the eligibility point system in a strategic manner. Therefore, the exact *"exchange rate"* proposed should not affect the overall auction outcome.

6.1 Facilitating substitutability across spectrum bands

151. Allowing substitutability between 1800MHz spectrum and sub-1GHz spectrum within the auction provides a level of flexibility within the auction that will facilitate a broad range of bidding behaviour and outcomes that are beneficial in ensuring that the resulting spectrum allocation across bands is efficient:

- Given the differing nature of the characteristics of sub-1GHz and 1800MHz spectrum and their respective strengths in the provision of advanced data and voice services (coverage with sub-1GHz spectrum, capacity with 1800MHz spectrum), it would appear to be desirable for an operator particularly for the provision of high-speed mobile broadband to have at least some spectrum at both 1800MHz and under 1GHz. However, it may be the case that beyond some certain amount of spectrum in each band a bidder might be prepared to fulfil its further spectrum needs taking into account relative prices. That is, beyond some minimum amount of both low and high frequency spectrum, bidders may regard spectrum in the available bands as substitutable with regard to fulfilling the remainder of their spectrum requirements. If this were to be the case (even at a rate of substitution differing from 1:1), allowing this type of swopping between spectrum bands as information about relative prices is revealed may allow the auction to reach an allocation that is more efficient than where substitution is not permitted. In the case where substitution is not facilitated, bidders can only maintain and reduce their demand for sub-1GHz and 1800MHz spectrum in progressive rounds where the balance of spectrum bid for is based on expectations of the *final* relative prices formed before the auction. This may result in a relatively less efficient outcome because while these expectations may be adjusted during the auction in response to the development of actual relative prices, it may not be possible to adjust bidding to reflect these changing relativities.

- Another issue in terms of increasing the likelihood of efficiency of the auction outcome through allowing substitutability stems from the differing scarcity for each of these two types of spectrum:
    - The 800MHz and 900MHz bands together contain 2x65MHz of spectrum and represent the entire supply of sub-1GHz spectrum harmonised for the provision of mobile broadband. As we have discussed, this spectrum is highly desirable for operators to use to provide high-speed services due to the cost savings involved in deploying and operating a network at these frequencies. Given the amount of this type of spectrum available and the intrinsic value of this spectrum, it is possible that competition for sub-1GHz spectrum will be significant.
    - The 1800MHz band contains 2x75MHz of spectrum and is at present used mainly for supplementing existing 900MHz networks with capacity. It is envisaged that this spectrum would fulfil a similar role where these bands are used for the provision of 3G and eventually 4G services. In addition to the high frequency spectrum being made available in this band, there is other high frequency spectrum that an operator could use to fulfil a similar role. Other similar spectrum would include at a minimum the 2.1GHz band. This band contains a further 2x60MHz of paired spectrum. Given the size of the band and the fact that existing operators might not see it as crucial to acquire 1800MHz spectrum as they all hold spectrum in the 2.1GHz band, competition in this band, if it exists, is likely to be moderate.

152. Furthermore, the magnitude of the level of competition in these bands is necessarily uncertain. If competition for sub-1GHz spectrum turned out to be strong, or competition in the 1800MHz band is unexpectedly weak, and relative prices adjust to reflect this, where substitutability is permitted the auction will facilitate the possibility that bidders can fall back to 1800MHz spectrum if sub-1GHz spectrum gets too expensive for them. This provision may be important for entrants, as the risk of getting less sub-1GHz spectrum than desired without being able to compensate with more 1800MHz spectrum is reduced.

153. Inevitably, the increase in flexibility of bidders to transfer their demand across bands during the auction may allow greater scope for undesirable strategic bidder behaviour. The main potential risk that may exist where bidders are allowed to transfer eligibility across lots of different values is that during the clock rounds bidders may be able to hide their demand for relatively expensive lots by bidding on relatively cheap lots. Where bidders were to do this, it would undermine the informational value of the open rounds. However, in this auction as proposed, all bids are binding. Therefore, where a bidder opted to bid during the clock rounds on relatively cheap lots where it had relatively higher value for the expensive lots, it risks being awarded the lots it bid on (i.e. the cheap lots in the example above) in these clock rounds.

154. For instance, where a bidder is attempting to hide its demand on relatively cheap lots, say in 1800MHz, when its actual demand for spectrum was on sub-1GHz spectrum, then it faces a non-trivial possibility of winning

undesired 1800MHz spectrum instead of the desired sub-1GHz spectrum as:

a) The act of simultaneously bidding on 1800MHz spectrum and not bidding on sub-1GHz spectrum (or bidding on a very small amount of this spectrum) may be sufficient to bring the clock rounds to a close, particularly if excess demand for spectrum across bands is low in the clock rounds;

b) The formulation of the winner determination algorithm is such that in essence it chooses between combinations of bids that have highest overall value. Thus, the existence of such an 1800MHz package bid might form part of the winning combination of bids.

155. Note that limitations on the transparency of the auction will dramatically limit opportunities for gaming at little cost for efficiency.

156. On balance then, given the benefits to allowing substitutability between sub-1GHz and 1800MHz spectrum and that features of the auction discourage the strategic use of this flexibility, we conclude that transferability of bidding behaviour across these different spectrum bands should be permitted. We consider the mechanics of how this transferability might be facilitated in the following sub-sections.

6.2 Issues arising when treating bids for bands with different lot values equally

157. In order to provide incentives for bidders to reveal information about their valuation through their bidding behaviour (which is the main reason for adopting an open auction format), bidders should be required to comply with activity rules that are set to encourage bidders to reveal their demand as the auction progresses. Without rules governing bidder activity there is the risk discussed above that bidders could act strategically, for example by 'hiding' their demand by not bidding on as much spectrum as they wish to win at round prices in the earlier rounds in an attempt to avoid pushing up prices on those lots that they want to win. This incentive is normally addressed through activity rules that make the right of a bidder to continue bidding in future rounds contingent on the bidder's activity in any given round.

158. If all lots offered in the auction were practically identical, we could use simple activity rules and measure a bidder's activity by the number of lots a bidder bids for in a round (in a given time slice in this case). This is the case for the proposed 800MHz/900MHz auction, and as such we have been able to use a straightforward activity rule in our related proposal; that is, within a time slice, a bidder can shift the balance of its demand between 800MHz and 900MHz lots freely from one round to the next, with the only constraints being that it cannot increase its overall demand for lots in a time slice in a round relative to its demand for lots in that time slice in the previous round.

159. For example, in the current 800MHz/900MHz auction proposals, each lot in a time slice has an implicit eligibility of 1. Under these current proposals, if a bidder bids on three lots in a particular time slice in a given round, say round n, the bidder will have eligibility to bid for up to 3 lots in that time slice in the following round, round n+1, and all subsequent

rounds. Similarly, if this bidder were to bid on less spectrum in the following round, say, 2 lots in the relevant time slice in round n+1, its eligibility to bid for spectrum in this time slice would be reduced to a maximum of 2 lots in round n+2 and all subsequent rounds.

160. In an auction with different lots and where bidders are allowed to switch between lots (i.e. where eligibility is transferable across different bands), matters are more complicated, in particular where lots in different categories might have very different values.

161. In the case of such a multi-band auction where value differences exist between lots in different bands and substitution is allowed between bands, an opportunity will arise for bidders to act strategically to hide their demand in another way than that described above, that is, to bid on lots in the relatively cheap lot categories to dampen demand for the more expensive lots which they actually want to win. This behaviour is risky for the bidder and the benefit (at least in a CCA) is limited. Nevertheless, we should make some sort of adjustment to the auction activity rules to adjust for this.

162. In particular, we need to make an adjustment that will preserve the incentive for bidders to bid truthfully in order for price discovery to still be effective. Such an adjustment needs to ensure that bidders cannot preserve eligibility for bidding on high value lots by bidding on low value lots during the clock rounds.

6.3 Proposed terms of substitutability: System of eligibility points

163. In order to set an adjustment that takes account of value differences across spectrum bands, we need to attribute weights to lots of spectrum in different bands that represent their relative value. These relative values are then represented by a number of eligibility points attributed to lots in each band. Activity rules would then work in the same way as in the simple case of the current auction proposals (where eligibility to bid is transferrable across bands and a bidder cannot bid for more spectrum in a round than it bid for in the previous round) with the exception that demand in a round and corresponding eligibility to bid in the following round is measured not be numbers of lots but by numbers of eligibility points.

164. Finding an appropriate ‘exchange rate’ that reflects substitutability then becomes important because the system of eligibility points will constrain bidders’ abilities to switch their demand between bands as relative prices change throughout the auction.

165. Ideally, we would wish to allocate a number of points to each lot so that they reflect to some degree the relative value differences between bands. Setting up such a system of eligibility points is however a challenge because a key reason for having an auction in the first place is that we do not know the absolute or relative value of spectrum in the various bands. However, we do not need the eligibility weights to be an exact reflection of the relative values of different bands, only a tolerable approximation to neutralise the worst excesses of any incentive to maintain a store of eligibility points by bidding on spectrum other than what the bidder actually wants to win.

166. We have considered the value of spectrum in the 1800MHz band relative to sub-1GHz spectrum in Section 7.2. Our findings suggest that the value of a lot of spectrum in the 1800MHz band is approximately half of that of a lot of sub-1GHz spectrum of the same size in the same time slice. We have on that basis set minimum prices for lots of 1800MHz spectrum at half the minimum price for lots of sub-1GHz spectrum. The simplest way to implement these weights across spectrum bands is to have twice as many eligibility points for sub-1GHz lots as for lots in the 1800MHz band:

Table 4: Eligibility points associated with spectrum in different bands

Band	Number of eligibility points attributed to a 2x5MHz lot
800MHz band	2
900MHz band	2
1800MHz band	1

167. To understand how the eligibility point system constrains bidders consider for example a bidder that can use spectrum in any of the above three bands to provide capacity. The eligibility point system will allow this bidder to trade off 800MHz and 900MHz spectrum on a one-to-one basis depending on the relative prices of these bands. However, if the sub-1GHz bands became relatively expensive compared with the 1800MHz band, the bidder would be able to switch to bid for more1800MHz spectrum on a two-to-one basis. This reflects the likely reduced value of 1800MHz spectrum compared with sub-1GHz.

168. While up to now we have considered the eligibility points system to represent an exchange rate of points based on the concept of value in terms of monetary value as a proxy for intrinsic value of different types of spectrum based on the capabilities that such spectrum enables, we must also consider such an exchange rate on a practical level.

169. For example, consider a bidder that bids for three lots of 2x5MHz in the 900MHz band in a given time slice in the first clock round because that is its preferred package at the reserve prices (and indeed the minimum prices). Consider now the case where the price of 900MHz lots in a given time slice increases proportionately more than the price of 1800MHz lots in each of the following three clock rounds. At the given prices in the fifth round, this bidder does not want to bid for three lots of 2x5MHz in the 900MHz band, but rather switch at least some of its demand to spectrum in the 1800MHz band. If more than one block is needed in this band in order to make up for one block less in the 900MHz band, then obviously the reduction in demand in the 900MHz band by one block should provide the bidder with the right to bid on more than one block in the 1800MHz band.

170. Therefore, we need to cross-check that bidders can reduce their demand or transfer their demand across categories of lots in response to price developments in a way that is sensible in the context of the types of combinations of spectrum that they can reasonably use to provide services now and over the duration of the licensing period in question. Specifically, we need to cross-check that the substitutability that the eligibility points system proposed would allow are not unduly constraining. Under the system of eligibility points proposed, where a bidder were to transfer some of its sub-1GHz demand to demand for lots in the 1800MHz band, reduction in demand for one 2x5MHz lot of sub-1GHz spectrum would result in the increase of eligibility to bid by two 2x5MHz lots of 1800MHz spectrum. This allows a bidder to buy more 1800MHz spectrum to make up for its inferior characteristics. Also, any bidder who drops out of bidding for sub-1GHz spectrum because this becomes absolutely or relatively too expensive (remembering that scarcity is likely to be much greater for these bands) would be able to pursue a back-up strategy of bidding for a greater amount of 1800MHz spectrum. Therefore, the proposed 1:2 weighting appears to give an appropriate degree of flexibility for bidders to substitute and to pursue “back-up” strategies.

7 Minimum prices for 1800MHz spectrum

7.1 Methodology for setting minimum prices

171. DotEcon previously carried out benchmarking analysis in order to estimate appropriate minimum prices for spectrum in the 800MHz and 900MHz bands (referred to jointly as sub-1GHz spectrum) in Ireland. This analysis has been presented in two reports:

- Part C of DotEcon Report 09/99c[16], published in December 2009 by ComReg alongside its own consultation document (09/99) on the award of spectrum in the 900MHz band; and
- A follow-up report to 09/99c updating the benchmarking exercise to take into account the consultation responses from 09/99, the inclusion of 800MHz spectrum in the same auction process and also updating the earlier analysis where additional data had become available. This report (10/71b) was published in September 2010 by ComReg alongside its own consultation (10/71) on a joint award of spectrum in the 800MHz and 900MHz bands.

172. In section 7.1.1, we first describe the methodology and data already used in the documents mentioned above for generating a minimum price for sub-1GHz spectrum. We then describe an approach for setting minimum prices for 1800MHz spectrum in Section 7.1.3. We apply this approach for 1800MHz benchmarking in Section 7.2 and deduce a minimum price for 1800MHz spectrum in a joint award with sub-1GHz spectrum in the section 7.2.3.

173. We perform consistency cross-checks of these results against technical studies that model network costs in Section 7.3. Finally, in Section 7.4, we provide recommendations on an appropriate minimum price level for 2x5MHz of 1800MHz spectrum and discuss the appropriate breakdown of the minimum price into annual Spectrum Usage Fees (SUFs) and an upfront reserve price for the auction.

7.1.1 Sub-1GHz benchmarking of minimum prices

174. In recommending minimum prices for sub-1GHz spectrum, the analysis in the DotEcon Report (09/99c) and Updated Benchmarking Report (10/71b) used spectrum auction results in the last decade (auctions from 2000-2010) as comparators. A variety of different averages and econometric forecasts were used to investigate the implied value of spectrum in Ireland.

175. In the data used, there was a relative scarcity of examples of awards of spectrum below 1GHz where a market value could be observed, as our previous reports describe. In particular, as the cornerstone of 2G mobile communication networks, GSM900MHz spectrum was not auctioned off in

[16] DotEcon Limited (December 2009), 'Liberalisation of spectrum in the 900MHz and 1800MHz bands – Final Report to ComReg', ComReg document 09/99c.

many countries, but awarded administratively to operators instead. In addition, only Germany and the US have auctioned off digital dividend spectrum. Therefore, given the thin sub-1GHz auction data, it proved necessary to use a variety of mobile-relevant frequency bands to provide a rich enough set of comparators to allow meaningful results, including bands above 1GHz (i.e. 2GHz, 2,1GHz, 2,6GHz and 1800MHz).[17]

176. The purpose of this exercise was only to estimate a conservative lower bound on the value of sub-1GHz spectrum in Ireland, hence the inclusion of data from other higher frequency bands was an acceptable approach. While the likely lower market value of higher frequency spectrum probably dragged down estimates, this did not matter as only a lower bound on likely value of sub-1GHz spectrum was sought. However, it is important to bear this in mind when interpreting these previous results.

177. In setting a minimum price, ComReg's objectives are that the minimum price should be sufficiently high to guard against uncompetitive outcomes (including providing a disincentive to tacit collusion), but not so high as to run a material risk of choking off efficient demand for spectrum. Hence, it was important to ensure that our benchmarking approach produced a conservative lower bound on the true market value of sub-1GHz spectrum, otherwise the risk of choking off demand would be too great.

7.1.2 Relative value of sub-1GHz and 1800MHz spectrum

178. There is good reason to expect lower frequency spectrum (i.e. 800MHz and 900MHz) to be more valuable than higher frequency spectrum (1800MHz, 2.1GHz and 2.6GHz) due to network cost savings associated with the superior propagation characteristics and more effective in-building coverage of this spectrum. This is consistent with technical studies which suggest that deployment cost of UMTS systems using sub-1GHz spectrum is between 60%-70% of the cost of a UMTS network using 2.1GHz frequencies[18]. Similarly, we can expect that the value of 1800MHz spectrum will be lower than corresponding liberalised spectrum at 900MHz or 800MHz simply due to differing propagation characteristics.

179. Furthermore, in the short run, there may be additional value differences created by the projected timing of handset and equipment availability differing across spectrum bands. In particular, 1800MHz spectrum is unlikely to be at the vanguard of technological improvements such as LTE. There is greater benefit to deploying these upgrades first at lower

[17] Note that as only Germany has auctioned liberalised sub-1GHz spectrum in its 800MHz, 1800MHz, 2.1GHz and 2.6GHz auction in May 2010, the available benchmarks useful for estimating the value of sub-1GHz spectrum have also lacked any 'liberalisation premium' that might exist with the award of licences without the restrictions on use linked to previous licences.

[18] In particular, we note that a Vilicom Report for ComReg (VIlicom, 2009, UMTS Network Design & Cost – Estimation for National UMTS 900, UMTS 1800 & UMTS21200 Networks for ComReg; ComReg document number 09/14a) for ComReg suggested that the deployment cost of a UMTS900 network in Ireland is 65.6% that of a UMTS 2100 network. In addition, this relationship holds when considering total cost of operators comprising CAPEX and OPEX. In the Ovum 2007 study for GSMA - 'Market Study for UMTS900', they found that cumulative CAPEX and OPEX savings for a UMTS900 operator compared to that of a UMTS2.1GHz operators was around 90%.

frequencies. Also, historical accident means that across much of Europe 800MHz spectrum is becoming available due to the switch off of analogue television at the same time that GSM900 licences are coming up for renewal. In contrast, GSM1800 licences typically have some time to run. This means that there are sound commercial reasons for global equipment manufacturers prioritising the lower frequency bands; individual MNOs within one country have very little influence over this timing as this is determined collectively by the industry.

180. Indeed, we observe that in the only spectrum auction in which liberalised frequencies in the sub-1GHz band and 1800MHz band were sold – the German spectrum auction in May 2010– the prices of the 800MHz licences were substantially greater than those of the higher frequency spectrum licences (1800MHz, 2.1GHz and 2.6GHz). We discuss in greater detail the relative value of sub-1GHz and 1800MHz licence price in the German May 2010 auction in particular in section 7.2.3 below.

7.1.3 Appropriate minimum prices for 1800MHz spectrum

181. As explained above, the method adopted for determining a minimum price for 800MHz and 900MHz spectrum was consciously slanted towards producing a conservative lower bound. However, if we were simply to reapply the same approach to 1800MHz spectrum, then we cannot interpret the results in the same way. In particular, we are more likely to produce a central estimate of market value, rather than a conservative lower bound. This is because our data set for producing the original estimates was relatively rich in comparators above 1GHz. Therefore, there is a danger that simply applying the same techniques without careful reinterpretation could run too high a risk of generating a minimum price that would choke off demand.

182. In fact, given the weight of higher frequency spectrum auctions in the data set applied in the DotEcon Report (09/99c) and Updated Benchmarking Report (10/71b), applying our original benchmarking approach and data set to the 1800MHz band would produce benchmarks of the market value of 1800MHz spectrum not far off that produced for sub-1GHz spectrum. However, we could not then interpret these estimates as a conservative lower bound value to the true market value of 1800MHz as it did for sub-1GHz spectrum.

183. A further problem is that comparators at 2GHz, 2.1GHz and 2.6GHz may tend to have higher value than 1800MHz spectrum despite their similar radio propagation characteristics, as the former bands may be earlier on the LTE upgrade path. There is no way of being certain about the materiality of this issue, but it is a real possibility. Therefore, the likely value of 1800MHz spectrum relative to other mobile bands above 1GHz is unclear.

184. In order to illustrate this point, consider a comparison of the value of 2.1GHz spectrum and 1800MHz spectrum. The average licence fee paid for 3G licences at 2.1GHz in Ireland was €22.3m in May 2010 terms

(however, Vodafone, O2, and Meteor paid approximated €27m each) for 2x5MHz[19]. By being willing to pay this amount, the MNOs demonstrated that the value they placed on 2.1GHz spectrum at the time was at least the amount that they actually paid. We used this figure as one of the benchmarks in the DotEcon Report (09/99c) and with a correction for inflation in Updated Benchmarking Report (10/71b) as we could be reasonably certain that the value of 900MHz and 800MHz spectrum would exceed this. However, we can be less sure that this figure is a lower bound on the value of 1800MHz spectrum. It is quite possible that the value of 1800MHz could be less than that of 2.1GHz spectrum.

185. A further issue in setting the relative minimum prices of different bands is that we do not want to distort bidders' choices between different bands. In particular, if the minimum prices of 800MHz and 900MHz bands are set on a conservative basis, but that of the 1800MHz band was not, demand might be diverted from the 1800MHz to sub-1GHz spectrum. This may not affect the ultimate outcome if the open rounds of the auction increase prices of sub-1GHz spectrum sufficiently to eliminate the initial price to value differential; however, the auction outcome might be affected if demand for 1800MHz spectrum is choked off.

186. Overall, we want to set minimum prices for different bands on a similar basis. In particular, we want to avoid setting a minimum price for some bands on the basis of a low risk of choking off demand, but then set prices for other bands on a different basis.

187. For these reasons, we applied an alternative approach to estimating an appropriate minimum price for the 1800MHz spectrum in Ireland: by investigating the *relative valuations* of sub-1GHz and 1800MHz spectrum from international benchmarks. Given a view about the likely relative valuations, we derive a minimum price for 1800MHz spectrum from the minimum price of sub-1GHz in Ireland (which ComReg's consultation (10/71) proposes to be €25m for a 2x5MHz licence of 15 years). This would ensure that the minimum prices of the various bands are all on a 'conservative lower bound' basis. Further, it would also reduce the possibility of distorting demand across the bands in the early stages of the auction if the relative opening price of one band is very high relative to others.

188. Note that the exact relative valuation of 1800MHz spectrum to that of sub-1GHz spectrum is not crucial for this purpose, rather a good approximation of this ratio (yielding a conservative lower bound to the actual market value of 1800MHz spectrum within a multi-band award process) would be effective. Where these relativities are somewhat different in reality, these will be reflected in different relative prices of sub-1GHz and 1800MHz spectrum in the auction itself; as long as both prices constitute conservative lower bounds to actual market value of the

[19] See footnote 54 from 09/99c on original benchmarking analysis and the calculation of average 3G licence prices in Ireland

respective spectrum, no efficient demand in either category will be choked off.

189. There are a limited number of countries that have awarded both sub-1GHz licences and higher frequency spectrum (specifically 1800MHz, 2.1GHz and 2.6GHz) on a liberalised basis. Therefore, we limit our analysis of the relative value of the bands concerned to comparing 1800MHz and sub-1GHz spectrum where similar technologies and/or services were deployed. This controls (to an extent) for differences in licence conditions between the frequency bands.

7.2 Analysis of relative spectrum value: 1800MHz and sub-1GHz bands

7.2.1 Methodology

190. In this sub-section we set out the benchmarking methodology used in estimating an appropriate minimum price for 1800MHz spectrum, taking into account the likely interaction between the relative demand of the sub-1GHz frequencies and 1800MHz spectrum and the particular circumstances in Ireland.

191. As with the case of the sub-1GHz spectrum, ComReg must fulfil its statutory functions, objectives and duties (noted in section 3.1 of DotEcon Report 09/99c) with the potential inclusion of 1800MHz spectrum in the upcoming auction. This means that ComReg's objectives in setting the minimum price level of 1800MHz spectrum would be similar to that of sub-1GHz spectrum including but not restricted to:

- To deter frivolous bidders without genuine business cases whose participation may prolong the auction process and waste resources;
- To ensure that administrative cost of the auction process is recovered;
- To disincentivise and guard against uncompetitive auction outcomes, including but not limited to that arising from tacitly collusive behaviour of potential bidders;

The minimum prices set for this auction represent one of the mechanisms which ComReg may utilise to achieve its objectives for spectrum release.

192. The minimum price of €25m in May 2010 terms for a 2x5MHz 15-year licence of sub-1GHz spectrum was set by considering a lower bound estimate of the market value of sub-1GHz spectrum within the range of €18-€26m. This minimum price was considered to reflect the objectives listed above. By deriving a minimum price for an equivalent 1800MHz licence based on the conservative lower bound estimate value for sub-1GHz and the relative market value of 1800MHz and sub-1GHz spectrum, we should obtain a minimum price for 1800MHz spectrum that is, similarly, a lower bound estimate of the market value of 1800MHz spectrum. This ensures that ComReg's objectives listed above are reflected within the minimum prices in a similar manner for 1800MHz spectrum as for 800MHz and 900MHz spectrum. Also, setting a minimum price for 1800MHz spectrum relative to that of sub-1GHz spectrum takes into account the multi-band nature of the upcoming auction and, in particular, the interaction of relative demand for each frequency band.

193. To establish the relative values, we calculate the ratio of the average licence price per MHz per population in local currency of 1800MHz spectrum to average licence price per MHz per population in local currency of sub-1GHz spectrum using a range of comparator awards. We calculate the relative band value both at an award and a country level where applicable. In particular, at an award level, licence prices of sub-1GHz frequencies are compared to that of 1800MHz frequencies for all such licences sold within the award (that is, these awards are multi-band in nature) where as for our analysis at the country level we compare all such licences that may have been awarded in separate auction processes (for instance across two single band auctions of these frequencies).

194. The average licence price per MHz per head of population in local currency is calculated as follows:

- In the case of the award-level relative band value (Award Relative Band Value), this is the mean licence price per MHz per head of population in local currency of the frequency band concerned across all licences of that particular frequency band in the auction in question; and
- In the case of the country level relative band value (Country Relative Band Value), this is the mean value of the auction average licence price per MHz per head population in local currency of the frequency band concerned (calculated as above at an auction level for each auction in the country for which that particular frequency licence(s) was/were offered) across all such relevant auctions in the country.

7.2.2 The data set

195. In this benchmarking exercise, we compare the average licence prices of spectrum comparable to that in the 1800MHz band (1800MHz or 1900MHz) to that of comparable sub-1GHz spectrum (700MHz, 800MHz or 900MHz):

- at the auction level in auctions for which both categories of frequencies were offered; and/or
- at a country level in countries which have held separate auctions for both category of frequencies under comparable economic and competitive conditions.

196. In order to include more GSM auctions in this analysis, we have drawn on all available GSM auctions from DotEcon's in-house Spectrum Awards Database, including those pre-2000 that were not included in the data set used for the benchmarking of sub-1GHz spectrum. As we are comparing the relative value of frequency bands concerned sold within the same auction process (and/or countries that auctioned licences of the frequency bands concerned across different auctions taking into consideration potentially differing economic and market conditions) it is not as crucial as for our previous analysis carried out for sub-1GHz spectrum that the data is contemporary.

197. However, our implicit assumption from using this approach is that the relative value of the sub-1GHz and 1800MHz frequency bands remains fairly constant over time. Given that differences in radio propagation characteristics arise from physical constraints, there is good reason to

expect this to be a tolerable approximation. In any case, we see from our results in Section 7.2.3 below that it is indeed the case that this value relativity appears relatively stable over time.

198. Looking at relative spectrum values across two different frequency bands within the same auction is advantageous as this controls for many factors (such as timing, extent of competition within the auction, country differences, etc.) that have a common influence on spectrum values across different bands. Clearly, there is always the possibility that such factors might impact significantly differently on different bands, but there is no particular reason to expect this.

199. The data from auctions where both categories of spectrum frequencies were awarded in a single process is thin, as there are only a handful of countries (see Table 6 below) that have held such auctions. To increase the reliability of our analysis, we also consider countries that have held separate auctions for both categories of spectrum frequencies at different times. This foregoes some of the benefit of looking at single award processes for both types of spectrum, in that we cannot control for common factors affecting the value of different spectrum bands that may have changed over time. Nevertheless, we will still control for many common factors (e.g. demographics, geographical and spatial differences affecting network build and, to a large degree, GDP differences in that differences across country are persistent over time). The sample used in calculating Country Relative Band Values is presented in Table 8.

200. Our analysis compares the metric of licence price per MHz per head of population in the licensed region between the categories of frequencies concerned to account for any differences in spectrum endowment or regional population differences across spectrum lots auctioned. The analysis also adjusts the duration of licences to a common 15-year basis to account for any licence duration discrepancies across auctions.

201. The licence price per MHz per head of population is left in nominal local currency terms when comparing relative value between the different categories of spectrum. Where we are comparing the relative band value of the spectrum frequency categories across auctions in different time periods, this approach ignores inflation effects on licence prices across auctions. However, where we consider only auctions held under comparable economic and competitive environments, these effects should be immaterial.

7.2.3 1800MHz spectrum benchmarking results

202. Table 6 below presents the relative band value of 1800MHz spectrum to that of sub-1GHz spectrum at an award level, comparing the relative licence prices of 1800MHz versus sub-1GHz spectrum awarded *via the same auction process*. We note that in these auctions the sub-1GHz spectrum is worth considerably more than 1800MHz spectrum. This is also consistent with observations in Table 7 where a significant premium is paid in Bulgaria and Greece for spectrum licence(s) containing sub-1GHz spectrum in addition to 1800MHz spectrum compared with the 1800MHz-only licence(s).

203. The Award Relative Band Value for the German 800MHz, 1800MHz, 2.1GHz and 2.6GHz auction in 2010 is very low compared to that of the

rest of the sample. In Table 7 below, we compare the final licence price premium over reserve prices for each frequency band auctioned. As the reserve prices for this German auction were low, these premiums are quite large. However comparing these percentages across bands, we note that there was significantly less competition for the higher frequency licences (1800MHz, 2.1GHz and 2.6GHz) relative to the 800MHz licences, with the final licence price premium over reserve of the 800MHz licences being nearly 40 times that of the higher frequency spectrum..

Table 5: Premium over reserve of licence prices paid in German Frequency Auction 2010

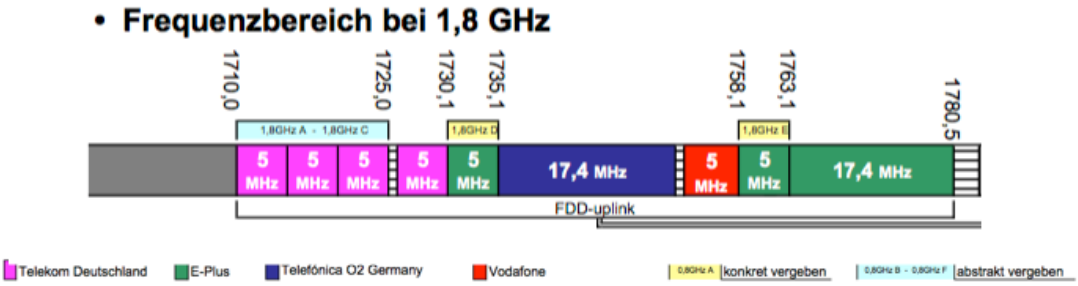
Frequency band	Percentage of licence price premium over reserve price
800MHz	23,600%
1800MHz	635%
2.1GHz	2,220%
2.6GHz	518%

Source: DotEcon Spectrum Awards Database

204. There were good reasons why competition for the 1800MHz band in the German auction in particular was weak. Figure 4 below illustrates the band plan for 1800MHz spectrum in Germany. The lots marked yellow and light blue above were sold in the May 2010 auction. Given the existing holdings of each operator in the 1800MHz band, there were obvious contenders for the available spectrum, especially since Deutschland Telekom (DT)'s existing 5MHz holding in the band split four of the five available blocks at the lower half of the FDD-uplink portion of the band into 3 blocks below its existing holdings and 1 block above, making the 3 blocks at the bottom of the band (the biggest contiguous chunk of spectrum available in the band) less attractive to other potential bidders[20]. Hence the Award Relative Band Value of 1800MHz to sub-1GHz spectrum for the German multi-band auction in May 1010 does not reflect that of a similarly competitive scenario for both bands and should be interpreted accordingly due to the particular local circumstances of this award.

[20] Particularly since no new entrants took part in the auction.

Figure 4: 1800MHz band plan in Germany



Source: BNetzA website[21]

205. The auctions in Australia and Brazil from Table 6 below offered regional lots. Depending on the auction format, the objective of bidders and their existing footprints, the relative band value at a regional level in these auctions may vary across regions due to idiosyncratic regional factors. Considering the national average price within the auction would therefore alleviate to some extent the idiosyncrasies at the lot and/or regional level and provide a more reliable estimate as to the relative band value of 1800MHz to sub-1GHz spectrum. The benchmarking analysis suggests that the Award Relative Band Value of 1800MHz to sub-1GHz spectrum is between **50%-60%.**

206. In addition, we note that the sub-1GHz spectrum in the first two PCS auctions in Australia in 1998 was reserved for entrants (not Telstra, Optus or Vodafone). The Award Relative Band Value for entrants in these auctions are presented in brackets in Table 6 below and suggest a greater disparity of the relative value of 1800MHz to sub-1GHz for these entrants' bids. We consider that given there were three entrants competing in each of these auctions, the relative band value in these auctions should reflect that of a competitive market.

207. Further, we have excluded any uncompetitive auctions. For example, Singapore (Public Cellular Mobile Telecommunications Services auction in 2008) and Austria (GSM auction in 2004) both held auctions where both relevant frequency bands were awarded; however, these auctions were not competitive and the licences were awarded at the reserve price. Unless the minimum prices in these auctions were set by the respective National Regulatory Authorities to reflect the market value for the frequencies concerned, including data from these auctions would not improve our estimate of the relative market value of 1800MHz versus sub-1GHz spectrum. In addition, Trinidad and Tobago also held an auction offering sub-1GHz and 1800MHz spectrum in 2005; however, it was a package-bid auction and it is not possible to distil the relative value of the frequency bands within a package bid comprising bids across these

[21] BNetzA website: http://www.bundesnetzagentur.de/cae/servlet/contentblob/160842/publicationFile/8778/DiagramSpectrum101015.pdf

bands. Hence we do not take into account the prices from the Trinidad and Tobago auction in 2005.

Table 6: Relative band value within an award

Country	Auction	Date	Relative band value of 1800MHz to sub-1GHz within an award	Number of sub-1GHz lots sold in auction	Number of 1800 MHz lots sold in auction
Australia	First PCS 800MHz and 1800MHz	20 Apr 1998	58.2% (36.6%)	62	149
	Second PCS 800MHz and 1800MHz	15 Sep 1998	58.9% (54.0%)	5	13
Brazil	2G licences	27 Dec 2007	50.1%	8	69
Germany	800MHz, 1800MHz, 2.1GHz and 2.6GHz	21 May 2010	3.5%	6	12

Note: In brackets – equivalent metrics considering entrant licences only

Table 7: Premium paid for licence containing sub-1GHz and 1800MHz spectrum relative to 1800MHz only

Country	Auction	Date	Auction average value per MHz per pop in local currency of licence(s) comprising sub-1GHz and 1800MHz spectrum	Auction average value per MHz per pop in local currency of licence(s) comprising 1800MHz spectrum only	Premium of licence containing sub-1GHz spectrum
Bulgaria	2nd GSM Licence Auction	18 Dec 2000	BGN2.61	NA	457%

	4th GSM License	18 Jul 2008	NA	BGN0.469	
Greece	2G	17 Jul 2001	€0.237	€0.150	58%

208. Table 8 below summarises the Country Relative Band Value for six countries which have held auctions for both sub-1GHz and 1800MHz frequencies. This considers *separate* auctions for the two categories of spectrum held in the same country, but at different times. It is important here that the economic and market conditions at the time when these licences were auctioned are comparable, otherwise the relative band value ratios would not be a good approximation of the relative market value of 1800MHz spectrum versus sub-1GHz spectrum.

Table 8: Relative band value within a country

Country	Auction	Date	Auction average licence price per MHz per pop in local currency	Relative band value of 1800 MHz to sub-1GHz within a country	Number if sub-1GHz lots sold in country	Number of 1800 MHz lots sold in country
Australia	First PCS 800MHz and 1800MHz	20 Apr 1998	Sub-1GHz: AUD0.156	4.53	68	222
			1800MHz: AUD0.090			
	Second PCS 800MHz and 1800MHz	15 Sep 1998	Sub-1GHz: AUD0.144			
			1800MHz: AUD0.085			
	Third PCS 800MHz	3 May 1999	Sub-1GHz: AUD0.016			
	PCS 2000	15 Mar 2000	1800MHz: AUD1.258			
Austria	GSM auction	1 Aug 1997	1800MHz: €0.559	4.93	5	6
	4th GSM auction	3 May 1999	1800MHz: €0.371			
	GSM	7 May	1800MHz:			

Country	Auction	Date	Auction average licence price per MHz per pop in local currency	Relative band value of 1800 MHz to sub-1GHz within a country	Number if sub-1GHz lots sold in country	Number of 1800 MHz lots sold in country
	1800MHz	2001	€0.204			
	GSM 2002	14 Oct 2002	1800MHz: €0.117			
	GSM 2004	11 Oct 2004	Sub-1GHz: €0.00603			
			1800MHz: €0.00561			
	900MHz	29 Sep 2008	Sub-1GHz: €0.0498			
Brazil	2G licences	27 Dec 2007	Sub-1GHz: BRL0.206	0.501	8	69
			1800MHz: BRL0.103			
Germany	GSM1800 MHz	1 Oct 1999	1800MHz: €0.154	0.124	6	15
	800MHz, 1800MHz, 2.1GHz and 2.6GHz	21 May 2010	Sub-1GHz: €0.724			
			1800MHz: €0.0254			
Norway	E-GSM	31 Oct 2001	Sub-1GHz: NOK2.04	0.450	6	2
	GSM 1800MHz	6 Dec 2001	1800MHz: NOK0.918			
US	Auction 1 – Nationwide Narrowband	29 Jul 1994	Sub-1GHz: US$3.65	0.588	2230	3074
	Auction 3-Regional Narrowband	10 Nov 1994	Sub-1GHz: US$5.20			

Country	Auction	Date	Auction average licence price per MHz per pop in local currency	Relative band value of 1800 MHz to sub-1GHz within a country	Number if sub-1GHz lots sold in country	Number of 1800 MHz lots sold in country
	Auction 4 – Broadband PCS A and B Block	13 Mar 1995	1800MHz: US$0.544			
	Auction 5- Broadband PCS C Block	6 May 1996	1800MHz: US$1.28			
	Auction 10 – PCS C Block Re-auction	16 Jul 1996	1800MHz: US$2.56			
	Auction 11 – Broadband PCS D and E & F block	14 Jan 1997	1800MHz: US$0.364			
	Auction 22 – C, D, E and F block Broadband PCS	15 Apr 1999	1800MHz: US$0.116			
	Auction 35 – C and F block Broadband PCS	26 Jan 2001	1800MHz: US$2.62			
	Auction 41 – Narrowband PCS	18 Oct 2001	Sub-1GHz: US$0.0409			
	Auction 51 – Regional Narrowband PCS	25 Sep 2003	Sub-1GHz: US$0.00247			
	Auction 50	29	Sub-1GHz:			

Country	Auction	Date	Auction average licence price per MHz per pop in local currency	Relative band value of 1800 MHz to sub-1GHz within a country	Number if sub-1GHz lots sold in country	Number of 1800 MHz lots sold in country
	– Narrowband PCS	Sep 2003	US$0.0378			
	Auction 58 – Broadband PCS	15 Feb 2005	1800MHz: US$0.739			
	Auction 71 – Broadband PCS	21 May 2007	1800MHz: US$0.357			
	Auction 73 – 700MHz	18 Mar 2008	1800MHz: US$1.09			
	Auction 78 – Broadband PCS	20 Aug 2008	1800MHz: US$0.268			

209. Of the country relative band values in Table 8, we consider that the Country Relative Band Value observed in Norway and the US to be reasonable approximations to the competitive relative market value of 1800MHz to sub-1GHz spectrum. In Norway, the E-GSM auction and 1800MHz auctions were held only a few months apart, using the same auction format. In the US, numerous PCS auctions and one 700MHz auction have been held between 1994 and 2008. While it can be expected that economic and market conditions faced by bidders in these auctions vary over time, both the sub-1GHz and 1800MHz spectrum auctions span across the 14-year period, which serves to net out to an extent these differing economic and market factors which would affect valuations for both these categories of spectrum at particular points in time.

210. The average price per MHz per head of population in Australia's PCS auction of 1800MHz spectrum in 2000 was much higher than that of the 1800MHz spectrum in the first and second PCS auctions in 1998. The PCS 2000 auction occurred around the time of the telecoms bubble at the turn of the millennium that also saw record spectrum prices achieved

globally, including in the UK and German 3G auctions. Overall, the inflationary impact of the PCS 2000 auction result on the value of 1800MHz spectrum in Australia does not present an accurate reflection of the relative value of sub-1GHz and 1800MHz spectrum in Australia. While the Country Relative Band Value for Australia does not constitute a good indicator of the relative band value of the frequencies, the consistency of the Award Relative Band Values from the first two PCS auctions in 1998 suggests that at least *within* auctions, the relative values of the bands are stable despite common factors shifting the value of all the bands (such as the 2000 bubble).

211. Austria has held several GSM auctions between 1997 and 2008, though mainly for 1800MHz spectrum. The instances in which the Austrian regulator has sold sub-1GHz spectrum were in the GSM auction in 2002 and subsequently in 2004 (which were both uncompetitive and lots were awarded at reserve prices) and more recently in 2008 in an auction process where three bidders competed for a single block of 2x0.8MHz in the 900MHz band (which would not be sufficient for an entrant business case and would be more attractive to incumbent operators seeking to marginally expand their existing spectrum holdings). Hence, overall, the Country Relative Band Value of 4.93 in Austria in Table 8 below is unlikely to reflect that of a competitive market for equivalent business case scenarios for 1800MHz versus sub-1GHz spectrum.

212. In Germany, we have explained above that the results of the German auction in May 2010 do not reflect a true and undistorted relative band valuation for 1800MHz and sub-1GHz spectrum. The other relevant auction in Germany was a GSM1800MHz auction in 1999 for which 2x10MHz of spectrum was sold. Given the discrete nature of the two auctions a decade apart, the respective economic and competitive conditions under which spectrum was valued by bidders in these auctions are unlikely to be similar. Therefore, the relative band value in Germany across these different auctions is not a good representation of the relative market value of the frequencies concerned, not least as spectrum in the most recent auction in May 2010 was awarded on a liberalised basis.

213. We should only be guided by the Country Relative Band Value when we can reasonably expect this ratio to reflect a competitive relative market valuation for 1800MHz and sub1-GHz spectrum across auctions of these frequencies where roughly comparable economic and market conditions apply. Limiting ourselves to these cases suggests a relative band value of approximately **45%-60%**. This is consistent with the range of award band values (i.e. ratios of value within a single award process).

7.3 Other evidence of relative band value

214. Ovum completed a report for the GSMA studying the market of UMTS900 technology in 2007[22]. They analysed the network cost of a UMTS900 network versus that of a UMTS2.1GHz network for markets in Western

[22] Ovum, 2007, "Market Study for UMTS900 – A report to GSMA".

Europe, Asia Pacific, Middle East and Sub-Saharan Africa, considering both the case where an operator utilised only 900MHz spectrum and where the operator utilised both 900MHz and 2.1GHz spectrum for UMTS. The study found that the cumulative CAPEX cost over a 5 year period for a UMTS900 operator would be around 60% that of a UMTS2.1GHZ operator. For an operator with both 900MHz and 2.1GHz spectrum, its cumulative CAPEX cost over a 5-year period is between 70%-80% that of an UMTS2.1GHz operator.

215. This is consistent with the Vilicom Report (09/41a) for ComReg on UMTS network design and cost, which estimates the deployment cost for national UMTS900, UMTS1800 and UMTS2.1GHz networks in Ireland. Vilicom's findings suggest that the deployment cost of a UMTS900 network is 65.5% of the cost of deploying a UMTS2100 network. Hence the case findings for the "Western Europe" case study in the Ovum study should be applicable to Ireland.

216. In particular, we note that the Ovum study also included a Net Present Value (NPV) analysis on potential improvement in cash flows of a UMTS900 operator (and of a UMTS900 and 2.1GHz operator) against that of a UMTS2.1GHz operator, taking into account revenues from the service usage against the cost savings mentioned above and their evolution over time. NPV improvements ranged from 30% for a UMTS900 and 2.1GHz operator to 70% for a UMTS900 only operator. This analysis takes into account that network cost savings from deploying UMTS at 900MHz would be re-invested in extending coverage, thereby attracting more customers. While we note that the analysis only considers the NPV over a 5-year period, the majority of differences in NPV between the two business cases concerned should be reflected in this period or we could treat the NPV improvements of 30%-70% as a lower bound value to actual respective NPV improvements.

217. Bidders' valuations of spectrum licences are generally based on the difference in expected cash flows with and without the spectrum considered. Therefore a 30%-70% improvement in cash flows would translate into a relative band value of 2.1GHz to 900MHz of approximately 60%-75% (or lower if 30%-70% constitutes a lower bound estimate to NPV improvements as mentioned above). This range would be discounted by an operator's mark-up of profits over cost should this be positive. We expect this mark up value to be small in a competitive telecommunications market.

218. Further, we would expect that the relative band valuation from such business case modelling for 1800MHz to sub-1GHz spectrum would be of a broadly similar magnitude to that of 2.1GHz to 900MHz spectrum examined in the Ovum report, as the propagation characteristics of 800MHz and 900MHz spectrum are roughly comparable, as should be the case for higher frequency spectrum between 1800MHz and 2.1GHz. Indeed, the Vilicom Report (09/14a) notes that the deployment cost of a UMTS1800 network is about 90% that of an UMTS2.1GHz network.

219. Overall, these studies on the network cost of rolling out UMTS using higher frequency spectrum versus that of sub-1GHz spectrum produces relative band valuations estimates that are consistent with our

benchmarking results that the relative band value of 1800MHz to sub-1GHz spectrum is within the range of 45%-60%.

7.4 Recommendation of a minimum price for 1800MHz spectrum

220. The results from the benchmarking analysis in Section 7.2 above suggest that consistent with both Award and Country Relative Band Values, the relative competitive market value of 1800MHz spectrum to that of sub-1GHz spectrum is 45%-60%. Applying this ratio to the conservative lower bound value estimate of sub-1GHz spectrum of €18-€26m for a 2x5MHz licence from 10/71b would yield a conservative lower bound range of approximately €8m-€16m for an equivalent licence in the 1800MHz band.

221. A tension exists between ComReg's objectives of setting a higher minimum price to guard against uncompetitive outcomes in the 1800MHz band in the auction and the greater risk of choking off efficient demand in the 1800MHz band. In particular, we note that where there are stronger concerns about uncompetitive scenarios in the auction for the 1800MHz band, a higher minimum price would be more discouraging of such outcomes; and where there are greater uncertainties over the market valuation of 1800MHz frequencies in Ireland a lower minimum price would minimise the risk that efficient demand may be choked off.

222. Setting a minimum price for 1800MHz lots within this range of €8m-€16m should represent a conservative lower bound value of the 1800MHz band in Ireland and thus limit the risk of choking off efficient demand. Therefore, strong concerns about potentially uncompetitive outcomes including those caused by tacitly collusive behaviour among bidders may warrant a minimum price towards the higher end of this range. Where such outcomes are less of a concern in the 1800MHz band, ComReg may wish to consider setting a minimum price more moderately within this range to better ensure efficiency of the auction process by minimising the risk of choking off efficient demand.

223. Non-trivial annual fees on licences (Spectrum Usage Fees (SUFs) in the Irish context) will discourage spectrum hoarding after the 1800MHz licences have been allocated, which is of particular importance in Ireland to ensure efficient use of allocated spectrum given the current absence of spectrum trading. We note that the revised EU framework for electronic communications networks and services[23] would allow spectrum trading in Member States. . Non-trivial SUFs will present an additional opportunity cost of holding spectrum which in turns applies pressure to trade any inefficiently used or hoarded spectrum.

224. Regarding the split of minimum prices into upfront and ongoing fees, we consider that there is no significant benefits from choosing a split of upfront reserve price and annual SUFs of the minimum price of 1800MHz

[23] See Article 9b of Directive 2002/21/EC of 7 March 2002 on a common regulatory framework for electronic communications networks and services (OJ L 108, 24.04.2002), amended by Directive 2009/140/EC (OJ L 337, 18.12.2009) and Regulation 544/2009 (OJ L 167, 18.6.2009).

spectrum that is different to that for sub-1GHz spectrum (i.e. 50/50). Indeed, if the balance between upfront charges and ongoing SUFs were different for different bands, there is a risk that choices between bands might be distorted by different payment terms (though this is less important as auction prices rise above the minimum price level). This would mean that the choice of spectrum across bands was not being made on the basis of network efficiency.

225. The suggested apportioned annual SUF should be sufficient to incentivise efficient use of spectrum and discourage spectrum hoarding by incumbents. Assuming a minimum price of €12.5m for a 2x5MHz 1800MHz licence (50% of the currently proposed minimum price of €25m for an equivalent sub-1GHz licence), the proposed annual SUFs for 1800MHz frequencies with a 50/50 split would be approximately 60% higher than current SUFs levels of existing 1800MHz operators. Therefore, it should present a higher disincentive to hoard spectrum as compared to current fees.

226. Therefore, we propose a 50/50 split for the minimum price of 1800MHz spectrum licences to be broken down into upfront reserve price and annual SUFs for the 2-time slice option as per Table 9 below. (The table also includes the breakdown between upfront reserve prices and SUFs for a 2x5MHz sub-1GHz licence). In this table, we have assumed a minimum price of €12.5m for a 2x5MHz 1800MHz licence, that is as above, 50% (close to the median in the 45%-60% range discussed above) of the minimum price currently proposed in 10/71 for sub-1GHz frequencies.

Table 9: Breakdown of minimum price into reserve price and SUFs for a 2x5MHz block with two time slices.

Frequency	Minim-um Price in May 2010 prices	Propor-tion of minim-um price in SUF	Disc-ount fact-or	Annual SUF in May 2010 prices	Reserve price for 2013-Jun 2015 licence (2.5 years) in May 2010 prices	Reserve price for Jun 2015-Jun 2030 licence (15 years) in May 2010 prices
1800MHz	€12.5m	50%	10.2%	€0.75m	€1.72m	€4.36m
Sub-1GHz	€25m	50%	10.2%	€1.52m	€3.44m	€8.73m

8 Coverage obligations

8.1 Coverage obligations for sub-1GHz spectrum

227. In its third consultation on the future award of spectrum in the 900MHz and 1800MHz bands (09/99)[24] ComReg observed that existing incumbents (that is, holders of spectrum licences in the 9000MHz, 1800MHz and/or 2.1GHz bands) have all exceeded the minimum coverage levels associated with their spectrum licences (see Tables 10 and 11 of ComReg document 09/99). Hence if licensees were permitted to use multiple frequency bands (1800MHz and 2.1GHz) to meet its coverage obligation as a result of winning liberalised 900MHz spectrum in an auction, it is reasonable to assume that existing incumbents would be able to achieve and sustain 90% geographic coverage within 3 years of the licence commencement date with coverage from national roaming agreements counting towards this coverage requirement.

228. For new entrants, ComReg proposed in this same consultation (09/99) that a new entrant would be given a longer period to meet equivalent rollout obligations to incumbents. The following coverage obligations were proposed:

- 30% of geographical coverage within 4 years of the licence commencement date;
- 70% of geographical coverage within 7 years of the licence commencement date; and
- 90% of geographical coverage within 10 years of the licence commencement date.

229. The proposed coverage obligations allowed national roaming coverage levels to count towards the coverage requirements. In its subsequent consultation paper on the release of 800MHz, 900MHz and 1800MHz spectrum (10/71)[25] however, taking into account the responses to its 09/99 consultation and the implications of awarding 800MHz spectrum alongside 900MHz, ComReg proposed a revised coverage obligation of 70% of population coverage within 3 years for all existing mobile incumbents and 70% of population coverage within 7 years for new entrants. Coverage achieved from national roaming deals would not count towards this coverage obligation level and 50% coverage would be required using the 800/900MHz bands in order to ensure a minimum deployment level in these bands.

230. In the remainder of this section, we consider the appropriate coverage levels to be required from 1800MHz licensees resulting from the

[24] ComReg, 2009, 09/99, *'Liberalising the future use of the 900MHz and 1800MHZ spectrum bands, Response to Consultation 09/14 and Further Consultation'*, Section 15.5.4.4.

[25] ComReg.2010, 10/71, *'800MHz, 900MHz & 1800MHz spectrum release, Consultation Paper'*, Section 4.6.3.

upcoming auction where 1800MHz spectrum is auctioned alongside 800MHz and 900MHz frequencies. In doing so, we consider the international practice of setting coverage obligations on these frequencies and recommend coverage obligations for 1800MHz licensees considering the specific conditions of the Irish market and the upcoming auction.

8.2 International experience of coverage obligations for mobile frequencies

231. In Table 10 below we survey the required coverage and/or rollout obligations of upcoming awards of sub-1GHz and/or higher frequency spectrum (1800MHz, 2.1GHz and 2.6GHz) and in Table 11 we look at the coverage and/or rollout obligations of licences in these frequencies that have already been awarded.

232. Generally, for all of these frequencies other than 2.6GHz spectrum, National Regulatory Authorities (NRAs) have specified some level of rollout or coverage obligation on mobile spectrum licences. In cases where incumbents' existing spectrum in the 900MHz and 1800MHz bands have both been liberalised (for instance in Denmark, Sweden and Finland) the coverage obligation levels set by the NRAs concerned is typically for incumbents to maintain existing voice coverage levels. Further, where existing incumbents win 900MHz and 1800MHz frequencies within an auction, for instance in Denmark, Singapore, Austria and Hong Kong, NRAs generally do not require any change to levels of coverage hence mainly require operators to maintain existing coverage[26]. Of the countries we observed, only in France did ARCEP impose more demanding coverage obligations when liberalising existing licences, increasing coverage requirements from 90% to 99% of population in metropolitan France[27].

233. In the cases referenced above, where the incumbent operators hold 900MHz and 1800MHz licences, coverage obligations for 900MHz spectrum versus that of 1800MHz were not differentiated. Often, in these cases, the coverage obligation has been defined in terms of a service obligation (for example, public mobile telecommunications) and NRAs have not been prescriptive about how the service obligation must be met. In Sweden for instance, the manner in which coverage levels are to be met is specified to be frequency band neutral.

234. However, where coverage obligations are specific to 1800MHz licences, it is common that less onerous conditions are placed on 1800MHz spectrum as compared to those on sub-1GHz frequencies. For instance, in the Netherlands, coverage obligations for higher frequency spectrum is less onerous in terms of the required scope of geographical coverage. In Germany, while overall population coverage obligations on 1800MHz

[26] Presumably existing coverage in these countries are already sufficiently high and there are no significant social benefits from demanding higher coverage levels from existing operators.

[27] Metropolitan France includes mainland France and the island of Corsica but excludes overseas French territories (Martinique, Guadeloupe, Réunion, and French Guiana).

frequencies are equivalent to those of the 800MHz band as specified for the German auction in May 2010 (50% of the population by the beginning of 2016), there were significantly more onerous coverage obligations prescribed to 800MHz licensees for at least one operator to serve the most rural areas before being permitted to roll out services in more urban locations. Similarly, coverage obligations for 1900MHz spectrum in the US are less demanding both in terms of the scope of coverage required and the time frame to meet the coverage obligations compared to 700MHz spectrum.

235. We also note that in the Netherlands and in the US, the level of required coverage on licensees of 1800MHz frequencies (1900MHz in the US) is increasing with the amount of spectrum held in the band. In the Netherlands this is specified as the land area that has to be covered per 5MHz paired block held, and in the US this is specified according to the size of the spectrum block held – a 30MHz block is associated with a higher coverage scope within the same time frame of that required for a 10MHz or 15 MHz block as well as an overall higher coverage requirement that is not imposed on licensees with 10MHz or 15MHz blocks.

Table 10: Information on upcoming awards regarding coverage and roll out obligations

Country	Frequency	Award date	Coverage Requirement
Europe			
Sweden	800MHz	Scheduled to be awarded in 2011, currently consulting	PTS is current consulting on its proposals to impose roll-out and coverage obligations to provide broadband access to fixed dwellings and business premises, which do not have broadband access by any other means on one specific block out of the six available blocks of 2x5MHz of the digital dividend spectrum in Sweden. These required roll-out locations are identified by PTS via their annual broadband mapping, currently 2800 locations are showed to lack broadband access. PTS will publish this list of locations by 31 Dec 2011: • 25% of these locations have to be covered by 31 Dec 2012; • 75% of these locations have to be covered by Jan 2013; and • 100% by 31 Dec 2014 PTS have specified the required level of service to be broadband speed of at least 1Mbps or higher, at a level defined by the government to be a speed at which would serve "functional internet access" Coverage has to be provided by infrastructure using the 800MHz frequencies however more cost effective mean may also be proposed. If there is excess demand for this lot, the lot will be auctioned off along with the other 5 blocks. A bid price of up to SEK300m (approximated €32m) set by PTS as an approximate to the maximum cost of required coverage, may be retained by the bidder to fund the roll out cost for the required coverage; any incremental bid value exceeding this SEK300m cap, is retained by PTS as auction revenues.
The Netherlands	800MHz, 900MHz, 1800MHz, 2.1GHz and	Scheduled to be awarded in 2011, currently consulting	Current consultation suggest a geographical coverage obligation based on the type of frequency and the amount of a particular frequency held by an operator: Within 2 years of award, for every 5MHz of spectrum held, a licensee has to roll out to an

Country	Frequency	Award date	Coverage Requirement
Europe			
	2.6GHz (unpaired)		area of: • 800MHz – 180km^2 • 900MHz - 144km^2 • 1800MHz - 40km^2 • 2.1GHz - 30km^2 • 2.6GHz - 20km^2 Within 5 years of award, for every 5MHz of spectrum held, a licensee has to roll out to an area of: • 800MHz – 1800km^2 • 900MHz - 1440km^2 • 1800MHz - 400km^2 • 2.1GHz - 300km^2 • 2.6GHz - 200km^2 The total land area in the Netherlands is 33,881km^2.[28]

[28] Ministerie van Economische Zaken (September 2010), 'Consultatiedocument met betrekking tot strategische nota mobiele communicate'

Country	Frequency	Award date	Coverage Requirement
Europe			
Malta	900MHz and 1800MHz	Scheduled to be awarded in 2010 depending on demand	Nationwide service coverage within 24 months of the conclusion of the award process
Asia Pacific			
Hong Kong	900MHz	Scheduled to be awarded at the end of 2010	Consultation on the proposed auction and licence conditions recommended a coverage obligation of 50% of population within 5 years[29]

Table 11: Information on completed awards regarding coverage and roll out obligations

Country	Frequency	Award date	Coverage Requirement
Europe			
Denmark	900MHz and 1800MHz	Licences awarded in December 2009, new licences awarded in October 2010	Liberalised licences carry the same coverage obligations as original licences except that the method in which such obligation can be met is technologically neutral. No coverage or roll-out obligations were specified in the Information Memorandum for the auction for 900MHz and 1800MHz spectrum freed up by the re-farming in proposed October 2010 auction.

[29] Coverage refers to network and service coverage. The band is currently used for GSM and is designated for public mobile services. The TA is also inclined to require the successful bidder to lodge a performance bond to ensure its compliance with the rollout obligations.

Country	Frequency	Award date	Coverage Requirement
Denmark	2.5GHz	May 2010	No coverage or roll-out requirements apply
Austria	2.6GHz	September 2009	Licensees are required to provide services to 25% of the population by 31/12/2013 with a minimum standard of 1MBit/s downlink speed and 256kBit/s uplink speed.
Austria	900MHz	September 2008	Should the frequencies be acquired by an applicant who has not previously been allocated frequencies in the GSM-900 or GSM-1800 range, the frequency allocation will be subject to the following levels of population coverage: • 5% coverage by December 31, 2009; • 10% coverage by December 31, 2010

Country	Frequency	Award date	Coverage Requirement
			The level of coverage is to be offered using an independently operated network.
Germany	800MHz	May 2010	(1) Minimum population coverage of 50% by each licensee by 01/01/2016[30] (2) Four roll-out categories in each Federal state were set out with a requirement that the roll out obligation has to be completed in ascending categories (roll our to rural areas first). The categories are defined as follows: • Category 1: underserved rural areas (pop<5001, but Federal States can determine whether other areas are underserved as well), minimum 90% coverage** • Category 2: 5000<pop<20,001, min. 90% coverage** • Category 3: 20000<pop<50,001, min. 90% coverage** • Category 4: 50000<pop, min. 90% coverage** Only once 90% coverage of a category has been met (where an area only needs to be covered by one operator to meet the coverage requirement) can operators then begin rollout to areas in the next category up The BNetzA also requires all winners of this spectrum to achieve coverage of 90% of the entire population in all underserved areas of each federal state by 1 January 2016
Germany	1800MHz, 2.1GHz and 2.6GHz	May 2010	Licensees of spectrum in the 1800MHz, 2.1GHz and 2.6 GHz bands are required to cover at least 25% of the population by 1 January 2014 and at least 50% of the population by 1 January 2016. The parameters to be observed will be determined subsequently in light of the technology deployed.

[30] The coverage requirement does not refer to any particular service but this frequency band was designated for mobile services with a preference for services providing high-speed internet to rural areas

Country	Frequency	Award date	Coverage Requirement
The Netherlands	2.6GHz	April 2010	Operators are required to roll out a network within 2 years.
Finland	2.6GHz	November 2009	There were no roll-out obligations specified though the Finnish government can cancel a licensee's licence if it has not within two years of the start of the licence period started operations in practice in accordance with the licence, unless due to technological development or overall economic conditions and by the licence holder's application the Finnish government orders otherwise.
France	2.1GHz	October 2009	The fourth 3G licensee in France will have to build a network to cover 25% of the French population before it can reach a roaming accord with other operators. The licensee must roll out to at least 25% of the population within two years (without roaming) and 80% of the population within eight years. Telephony, messaging, Internet access and service data transmission, with a success rate of at least 90% for each service must be offered in the covered areas. When the licensee has met its coverage obligation of 25% of the population, the licensee will receive, for six years, a right to roaming GSM on one of the three existing mobile networks. In addition, the operators of existing 2G/3G sites will be required to share these sites with the licensee, allowing the licensee to co-locate its 3G equipment. If these roll-out obligations are met, the licensee will be awarded 2x5MHz in the 900MHz band on 31December 2012 in very dense areas.
France	900MHz and 1800MHz	Renewed for various operators across 2006 and 2007	Operators are to ensure metropolitan coverage of white areas (busy areas such as town centres, tourist areas, and priority transport links). Including these white areas, operators are to cover 99% of the metropolitan population and the main roads in each country. Within the coverage obligations, operators are required to provide a minimum standard of service defined as - in addition to telephony services, at least: • One form of messaging communication service such as MMS, SMS or email; • At least one transfer and packet data services such as GPRS; and

Country	Frequency	Award date	Coverage Requirement
			• At least one service based on the location of the user
Sweden	900MHz	March 2009	Maintain percentage area coverage per county for a mobile telephony service that is currently being maintained until 31/12/15. Coverage may be provided by using one's own or another licence holder's infrastructure in the 900MHz, 1800MHz and 2.1GHz bands.
Sweden	2.6GHz	May 2008	No coverage or roll-out requirements apply
Poland	900MHz	December 2008	Both E-GSM licensees undertook commitments to launch the provision of services based on granted frequency resources within 24 months. The companies are also obliged to meet population coverage criteria of at least 30% by the end of 2009, 55% by the end of 2010 and 80% by the end of 2012.
Norway	2.6GHz	November 2007	No coverage or roll-out requirements apply.
Iceland	1800MHz	April 2007	The minimum requirement for each frequency rights holder is that the GSM service reach at least 40% of Icelanders no later than 1.5 years (18 months) after the issuance of the frequency authorisation. The GSM service must reach at least 60% of Icelanders three (3) years after the issuance of the frequency authorisation. It is required that the frequency authorisations be brought into use within twelve (12) months from their issuance. Otherwise, PTA reserves the right to cancel the frequency authorisation. An area is considered to have GSM service if the field strength, as measured outdoors at a height of 1.5m, is at least 64 dB µV/m.
Macedonia	900MHz and 1800MHz	February 2007	The license conditions include a requirement to launch operations within 6 months following the licence grant date and to provide coverage of 30% of the population within 12 months after the grant date. 50% of the population has to be covered within 24 months and 90% of the population has to be covered within 48 months.

Country	Frequency	Award date	Coverage Requirement
Asia-Pacific			
Hong Kong	1800MHz	June 2009	Only existing mobile operators could bid for the 6 blocks (0.8MHz paired each) of spectrum as addition capacity to expand provision of public mobile telecommunication services in Hong Kong, hence there were no coverage obligations other than those attached to their existing mobile spectrum frequency licences.
Hong Kong	2.6GHz	January 2009	Roll out obligation was service dependent: (a) where the scope of the service authorised under the Licence includes a fixed service, coverage of the network and the service shall be provided within 5 years from the issue of the Licence and maintained thereafter, to a minimum of 200 commercial and/or residential buildings in Hong Kong; AND (b) where the scope of the service authorised under the Licence includes a mobile service, coverage of the network and the service shall be provided within 5 years from the issue of the Licence and maintained thereafter, to an area where at least 50% of the population of Hong Kong live from time to time.
India	2.1GHz	May 2010	Licensees of metro areas shall be required to provide service in at least 90% of the service area, street coverage in the relevant service area, within five years. Licensees of category A, B and C services areas shall ensure that at least 50% of the District Headquarters ("DHQ") in the service area will be covered, out of which at least 15% of the DHQs should be rural Short Distance Charging Areas ("SDCA")[31], within five years of the Effective Date. Further: • The operator shall also be permitted to cover any other town in a District in lieu of the DHQ; • Coverage of a DHQ/ town would mean that at least 90% of the area bounded by the

[31] SDCA is defined as per the definition used by the Census of India. Rural SDCA is defined as an area where 50% of the population lives in the rural areas.

Country	Frequency	Award date	Coverage Requirement
			Municipal limits should get the required street coverage in the relevant service area; • The choice of DHQs/ towns to be covered and further expansion beyond 50% of DHQs/ towns shall lie with the operator. The start date against which obligations will be linked shall be the later of the date when the spectrum is allocated and the date when a licence to operate services, if applicable, is granted to the operator. If the licensee does not achieve its roll out obligations, it shall be allowed a further period of one year to do so by making a payment of 2.5% of its successful bid amount (i.e. spectrum acquisition price) per quarter or part thereof as liquidated damages. If the operator does not complete its roll out obligations even within the extended period of one year, the spectrum assignment shall be withdrawn.
Singapore	1800MHz	February 2009	Licensees that do not already have a nationwide Public Cellular Mobile Telecommunications Service network are required to roll out a nationwide Public Cellular Mobile Telecommunication Service network in 2 years.
Singapore	900MHz and 1800MHz	February 2008	Licensees that do not already have a Public Cellular Mobile Telecommunications Service network are required to launch a nationwide coverage of Public Cellular Mobile Telecommunication Services within 2 years
Singapore	2.1GHz	October 2009	Licensees carry a requirement to roll out 3G mobile communication systems and services nationwide and provide coverage for the whole island of Singapore (including Mass Rapid Transit underground stations/lines and road tunnels), the offshore islands and the territorial waters up to 15 km from the coastline of Singapore. The timeline for providing these services differs for entrants and existing 3G operators: New entrants will be required to provide 3G systems and publicly available services nationwide within 2 years from the date of grant of the 3G Spectrum Right (2010). Existing 3G operators are required to put the spectrum to use for the provision of publicly available 3G services within 1 year from the date of grant.
New Zealand	800/900MHz	Offered in November 2007	Within five years of purchase: • The licensee must provide a cellular service that is available for use by, and is being

Country	Frequency	Award date	Coverage Requirement
			offered for use on a commercial basis to, at least 65% of New Zealand's resident population without relying on infrastructure (including networks) provided by persons other than the licensee; and • The cellular service provided must operate 24 hours per day, seven days per week (excluding reasonable outages including those for maintenance and construction.
Australia	800MHz	Awarded between 1998-1999	There is no coverage obligations in the original PCS 800MHz licences described in the auction documentation It is not clear what the licence conditions on coverage will be for re-farmed spectrum and for digital dividend spectrum
North America			
Canada	2.1GHz	May 2008	Between 10% and 50% of the regional population (licences were regional) within 5 years. Roll out obligation was with reference to Advanced Wireless Services and was roughly proportional to population density of the region[32]
USA	1900MHz and 2.1GHz	August 2008	AWS licensees (2.1GHz licensees) must make a showing of "substantial service" in their license areas within the prescribed license term. "Substantial" service is defined as service that is sound, favourable, and substantially above a level of mediocre service which just might minimally warrant renewal. Any licensee that fails to meet this requirement will forfeit its license and the licensee will be ineligible to regain it. Broadband PCS licensees must serve at least one-quarter of the population in their licensed area or make a showing of "substantial service" in their licensed area within five years of the original license date. These construction requirements refer to licenses consisting of 10 MHz and 15 MHz blocks.

[32] See Annex 2 of Industry Canada's *Policy Framework for the Auction for Spectrum Licences for Advanced Wireless Services and other Spectrum in the 2 GHz Range* for the regional breakdown of roll out targets.

Country	Frequency	Award date	Coverage Requirement
			Broadband PCS licensees of 30MHz blocks must serve with a signal level sufficient to provide adequate service to at least one-third of the population in their licensed area within five years of being licensed and two-thirds of the population in their licensed area within ten years of being licensed. Licensees may, in the alternative, provide substantial service to their licensed area within the appropriate five- and ten-year benchmarks. Broadband PCS Licensees (1900MHz licensees) have a renewal expectancy based on the provision of substantial service and substantial compliance with applicable Commission rules, policies, and the Communications Act.
USA	700MHz	March 2008	Licensees must provide signal coverage and offer service[33] to (1) at least 35% of the geographic areas of their licences within four years of the end of the DTV transition, and (2) at least 70% of the geographic areas of their licences at the end of the licence term.
USA	1900MHz	May 2007	Licensees of 30MHz blocks must serve with a signal level sufficient to provide adequate service to at least one-third of the population in their licensed area within five years of being licensed and two-thirds of the population in their licensed area within ten years of being licensed. Licensees may, in the alternative, provide substantial service to their licensed area within the appropriate five- and ten-year benchmarks. Licensees of 10MHz or 15MHz blocks must serve at least one-quarter of the population in their licensed area or make a showing of "substantial service" in their licensed area within five years of the original license date. Failure by any licensee to meet these requirements will result in forfeiture or non-renewal of the license and the licensee will be in- eligible to regain it.

[33] The 700 MHz Band licences may be used for flexible fixed, mobile, and broadcast uses, including fixed and mobile wireless commercial services (including FDD- and TDD-based services); fixed and mobile wireless uses for private, internal radio needs; and mobile and other digital new broadcast operations. These uses may include two-way interactive, cellular, and mobile television broadcasting services.

Country	Frequency	Award date	Coverage Requirement
South America			
Brazil	800MHz and 1800MHz	December 2007	Licences should: • Within 12 months, to cover 50% of urban areas in 50% of state capitals and municipalities with more than 500,000 inhabitants and also in Region II and Federal Districts; • Within 24 months, fully cover the state capitals, municipalities with more than 500,000 inhabitants and also Region II and Federal Districts; • Within 36 months, to cover 50% of urban areas in 50% of municipalities with more than 200,000 (but less than 500,000) inhabitants; • Within 48 months, fully cover the municipalities with more than 200,000 (but less than 500,000) inhabitants; • Within 60 months, fully cover municipalities with more than 100,000 (but less than 200,000) inhabitants; and Full coverage for a location is deemed met when at least 80% of urban areas in the location are covered.

8.3 Recommended obligations for 1800MHz spectrum in Ireland

236. Taking into account international experience and the relative propagation characteristics of sub-1GHz and 1800MHz spectrum, we would support less onerous coverage obligations on 1800MHz frequencies compared with frequencies under 1GHz. Going down the route of setting less onerous coverage obligations for 1800MHz spectrum relative to sub-1GHz spectrum and making the manner in which coverage obligations have to be met frequency band neutral (across bands auctioned - 800MHz, 900MHz as well as other mobile spectrum holdings, i.e. 2.1GHz)[34] would imply that 1800MHz licence coverage conditions would be binding only for a bidder that wins 1800MHz spectrum only; if a bidder were to win both sub-1GHz and 1800MHz spectrum, its coverage obligations as a result of being awarded spectrum in the 1800MHz band would be met by meeting the coverage obligations linked to its sub-1GHz licence. Thus in setting the relevant coverage obligations for 1800MHz spectrum, the key consideration for ComReg is the appropriate level of coverage obligation for an entrant winning 1800MHz spectrum only. Further, we consider the case of an existing incumbent (which comprises Vodafone, O2, Meteor or H3GI) winning 1800MHz spectrum only below.

237. The existing coverage obligations of 3G licensees imposed on entrants (for example H3GI in 2002 when the 3G licences were awarded) were less demanding than those on incumbents (mobile operators with 900MHz and/or 1800MHz spectrum) in terms of the speed of rollout defined for entrants to reach the specified coverage levels[35]. In particular, we note that these rollout targets were pre-offered in a beauty contest to award the licences in 2002 rather than a specified licence condition.

238. In a similar vein for sub-1GHz spectrum, ComReg has proposed in 10/71 that an entrant would enjoy a longer period to fulfil an equivalent level of coverage obligation (70% of population) required of sub-1GHz licensees. Thus it would be consistent with ComReg's existing policies on coverage obligations and with international experience to place less onerous obligations on an entrant winning spectrum in the 1800MHz band.

239. Given the similar propagation characteristics of 1800MHz and 2.1GHz spectrum, it would be sensible that the obliged scope of coverage set for the 1800MHz spectrum and time periods within which these obligations have to be met be comparable to that for 2.1GHz spectrum, as one can expect comparable business case scenarios for rollout of services using

[34] See 10/71 Section 4.6.2 and 4.6.3 for a discussion of a technology-independent implementation of coverage obligation across multiple bands.

[35] Vodafone, O2 and Meteor had to achieve 33% coverage of population with their 2.1GHz licences within 1.5 years (Vodafone within 6 months) while H3G's 2.1GHz licence did not have this first coverage level step of 33% of population but instead its first required coverage target level was 53% of population in 3 years.

1800MHz and 2.1GHz spectrum. Such an approach would be particularly sensible if there were strong motivations for a policy of band neutrality. If considered, this would link the spectrum policies in other higher frequency spectrum bands that are to be released in the foreseeable future (such as the 2.3GHz band, the 2.6GHz band and indeed 2.1GHz licences when these come up for renewal).

240. Therefore, considering these details discussed above, we consider that the coverage obligation for 1800MHz spectrum should be:

- Less onerous than the 70% population coverage scope of sub-1GHz; and
- Comparable to that of 2.1GHz spectrum, particularly the time period within which coverage has to be met; and
- Band neutral, consistent with the proposed approach for the coverage obligations of sub-1GHz licences.

241. According to these suggested conditions, the coverage obligations on a 1800MHz licensee would only be binding for a new entrant winning 1800MHz spectrum only as:

- An entrant (or incumbent) winning sub-1GHz and 1800MHz spectrum in the auction would necessarily meet its 1800MHz coverage obligations when it meets those of its sub-1GHz licences given the latter should be more onerous as discussed above; or
- An incumbent's rollout of 3G services as required by its 2.1GHz licence will more or less cover that of the requirement set out for 1800MHz spectrum as the two have been proposed in the discussion above to be similar.

242. More particularly, since the coverage obligation for 1800MHz frequencies will only be relevant in the case of a new entrant with only 1800MHz spectrum, the coverage obligation set for 1800MHz spectrum should be comparable to that of the level set for an entrant with 2.1GHz spectrum only, namely that of Hutchison[36]:

- 53% of population coverage in 3 years;
- 80% of population coverage in 4 years; and
- 85% of population in 5.5 years

243. Further, considering that the coverage obligation for sub-1GHz spectrum is set at 70% of population for both new entrants and incumbents, the coverage obligations for an entrant with 1800MHz spectrum only should not be more onerous than that of a sub-1GHz entrant (70% of population within 7 years).

[36] ComReg, 04/16, Hutchison 3G licence schedule 5 part 1 section 6.

244. Hence, in line with the discussion above, we would propose that the coverage obligation for 1800MHz spectrum to be 70% of population coverage in 7 years which is identical to that proposed for sub-1GHz spectrum.

245. For an 1800MHz operator wanting to deploy LTE without access to other spectrum, there may be a risk that equipment availability might make this timetable impractical. This is unlikely to be an issue for operators with access to spectrum in other bands. Therefore, a case might be made for relaxing the coverage obligation for a pure 1800MHz operator. However these obligations are not particularly onerous and there is a need to consider the possibility of competitive distortions if the 1800MHz spectrum had less onerous obligations than that of 2.1GHz spectrum. For 800MHz only operators the situation would be even less severe, as equipment availability in the 800MHz band seems to be ahead of that for the 1800MHz band. In particular, 800MHz spectrum is currently awarded on a harmonised basis for LTE usage and has already been awarded in some regions, so that a sufficient demand for equipment exists to encourage fast development of equipment. Overall, we conclude that the proposed obligations strike a reasonable balance between these competing considerations.

246. To guard against spectrum hoarding in the 1800MHz band by incumbents, ComReg may also wish to apply a similar condition that was proposed for sub-1GHz spectrum for at least 50% of the coverage requirement to be met through the use of 1800MHz spectrum. However, we note that in the case of 1800MHz spectrum, given it may be more suited for the use of additional urban capacity more than for network roll out, it may not be sensible to impose as strict a usage or roll out obligation on the 1800MHz spectrum as that for sub-1GHz spectrum as there may be higher levels of uncertainty over when additional urban capacity may be required in the running of a network.

247. In addition, there may be benefits to be considered from relating the level of coverage required to the amount of 1800MHz spectrum held as the Netherlands are proposing to do with 1800MHz spectrum and US have done with PCS Broadband licensees (1900MHz). For instance, for an entrant with only 1800MHz spectrum, owning a small chunk of 1800MHz spectrum, say below 2x15MHz, may not present an economically sensible case for obligating extensive rollout. However given that the only relevant case for which the 1800MHz coverage obligation would be binding is in the case for a 1800MHz only entrant, it would seem that there is limited variation of the potential business cases to be considered for this purpose and thus minimal benefits from a more complex tiered coverage obligation structure relating proportionally to 1800MHz holdings.

248. Overall, the coverage obligations for 1800MHz spectrum should not be overly onerous taking into consideration that the coverage obligations should be set considering the business case of a new entrant with 1800MHz only spectrum and that 1800MHz spectrum would likely be used for high urban capacity. This would ensure a balanced trade off between guarding against inefficient use of spectrum while not placing overly onerous licence conditions that would discourage efficient demand for the spectrum.