An Coimisiún um
**Rialáil Cumarsáide**
Commission for
**Communications Regulation**

# Proposed award process for rights of use in the 700 MHz, 2.1 GHz, 2.3 GHz and 2.6 GHz bands

## a report from DotEcon Ltd

**Consultant Report**

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# Proposed award process for rights of use in the 700 MHz, 2.1 GHz, 2.3 GHz and 2.6 GHz bands

Prepared for ComReg
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# 1 Introduction

The Commission for Communications Regulation (ComReg) is considering the award of licences for the use of radio frequencies in some or all of the 700 MHz, 2.1 GHz, 2.3 GHz band and 2.6 GHz bands in Ireland. It has appointed DotEcon as its advisor for the design of the proposed award process.

In this report we consider the key issues for the award and recommend an appropriate approach to assigning licences for the use of these frequencies in line with ComReg's statutory objectives.

In June 2018 ComReg published a consultation document (ComReg 18/60) setting out and inviting comments on its proposals for the relevant bands to be included in this proposed award. In the appropriate sections below, we also provide our analysis of the comments received in response to the consultation relating to issues relevant for the design of the award.

## 1.1 Objectives for the award

*ComReg's statutory objectives*

ComReg has summarised its statutory objectives relevant to the management of radio spectrum in its Radio Spectrum Management Strategy 2019 – 2021[1] (the "**Spectrum Management Strategy**").

ComReg's primary objectives in carrying out its statutory functions in the context of electronic communications include:

- promoting competition;
- contributing to the development of the internal market;
- promoting the interests of users within the Community;
- ensure the efficient management and use of the radio frequency spectrum in Ireland; and
- unless otherwise provided for in Regulation 17 of the Framework Regulations, taking the utmost account of the desirability of technological neutrality in complying with the requirements of the relevant Irish regulations, in particular those designed to ensure effective competition.

With regard to the assignment of licences for the use of radio spectrum, ComReg's key objectives are:

- to achieve an efficient allocation and to ensure that the spectrum is subsequently used efficiently;

[1] ComReg 18/118.

- to grant licences on the basis of selection criteria that are objective, transparent, non-discriminatory and proportionate; and
- where a competitive procedure is to be used, to ensure that such a procedure is fair, reasonable, open and transparent to all interested parties.

*Award format*

In its Electronic communications strategy statement 2017 – 2019 (the "**ECS Strategy Statement**")[2] ComReg outlined its current thinking on the advantages of certain award mechanisms, including auctions. It reiterates ComReg's previously held position of not necessarily favouring any specific approach for awarding spectrum rights of use, preferring to consider each award on its merits. Nevertheless, the Statement acknowledges that auctions offer clear potential benefits. We propose the use of an auction for this proposed award given the strong possibility that the available spectrum could be oversubscribed and the difficulties associated with determining an efficient allocation administratively.[3]

Where auctions are to be used, ComReg does not favour any particular auction format, but rather believes that formats should be assessed based on the specific circumstances of each award. We consider a number of standard auction formats and assess their suitability for this proposed award. Overall we consider that the Combinatorial Clock Auction (CCA) format is likely to best support the objectives for the award.

*Competition considerations*

An award process can often achieve an economically efficient outcome by assigning spectrum to the users with greatest value for it. However, in certain circumstances it may be appropriate to adopt provisions to avoid highly asymmetric spectrum holdings if this could weaken competition in the downstream markets; in such a case, valuations for spectrum would in part reflect potential distortions to competition through the creation, maintenance or extension of market power. For this proposed award, to support the objective of efficient assignment, we consider that there are good arguments for applying caps on the amount of spectrum that any bidder can be allocated to prevent excessively asymmetric holdings post-award between the existing mobile network operators (MNOs). We suggest two different caps, one on sub-1 GHz holdings, and a separate cap on the overall amount of spectrum that any one licensee can be allocated. The level of the proposed caps, and the reasoning behind them, are discussed in detail below.

[2] ComReg Document 17/31.

[3] At paragraph 5.49.

## 1.2 Summary of recommendations

*2 1.GHz licence alignment and time slices*

The existing rights of use held by the three MNOs expire at different times. The licences of Three and Vodafone expire in 2022 (several months apart), and the licence held by Meteor expires approximately 5 years later in 2027. We understand that it is ComReg's preference to use this award to align the expiry dates of any new rights of use issued for the band.

To avoid disruption to existing services, help minimise complexity in the award process, and support ComReg's preference for aligning the expiry dates, there is likely to be a benefit in providing Three with the option to prolong its existing 2.1 GHz rights of use[4] so that they expire at the same time as Vodafone's. New 2.1 GHz rights of use available in 2022 could then be issued with a common start date of 16 October 2022.

Although Meteor's current 2.1 GHz licence does not expire until March 2027, there are good arguments for including new rights of use for the associated spectrum in this proposed award. As a result, the proposed award would include 2.1 GHz rights of use for 2x45 MHz of spectrum available from October 2022, and rights of use for a further 2x15 MHz available from March 2027. On this basis, we recommend making the 2.1 GHz spectrum available in two time slices, similar to the approach used in the 2012 MBSA:

- the first time slice would run from 16 October 2022 to 11 March 2027 (when Meteor's licence expires), with 2x45 MHz being available in this time slice; and
- the second time slice would run from 12 March 2027 to licence expiry (which we anticipate would be set in line with the expiry dates for the new 700 MHz, 2.3 GHz and 2.6 GHz rights of use), with 2x60 MHz being available in this time slice.

We do not see a need to award the 700 MHz spectrum in two time slices. However, to allow maximum flexibility for switching between the available higher frequency bands, we recommend that the 2.3 GHz and 2.6 GHz spectrum is made available in two time slices; the first would start at the end of the award (since these bands are available earlier than the 2.1 GHz band), but the end date of the first time slice and the start and end dates of the second time slice would align with those for the 2.1 GHz band.

*Early liberalisation for current 2.1 GHz licences*

The current 2.1 GHz licences restrict use of the spectrum to the provision of UMTS. There are clear potential benefits in liberalising those licences so that operators are able to use the frequencies on a service and technology neutral basis.

[4] This does not include the option of prolonging Three's spectrum rights in the unpaired 2.1 GHz Band.

For the time period up to 15 October 2022, we estimate that the fees paid by the MNOs for their existing licences are likely to be in excess of the current market price of the liberalised spectrum, and on this basis we consider that liberalisation could be allowed without the need for additional fees. Further, for this time period this is unlikely to have any anti-competitive impact as all MNOs would be treated equally.

For the time period 16 October 2022 to 11 March 2027, while benchmarking suggests that a suitable approach would also be to allow for liberalisation with no additional fees, due to Meteor's licence expiring significantly later, there may be concerns about unfairness and potential competitive distortion if Meteor were to liberalise its licence but the auction then demonstrated that a market price for liberalised 2.1 GHz spectrum is above Meteor's current licence fees. In this case, it may be appropriate to apply a potential spectrum liberalisation fee mechanism that would require some payment by Meteor in the event that the market price of 2.1 GHz licences implied by the award outcome were higher than the current fees.

*Competition concerns*

It would be prudent to apply measures to protect competition in the mobile market, although these do not need to be overly restricitive. Even though there is already some asymmetry in the distribution of spectrum across the MNOs, there is no clear justification for actively seeking to reduce this asymmetry. Moreover, given the large amount of spectrum available and potential developments in small cell networks and/or the FWA market, we do not see any particular reason why some increase in the asymmetry should be of concern. However, we would still recommend putting a restriction on the amount of spectrum that can be held by any single bidder after the proposed award, to avoid highly asymmetric outcomes that might be anti-competitive.

Given the likely importance of the 700 MHz spectrum (and other sub-1 GHz bands) for downstream competition, we recommend applying a separate competition cap on the amount of sub-1 GHz spectrum any operator can hold after the award. Alongside this, we propose an overall competition cap on total post-award spectrum holdings. We recommend that a sub-1 GHz competition cap of 70 MHz and an overall competition cap of between 375 MHz and 420 MHz would be appropriate.

*Lot structure*

Regarding the lot structure, in most cases we see no reason to deviate from the guidance in the relevant EU/CEPT harmonisation decisions which suggest that lots should be made available in blocks of 5 MHz. Where possible, we would recommend awarding these initially as frequency generic-lots, with specific frequency assignments determined afterwards. There may be a need to deviate from this approach with regard to the 2.3 GHz band and 2.6 GHz bands, where power restrictions exist, and in the 2.3 GHz band where

existing regional licences mean that it might be better to make some parts of the band available as larger frequency-specific lots.

*Fees and minimum prices*

In line with ComReg's typical approach, we propose that the licence fees to be paid are split between a Spectrum Access Fee (SAF), payable on completion of the award process, and annual Spectrum Usage Fees (SUFs), paid throughout the term of the licence. This creates incentives to return inefficiently unused spectrum to ComReg and helps to encourage participation in the award (from serious bidders). We recommend that ComReg sets a minimum price for each lot, split between the minimum SAF and the ongoing SUFs. Maintaning a reasonable SAF helps to disincentivise speculative or strategic bidding. We recommend applying a 40/60 split of the minimum price between the minimum SAF and the SUFs, as for the recent 3.6 GHz award in Ireland.

*Format for award of frequency generic lots*

In terms of the award format for assigning frequency-generic lots, we recommend use of an auction process rather than an administrative assignment, given the efficiency and transparency benefits associated with auctions. In this proposed award, it is very likely that there will be strong complementarities between lots (within bands, across bands, and across time slices), and we therefore consider that a combinatorial auction format that supports package bidding is crucial to mitigate aggregation risk and substitution risk.

Furthermore, we consider that an open auction format is likely to be more suitable than a sealed-bid process. An open auction mitigates various uncertainties faced by bidders. More importantly, it provides information that can be used by bidders to focus on submitting bids they are more likely to win; this feature is likely to be particularly relevant given the large number of lots available and the challenges this creates for determining how to bid given the large number of potential packages of lots.

In light of these considerations, we have narrowed down the list of candidate auction formats to include the combinatorial clock auction (CCA), and the combinatorial multiple round ascending auction (CMRA). The required features of the auction, with multiple bands and time-slices, preclude the use of an SMRA. Of these candidate formats, we recommend using the CCA. As bidders may be potentially interested in a very large number of alternative spectrum portfolios, with the CMRA this would require considering/managing a large number of bids in each round which could be challenging. In contrast, in the CCA bidders only need to determine their optimal bid in each clock round before considering a wider set of bids in a single supplementary bids round. The CCA format also offers the benefit of having already been used in Ireland for the previous 2012 MBSA and the 3.6 GHz band awards.

*Assignment of specific frequencies*

The specific frequencies assigned to winners of frequency-generic lots would be determined in a follow-up sealed-bid assignment

stage. Where possible, winning bidders would be guaranteed a contiguous assignment (within each band). To support this, we recommend applying a requirement for Meteor to relocate its current spectrum holdings in the 2.1 GHz band by participating in the assignment stage of the award and competing for its preferred frequencies (with any additional 2.1 GHz lots it wins in time slice 1 forming a contiguous block with its current holdings).

We also consider that for a bidder that wins the same amount of spectrum (in a particular band) across both time slices, there may be a benefit (through avoiding retuning costs) in being assigned the same frequencies in each time slice. We therefore recommend that a bidder who wins the same number of lots in both time slices in a particular band be guaranteed the same frequencies in that band in each time slice. Prices for being awarded a particular frequency assignment would be determined using an opportunity-cost based pricing rule.

## 1.3 Structure of this report

The report is structured as follows:

- In Section 2 we set out our understanding of the spectrum proposed for award, the relevant harmonisation decisions, current use of the frequencies, and the potential demand.
- Section 3 provides our assessment and recommendations with regard to the alignment of current 2.1 GHz licence period and the approach to early liberalisation.
- In Section 4 we provide recommendations on suitable measures for safeguarding competition (in the form of competition caps).
- Section 5 sets out a provisional lot structure for the award.
- Section 6 provides recommendations on the fee structure and the need for minimum prices.
- In Section 7 we discuss the potential format for the award, with emphasis on the Combinatorial Clock Auction and the Combinatorial Multiple Round Ascending auction formats.
- In Annex A we give a more detailed commentary on the other auction formats considered.

# 2 Available spectrum

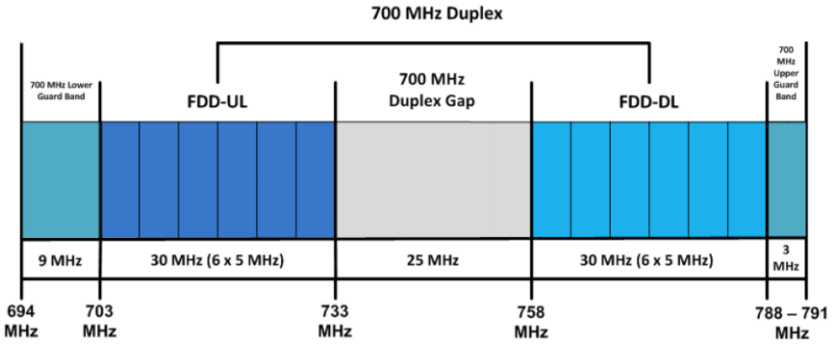
## 2.1 The 700 MHz band

*The 700 MHz band*

The 700 MHz band consists of 96 MHz of contiguous spectrum, comprising:

- the **700 MHz Duplex**: 703-733 MHz (FDD uplink) paired with 758-788 MHz (FDD downlink);
- the **700 MHz Duplex Gap**: 733-758 MHz; and
- the **700 MHz Guard Bands**: 694-703 MHz and 788-791 MHz.

*Figure 1: The 700 MHz band*




*Source: ComReg 18/60*

*Only the 700 MHz Duplex will be included for award*

For this proposed award, ComReg is proposing to make available only the 2x30 MHz of spectrum in the 700 MHz Duplex. The other parts of the band – the Duplex Gap and the Guard Bands – will not be included given, among other things, the current lack of compatible devices for parts of this spectrum, and the potential for this spectrum to be considered in any national policy decision for other uses, including PPDR.

*700 MHz harmonisation*

The 700 MHz Duplex is harmonised across Europe for terrestrial systems capable of providing wireless broadband electronic communications services, in accordance with Article 3 of the 700 MHz EC Implementing Decision (EU) 2016/687 of 28 April 2016.

The 700 MHz band is also harmonised at CEPT level via ECC Decision 15(01) of 6 March 2015, which sets out the least restrictive technical conditions ("LRTCs") and frequency arrangements for the introduction of mobile fixed communication networks ("MFCNs").

Decision 2017/899 of the European Parliament and Council of 17 May 2017 includes an obligation on the timeframe for allowing the use of the 700 MHz Band for terrestrial systems capable of providing WBB ECS (by 30 June 2020) and a deadline for establishing the necessary

cross-border frequency coordination agreements within the Union (31 Dec 2017).

Further details on the 700 MHz harmonisation can be found in ComReg document 18/60.

### Current use of the 700 MHz Duplex

*The 700 MHz Duplex is expected to be free from 4 March 2020*

Parts of the 700 MHz Duplex are currently assigned to Raidió Teilifís Éireann (RTÉ) and is used for the provision of DTT. However, these DTT licences are expected to be migrated from the 700 MHz band by 4 March 2020.

There are no other current primary licences for spectrum in the 700 MHz Duplex, meaning that the entire 2x30 MHz should be available from 4 March 2020.

*Device ecosystem*

As noted in ComReg 18/60, there are already over 1,200 devices compatible with the 700 MHz Duplex, and we anticipate that this device ecosystem is likely to grow significantly given the expected role of the band for 5G deployment.

## 2.2 The 2.1 GHz Band

*The paired 2.1 GHz spectrum will be included for award*

For this proposed award ComReg is proposing to make available a total of 2x60 MHz of paired spectrum in the 2.1 GHz band, comprising the frequency range 1920-1980 MHz paired with 2110-2170 MHz.

*Harmonisation at European level*

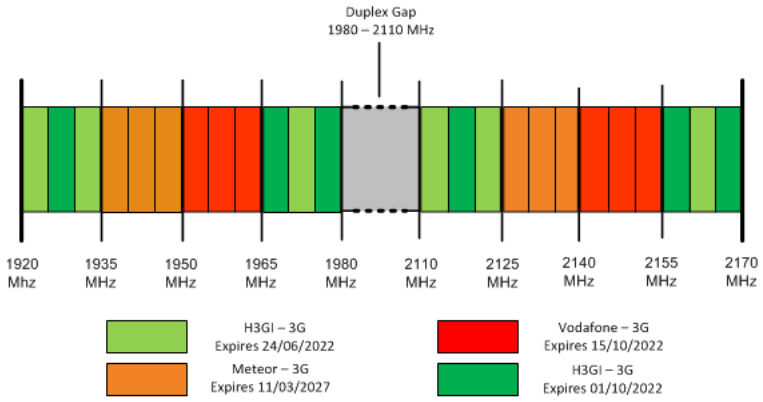
This spectrum is harmonised:

- at CEPT/ECC level for MFCN including IMT in accordance with the 2012 revision to ECC Decision (06)01 (which previously harmonised the spectrum for UMTS/3G services); and
- at EU level, through Decision 2012/688/EU, which harmonised the 2.1 GHz band for terrestrial systems capable of providing ECS in the EU.

*The unpaired 2.1 GHz band will not be included*

The 2.1 GHz range also includes a contiguous 20 MHz block of TDD spectrum in the frequency range 1900-1920 MHz. This spectrum was originally harmonised for UMTS/3G by ECC Decision (06)01 but was removed as part of the 2012 amendment given the very limited use of the spectrum for providing 3G in Europe. It was subsequently harmonised by ECC Decision (15)02 for the broadband Direct Air-to-Ground Communications (DA2GC) which was subsequently withdrawn by ECC Decision (18)01 noting that the band is under discussion with regard to the use by other alternative radio technologies . Given its unsuitability for WBB services, ComReg has decided not to include the unpaired 2.1 GHz spectrum in this proposed award.

*Figure 2: The current 2.1 GHz band*




*Source: ComReg 18/60*

## Current use of the 2.1 GHz paired band

*Current licences for 2.1 GHz paired spectrum*

The paired 2.1 GHz spectrum is currently assigned to the three MNOs for the provision of UMTS/3G services (in accordance with ECC Decision (06)01):

- Three currently has access to 2x30 MHz of the available 2.1 GHz spectrum, split into two non-contiguous 2x15 MHz blocks. These comprise three 2x5 MHz spectrum rights in the 'A Licence', which expire on 24 July 2022, and three 2x5 MHz spectrum rights in the 'B Licence', which expire on 01 October 2022. Each of Three's 2x15 MHz blocks include spectrum associated with the A Licence and spectrum associated with the B Licence. The A Licence was initially assigned to Hutchison, and the B Licence to Telefonica; when the two companies merged, Three acquired all of their combined 2.1 GHz spectrum.
- Vodafone has a licence for a contiguous 2x15 MHz block of 2.1 GHz spectrum, which expires on 15 October 2022.
- Meteor has access to a contiguous 2x15 MHz block of 2.1 GHz spectrum, and its licence expires on 11 March 2027.

*The spectrum is available at different times*

This means that:

- 2x45 MHz of spectrum will become available in 2022 (at various times); and
- an additional 2x15 MHz will be available from 2027.

*Licence alignment and early liberalisation*

At present the current licences expire at different times, with Meteor's licence expiring approximately five years later than the others. We understand that ComReg has a preference, where possible, to align the expiry dates of any 2.1 GHz licences allocated in the future (i.e. in this proposed award).

As mentioned in ComReg 18/60, it may also be desirable for the use of the 2.1 GHz spectrum to be liberalised before the current licences

expire. Currently, the 2.1 GHz licensees are restricted to using the spectrum for UMTS services only, but changing the licence terms could allow for more efficient use of the frequencies to the benefit of consumers. Both of these issues create complications for the award process – we discuss these, and our recommended solutions, in detail in Section 3 below.

*Device ecosystem*

As reported in ComReg 18/60, the 2.1 GHz band has been used to provide 3G services across Europe for many years and there is already an extensive device ecosystem compatible with the spectrum.[5] In Ireland, the current licensees have used the paired 2.1 GHz spectrum as part of the capacity layer for the provision of UMTS (in accordance with the licence conditions).

# 2.3 The 2.3 GHz band

*Available 2.3 GHz spectrum*

The 2.3 GHz spectrum to be included in the award comprises a contiguous 100 MHz block in the frequency range 2300 – 2400 MHz.

*Harmonisation of the 2300 MHz band*

ECC Decision (14)02 ("2.3 GHz ECC Decision") harmonised the 2.3 GHz band at CEPT level, setting out the frequency arrangement and LRTC for the band, although an EC implementing decision has not yet been adopted in order to allow flexibility for Member States to support current uses.

## Current use of the 2.3 GHz band

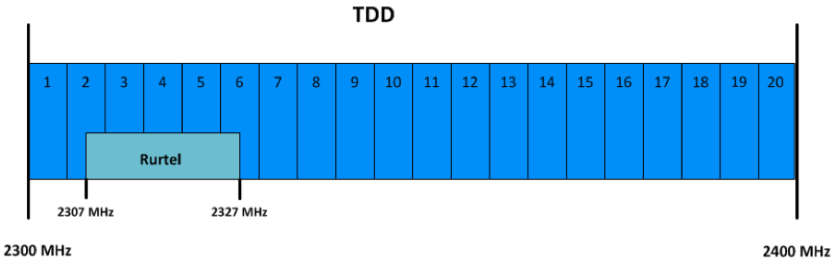
The 2.3 GHz Band is largely unused in Ireland, although 45 regional licences are currently held by Eir in the frequency range 2307 – 2327 MHz, covering parts of Kerry, Galway and Donegal. These licences are used by Eir to operate its Rurtel service, a point-to-multipoint system providing fixed telephony in rural areas, in order to meet its universal service obligation (USO). Although the number of subscribers is currently (as of January 2018) fairly low and declining,[6] ComReg's understanding is that these customers also do not have access to alternative fixed telephony services.

Frequencies in the range 2307 – 2327 MHz are unused elsewhere in Ireland, while the remaining frequencies in the 2300 – 2400 MHz band are currently entirely free.

[5] The GSA identified 6,282 LTE capable devices that could operate using 2.1 GHz spectrum.

[6] As noted in ComReg document 18/60, para. 3.59.

*Figure 3: The current 2.3 GHz band plan*




*Source: ComReg 18/60*

In document 18/60, ComReg noted that it may be possible to allocate new national licences for the 2300 MHz band, but with "*possibly a limited number of temporary coordination zones corresponding to the areas and frequencies covered by Eir's existing Rurtel licences*". This may have implications for the lot structure in the award, depending on the extent to which it is considered these restrictions would impact the value of the spectrum relative to the unrestricted frequencies.

Although the band has to date not been widely used in Europe for WBB, there is significant potential for these services to emerge given:

- the harmonisation at CEPT level for MFCN;
- the similar propagation characteristics between the 2.3 GHz frequencies and other capacity bands such as 2.6 GHz and 2.1 GHz, making it a potential substitute for these capacity bands and/or a complement to sub-1 GHz spectrum; and
- the existence of an extensive device ecosystem[7] for the band due to its prominent use in markets outside of Europe (such as Asia.

## 2.4 The 2.6 GHz band

A total of 190 MHz will be available for award in the 2.6 GHz band, in the frequency range 2500 – 2690 MHz.

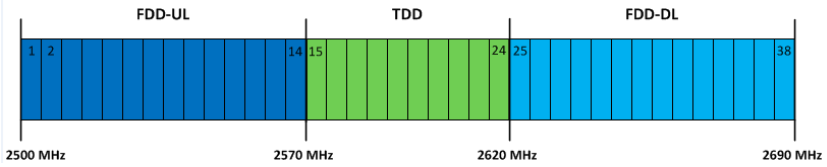
ECC Decision (05)05 (amended in July 2015) harmonises the band for MFCN at CEPT level, setting out the LRTC to be applied to the use of the spectrum as well as the (primary) band plan arrangement, comprising:

- the 2.6 GHz Duplex: 2x70 MHz for FDD operation in the frequency bands 2500 – 2570 MHz (uplink) paired with 2620 – 2690 MHz (downlink); and
- the 2.6 GHz Duplex Gap: a contiguous 50 MHz block of spectrum in the band 2570 – 2620 MHz, which can be used for

[7] As of May 2018, 3,779 devices have been identified by the GSA as being capable of operating in the band.

TDD or other usage modes complying with the technical conditions.

*Figure 4: The 2.6 GHz primary band plan*




*Source: ComReg 18/60*

The 2.6 GHz band is also harmonised at EU level by European Commission Decision 2008/477/EC which sets out conditions for availability and use of the spectrum, determines Block Edge Mask parameters and specifies a range of usage modes in the band including Frequency Division Duplex (FDD) and Time Division Duplex (TDD). The EC Decision is largely consistent with the frequency arrangements set out in ECC Decision (05)05, but allows for additional flexibility in that some or all of the 2.6 GHz Duplex sub-bands may be used in part or in full for TDD (to be decided at national level), provided this is in equal parts in both the upper and lower parts of the band starting at 2690 MHz and 2570 MHz (extending downwards).

At present we understand that ComReg intends to assign the 2.6 GHz spectrum in accordance with the band plan set out in ECC Decision (05)05 (the 'primary band plan' i.e. 2x70 MHz of FDD spectrum and 50 MHz of TDD spectrum), and we do not see any reason to do otherwise. If the consultation responses highlight a demand for additional TDD spectrum which would materially improve the efficient use of spectrum, it may be possible to include flexibility within the award process to allow the market to determine the combination of FDD and TDD spectrum that is assigned.[8] However, this would add significant complexity to the award (for stakeholders and for the regulator) and we would advise against such an approach unless there is good reason to believe that it would improve the efficiency of the spectrum assignment.

## Current use of the 2.6 GHz band

*Spectrum Availability*

The 2.6 GHz band was previously licensed in Ireland for the provision of pay-TV services using a Multipoint Microwave Distribution System ("MMDS"). These licences expired on 18 April 2016 and the whole of the band is currently free for assignment.

*Device ecosystem for the 2.6 GHz band*

The band is already being used extensively for MFCN/ECS services in Europe (and globally) and has a mature device ecosystem. As of May

[8] This might be similar to the approach taken for the Netherlands 2.6 GHz auction in 2012.

2018, the GSA reports that 6,974 devices are compatible with the 2.6 GHz Duplex and 2,906 compatible with the Duplex Gap.

## 2.5 Licence duration

Our understanding is that ComReg intends to make the new licences for the 700 MHz, 2.3 GHz and 2.6 GHz spectrum available for an overall period of 15 years. Licences for new rights of use in the 2.1 GHz band would commence on expiry of existing licences, and the final expiry date would be the same as for the other bands in this proposed award. The new 2.1 GHz licences would, therefore, run for a little less than 15 years in total (regarding the spectrum currently assigned to Vodafone and Three) or a little less than 10 years (for the spectrum currently assigned to Meteor).

This is in line with previous licences allocated by ComReg,[9] and we do not see any particular need to deviate from this approach.

## 2.6 Potential demand

*Potential demand for the 700 MHz band*

As discussed above, the 700 MHz band is harmonised across Europe for terrestrial WBB ECS and has been highlighted by the RSPG as a primary band for 5G WBB below 6 GHz. The favourable propagation characteristics of the sub-1 GHz spectrum means that it is likely to be important for cost effective wide-area deployment of 5G WBB services, complementing the use of the recently assigned 3.6 GHz spectrum for the 5G capacity layer.

We expect that the main source of demand for the 700 MHz Duplex is likely to come from the three incumbent mobile network operators (MNOs): Vodafone; Three and Meteor. As well as providing the coverage layer for initial 5G services, the 700 MHz spectrum would provide access to additional sub-1 GHz spectrum at a time when the operators need to roll out and expand their 4G and 5G networks whilst also maintaining older 2G and 3G services. There is unlikely to be demand from fixed wireless operators; the limited amount of contiguous spectrum in the sub-1 GHz bands makes it less attractive for providing services that require higher capacity links.

*Potential demand for higher frequencies*

The other bands proposed for the award (2.1 GHz, 2.3 GHz and 2.6 GHz) have been also harmonised for WBB ECS across Europe to varying degrees. They have similar propagation characteristics and,

[9] Licences awarded in the 2012 MBSA had a duration of 15-17 years, and the 3.6 GHz licences assigned in 2016 were for a period of 15 years.

as discussed above, all three bands have an existing device eco-system. The 2.1 GHz and 2.6 GHz bands are well established in Europe for MFCN/ECS, and although the 2.3 GHz band is not yet widely used in Europe for WBB, it is used extensively elsewhere (Asia, Australia, Africa) and there is growing interest amongst other EU Member States.[10]

These higher frequency bands are less suitable than the 700 MHz frequencies (and other sub-1 GHz bands) for providing wide-area mobile coverage, but are useful in urban/sub-urban areas and/or traffic hotspots for providing additional capacity. In this role, the spectrum available in the supra-1 GHz bands may be seen as complementary to the lower frequencies, with lower frequencies providing wide-area coverage and higher frequencies providing capacity where traffic density is higher. Frequencies both above and below 1 GHz are needed for efficient deployment of a typical mobile network.

Frequencies above 1 GHz are also likely to be attractive for fixed wireless providers, for which the capacity and throughput that can be achieved using bands with larger amounts of contiguous spectrum available is important. Whilst sub-1 GHz spectrum may have better propagation characteristics, the amount of contiguous spectrum available is much more limited. Bands in the 2-4 GHz range have best potential to provide fixed wireless connections for residential customers and small businesses, with higher frequencies above 6 GHz (such as the 10.5 GHz band already licenced under the FWALA/BWALA schemes in Ireland) offering higher capacity links for business users and backhaul for network operators.

[10] For example, as discussed in ComReg 18/60, the UK was the first to award 2.3 GHz spectrum for MFCN in Europe in 2018, and other Member States such as Denmark, Sweden and Hungary are planning to award the band within the next two years.

# 3 Alignment and early liberalisation of 2.1 GHz licences

As set out in Section 2.2, ComReg is planning to include a total of 2x60 MHz of 2.1 GHz paired spectrum in the proposed award, all of which is currently licensed to the three MNOs with a range of licence expiry dates.

We understand that ComReg has a preference to align the expiry dates for all of the new 2.1 GHz licences issued in this proposed award. This would be beneficial for effective long-term spectrum management and future efficient allocation and use of spectrum in line with ComReg's objectives. In particular, future licence re-award or renewal would be simplified and there would be greater flexibility to reconfigure spectrum holdings across licensees.

Under current 2.1 GHz licences, awarded via beauty contest, the licensees were required to pay a Spectrum Access Fee[11] (SAF), split across a number of payments during the first 15 years of the licence term. These are set out in Table 1 below, which shows the (inflation unadjusted) fees due in each year relative to the licence award date.

*Table 1: Spectrum Access Fees[12] for current 2.1 GHz FDD licences (payments still to be made in orange)*

| Year | Three A Licence | Three B Licence | Vodafone | Meteor |
|---|---|---|---|---|
| 0 | €12.7m | €44.4m | €44.4m | €44.4m |
| 1 | €0 | €0 | €0 | €0 |
| 2 | €0 | €0 | €0 | €0 |
| 3 | €0 | €0 | €0 | €0 |
| 4 | €0 | €3.8m | €3.8m | €3.8m |
| 5 | €0 | €3.8m | €3.8m | €3.8m |

[11] The Spectrum Access Fees (and payment schedule) mentioned in relation to current 2.1 GHz rights of use are specific to those rights of use, and should not be confused with the proposals elsewhere in this document for Spectrum Access Fees applicable to new rights of use in the 700 MHz, 2.1 GHz, 2.3 GHz and 2.6 GHz bands that will be determined as part of this award.

[12] This is based on the fees set out in S.I. No. 340 of 2003 (http://www.irishstatutebook.ie/eli/2003/si/340/) where the year 15 payment is corrected for the €0.2m rounding error.

| | | | | |
|---|---|---|---|---|
| 6 | €2.5m | €3.8m | €3.8m | €3.8m |
| 7 | €2.5m | €3.8m | €3.8m | €3.8m |
| 8 | €2.5m | €3.8m | €3.8m | €3.8m |
| 9 | €2.5m | €3.8m | €3.8m | €3.8m |
| 10 | €2.5m | €7.6m | €7.6m | €7.6m |
| 11 | €5.1m | €7.6m | €7.6m | €7.6m |
| 12 | €5.1m | €7.6m | €7.6m | €7.6m |
| 13 | €5.1m | €7.6m | €7.6m | €7.6m |
| 14 | €5.1m | €7.6m | €7.6m | €7.6m |
| 15 | €5.1m | €9.1m | €9.1m | €9.1m |
| **Total** | **€50.7m** | **€114.3m** | **€114.3m** | **€114.3m** |

In addition to these SAFs, annual Spectrum Usage Fees (SUFs) of €1,904,610 apply to the 2 x 15 MHz of spectrum in each licence.

In relation to the payment of SAFs, Three and Vodafone each made their final SAF payment in 2018. Meteor's licence started five years later. As of June 2019, Meteor still has the last three of the SAF payments to make (totalling €24.3m on an undiscounted basis).

The current licences include restrictions that prevent the spectrum from being used for services other than UMTS/3G. In its consultation document, ComReg has put forward the possibility of liberalisation for these licences. This would allow licensees to use the spectrum from the date of liberalisation over the remainder of the licence term for services other than UMTS/3G, which may in turn generate both benefits for consumers and cost savings for operators. This would also be in line with EC Decision 2012/688/EU and the general movement towards technology-neutral and service-neutral licensing.

We agree that providing early liberalisation for the current 2.1 GHz licences can provide significant benefits to consumers. However, it is important that modifying licence terms is done in a manner that would not unduly distort competition, for example by creating windfall gains that accrue unfairly across operators. This can be achieved, for example, by ensuring that the prices to be paid for liberalising existing licences were in line with the market price of liberalised use licences implied by the bids submitted for Generic Lots in the auction.

Overall, the current 2.1 GHz licences present some challenges for the proposed award:

- to align licence end dates given the staggered expiry dates of the current licences, it is likely that spectrum would need to be awarded in different 'time-slices', similar to the approach taken in the 2012 MBSA; and
- if licences are to be liberalised early, then options need to be offered to each licensee setting out what (if any) charges will be applicable for a liberalised licence to ensure fairness, and how this will be implemented within the overall proposed award process.

NERA, in a submission on behalf of Three[13], has suggested that given the complications surrounding the 2.1 GHz band, it may be more appropriate to liberalise the current licences and assign new rights of use for the spectrum in a separate process. In particular, NERA believes that the simplest approach would be to award the spectrum directly to the three MNOs in blocks of 2x20 MHz, with operators transitioning to their new holdings on expiry of existing licences. We disagree with this proposal on the basis that it would explicitly, and unreasonably, preclude any competition for the spectrum from other potential users. Existing operators do not have any special claim to the spectrum once their licences expire and there is no good reason why they should not have to compete for it with other potential users. Furthermore, even if relative valuations might differ across bands, 2.1 GHz spectrum is likely to be substitutable for other spectrum in the proposed award (i.e. the 2.3 GHz and 2.6 GHz bands), so bidders might be willing to switch their demand across bands depending on relative prices, and thus including all of this spectrum in the same award where possible is likely to support an efficient allocation of the spectrum.

We set out below our assessment and recommendations on the potential approach to liberalising the current 2.1 GHz licences and aligning the expiry dates for future rights of use for spectrum in the band.

## 3.1 Approach used in the 2012 MBSA

Early liberalisation and licence endpoint alignment were features of the MBSA in 2012. At the time, Vodafone, Telefónica O2, and Meteor all had existing licences in the 900 MHz and 1800 MHz bands that were restricted to GSM use. ComReg wished to use the MBSA to assign liberalised rights of use in those bands, but this was

[13] NERA Economic Consulting, 2018, '*Preparing for the 2019 Irish multi-band spectrum award, December 2018*'

complicated by the fact that the current licences were expiring at different times for different bidders:

- 900 MHz: Vodafone, Telefónica O2, and Meteor each held a 2x7.2 MHz licence (from a total of seven 2x5 MHz blocks available). The licences of Vodafone and Telefónica O2 were due to expire in January 2013 (following the grant of interim GSM 900 MHz licences to these operators between May 2011 and January 2013), and Meteor's was due to expire in July 2015.
- 1800 MHz: Vodafone, Telefónica O2, and Meteor each held a 2x14.4 MHz licence (from a total of fifteen 2x5 MHz blocks available). The licences of Vodafone and Telefónica O2 were due to expire in December 2014, and Meteor's was due to expire in July 2015.

To help resolve this complexity, ComReg offered the available spectrum in two 'time slices':

- Time Slice 1 ran from 01 February 2013 until 12 July 2015 i.e. from the expected earliest commencement date of new licences (following the expiry of Vodafone's and Telefónica O2's 900 MHz licences) up to the point at which all current licences had expired; and
- Time Slice 2 ran from 13 July 2015 until 12 July 2030 i.e. from the end of Time Slice 1 until the point at which all licences on offer in the award would expire.

Time Slice 1 included lots associated with frequencies still licensed to bidders. These were known as 'Party-Specific Lots' and only the current licensee could bid for them. If a bidder were to win a Party-Specific Lot, it would be allowed to use the associated frequencies on a liberalised use basis; if it failed to win one of its Party-Specific Lots, it would keep its current licence for the frequencies and the GSM usage restrictions would still apply. A bidder winning Party-Specific lots was analogous to the bidder handing back its existing licences to ComReg and receiving new licences for the same spectrum on a liberalised use basis, subject to the bidder retaining its existing GSM licences if it did not bid for or win its Party-Specific Lots in the auction.

All of the spectrum not already licensed during Time Slice 1 was offered as Generic Lots, for which all bidders could bid (subject to competition caps) and which were valid for the period covered by Time Slice 1. All of the spectrum available in the award was offered as Generic Lots for Time Slice 2.

For example, a total of seven 2x5 MHz lots were available in the award in the 900 MHz band. Two of these were already licensed to

Meteor for Time Slice 1 under its existing GSM licence.[14] Time Slice 1 therefore included five Generic Licences (for which any of the bidders could bid) and two Party-Specific Lots (for which only Meteor could bid). For Time Slice 2, seven Generic Lots were available in the 900 MHz band.

To avail of the early liberalisation option, bidders were required to pay a price based on the bids received in the auction (which was run using a Combinatorial Clock Auction format) for the Generic Lots in the same band and Time Slice:

- Round prices for the Party-Specific lots during the primary bid rounds were set equal to the prices for the equivalent Generic Lots.
- The final prices to be paid by winning bidders for the Party-Specific Lots (or more precisely, packages containing Party-Specific Lots) were calculated using an opportunity-cost based pricing rule with Party-Specific Lots treated (for the purpose of pricing only) as if they were available to all bidders.

These rules meant that the prices to be paid for liberalising existing licences were in line with the market price of liberalised use licences implied by the bids submitted for Generic Lots in the auction.

## 3.2 Licence period alignment

Regarding the goal of aligning the new licence terms, there are three key periods to consider:

- up to 15 October 2022 (when all of Vodafone's and Three's licences will have expired);
- 16 October 2022 to 11 March 2027 (when Meteor's licence expires); and
- 12 March 2027 until the envisaged expiry date of new licences.

*Now to 15 October 2022*

Three's A Licence expires on 24 July 2022 and its B Licence expires on 1 October 2022. Vodafone's licence expires on 15 October 2022.[15] This small difference creates complications when determining the start date for the new licences when re-awarding that spectrum.

With those expiry dates, if the start dates of the new rights of use were to be the same (i.e. 16 October 2022 at the earliest) then this creates potential issues regarding continuity of service. For example, if Three were to win new 2.1 GHz rights of use in the award there

[14] We note that Meteor's GSM licence was for 2x7.2 MHz (rather than 2x10 MHz), but this was counted as two 2x5 MHz Party-Specific Lots for the purpose of the award. If Meteor failed to win any of the 900 MHz Party-Specific Lots it would only be allowed to use 2x7.2 MHz in the 900 MHz band, in accordance with its GSM licence.

[15] Note that Meteor's 2.1 GHz licence expires in 2027 and is not relevant for this section of the discussion.

would be a period between expiry of its rights of use in its current licences and the start of the new rights in which Three would have no access to any 2.1 GHz spectrum. The services provided by Three using its 2.1 GHz spectrum at the time would have to be either temporarily suspended or migrated to an alternative band (at least until the new 2.1 GHz licences commenced), which could be costly and unnecessarily disruptive.

In order to meet the objective of this spectrum being efficiently used, there is a strong case to either:

- allow for any new 2.1 GHz rights of use awarded to Three to start immediately on expiry of its current licences; or
- prolong Three's existing 2.1 GHz rights of use so that they expire at the same time as Vodafone's licence (15 October 2022) (such as by issuing new "interim" rights of use).

Of these two options we consider the latter to be preferable. Issuing such new interim rights to Three would allow for a common separation date between the current licences and new rights of use (not counting the Meteor licence). If it won new 2.1 GHz rights, Three and its customers would avoid the risk of disruption to its 3G services. In the case of a reallocation of specific frequencies across existing licensees (and potentially with new licensees in the band), there would be a single point at which the operators should switch from using their old frequencies into the new band plan.

In contrast, setting Three's new rights to start on expiry of its current licences might require more complex rules over when these rights could start and at what point a change of band plan would take place in order to retain compatibility with Vodafone's licence expiry date. For example, were Three to win new rights to the frequencies currently used by Vodafone, it would not be possible for those rights to commence before Vodafone's expired, unless Vodafone were willing to clear the frequencies early. A set of rules would be required to deal with all cases such as this, which in our view would create unnecessary complexity when essentially the same outcome could be achieved much more easily by effectively extending Three's current rights by approximately four months for those held under its A Licence and 15 days for those held under its B Licence.

There are other options that could be considered for maintaining service continuity, such as allocating different start dates to different frequencies (to align with current expiry dates) or making the spectrum available for award in short-term time slices covering the period up to 15 October 2022 (e.g. 24 July – 01 October 2022 and 01 October – 15 October 2022). However, both of these options would create significant complexities for the award design. Such approaches could even distort bidding incentives for bidders who might gain from disrupting Three's services or exploiting the fact that Three would have a higher value for winning specific frequencies (say to make it pay a higher price). Therefore, we

consider that these alternatives could distort competition in the award contrary to the objective of ensuring spectrum is efficiently assigned and used.

For these reasons, we consider that issuing new interim rights to Three is the simplest and most practical approach. Given the very short amount of time for these interim rights (a maximum of less than four months), we do not consider it likely that this could have a detrimental impact on competition within the downstream mobile service market by offering Three any material competitive advantage over the other MNOs or new parties interested in this spectrum. All of the new rights of use for the frequencies currently assigned to Vodafone and Three could then start together on a common date of 16 October 2022.

To ensure fairness to the other 2.1 GHz licensees, ComReg may wish to charge a fee for these interim rights. A reasonable approach to this might be to impose a pro-rated charge based on the fees (i.e. both spectrum access fees and spectrum usage fees) being paid by the other MNOs for their existing licences, updated in line with the CPI. This approach would also be consistent with that taken by ComReg in its 2012 MBSA in respect of the interim 900 MHz rights of use granted to Vodafone and Telefonica O2.

If Three does not apply to take some or all of the interim rights, then the associated existing spectrum rights would end in accordance with the current expiry dates. In this case, the start dates for new rights could still be set to align with new rights for all of the other 2.1 GHz spectrum currently assigned to Three and Vodafone.

*October 2022 to March 2027*

During the period 2022 – 2027 Meteor will have continued access to 2 x 15 MHz of 2.1 GHz spectrum, either on a liberalised use basis or with the current restrictions still in place. Meteor's licence will eventually expire on 11 March 2027, at which point the associated spectrum will be available for reassignment. ComReg intends to establish that reassignment as part of this award, in conjunction with assigning new rights to 2.1 GHz frequencies currently used by Vodafone and Three. This is because the expiry of Meteor's 2.1 GHz licence will occur during the period of any new 2.1 GHz rights assigned in this award. The efficient allocation of the 2.1 GHz band (and potentially also other substitute capacity bands) is best achieved by resolving the allocation of all blocks within the band in a common process, rather than re-awarding the spectrum subject to Meteor's expiring licence in a separate award after 2027.

On this basis we expect that the new rights for the spectrum currently assigned to Meteor would commence on 12 March 2027, but be available in this award.

The new rights that commence in October 2022 could be set to expire after the full term of the period for which ComReg proposes to make overall licences valid, or at the same time as Meteor's current licence (11 March 2027). Under the latter approach, further

rights would be issued for this spectrum that would run from 12 March 2027 until the planned latest expiry date. This necessitates the use of time slices within the award process (as for the 2012 MBSA).

The use of time slices is likely to be required (see below) but need not be unduly complicated. However, the use of time slices requires an auction format that minimises the risk of bidders being assigned rights for one time period but not the other in the event that they require and are willing and able to successfully bid for rights that run for the full term; this would be resolved, for example, by using an auction format that allowed for package bidding.

*March 2027 – licence expiry*

All of the 2.1 GHz spectrum rights available during the award could be given the same expiry date.

*Summary recommendation*

Overall, our recommendations in terms of 2.1 GHz spectrum rights alignment would be the following:

- Provide Three with an option to prolong its existing 2.1 GHz rights of use so that they expire at the same time as Vodafone's licence (15 October 2022) (such as by issuing new interim rights of use, with an appropriate fee).
- Make available new 2.1 GHz rights of use for those expiring in October 2022, for the period 16 October 2022 to 11 March 2027 (to coincide with Meteor's current licence expiry).
- Make available new 2.1 GHz rights of use for the full 2x60 MHz available in the 2.1 GHz band, for the period 12 March 2027 until a common expiry date (based on ComReg's proposed overall licence duration for the spectrum).

# 3.3 Early liberalisation

## 3.3.1 Benefits of early liberalisation

Applying an early liberalisation option on the current 2.1 GHz licences would mean that (where efficient), the spectrum could be used earlier for the provision of services other than UMTS. This may bring about significant benefit for consumers and potential cost savings for operators by facilitating transition to more spectral efficient technologies.

*Periods for early liberalisation*

All of the new rights of use to be allocated in the proposed award will be on a liberalised use basis. Therefore, there are two key periods to consider with regard to early liberalisation of current licences:

- The period up to the expiry of Vodafone and Three's licences on 15 October 2022 (based on the recommendations above where Three could obtain interim 2.1 GHz spectrum rights); and

- 16 October 2022 – 11 March 2027, covering the period in which Meteor's existing licence is still valid, but following the expiry of Vodafone's and Three's existing licences.

For both of these periods there would appear to be clear potential benefits in liberalising the 2.1 GHz licences so that operators are able to use the frequencies on a service neutral and technology neutral basis. Although used for 3G services in Ireland to date, the 2.1 GHz band has similar propagation characteristics to 2.6 GHz and 2.3 GHz spectrum. It could therefore provide additional capacity for new 5G services, or for existing technologies (4G) at a time when operators need to manage their spectrum use for developing and expanding new services whilst also maintaining legacy networks for current services. Furthermore, at a time when 3G services would seem likely candidates to be phased out before 2G (which might be in use for some time to support roamers and GPRS machine-to-machine services), the ability to re-farm the spectrum currently used for 3G might prove particularly beneficial.[16] Liberalising the current 2.1 GHz spectrum would also be in line with the requirements of ECC Decision 2012/688/EU.

### 3.3.2 Timing of liberalisation

*Options for when to liberalise*

There are three distinct options regarding the time from which operators could be allowed to liberalise their current 2.1 GHz licences:

- immediately (or at least as soon as possible);
- after ComReg has finalised its substantive decisions regarding this proposed award (and any links to the liberalisation process); or
- after the proposed award has been completed.

As a matter of principle, allowing for liberalisation of the 2.1 GHz licences to take place sooner rather than later would allow operators to reap the maximum potential benefit from liberalisation. However, it may be preferable to wait until at least the point at which substantive decisions have been made regarding this award and the liberalisation process, thereby ensuring that all operators will have reasonable clarity in advance over the terms of liberalising their own licences.

[16] NERA (in its 2018 report prepared and submitted to ComReg on behalf of Three) highlights that the expiry dates of the 2.1 GHz licences are not aligned with the commercial timetable for 3G switch-off, so without liberalisation the 2.1 GHz spectrum may not be well used in the final years of the licence terms.

*There are benefits to liberalising earlier, but delaying until after finalising award decisions may be sensible*

The alternative of waiting until after the award before liberalisation would be allowed does not seem to offer any significant additional benefit relative to the option of liberalising after the award decisions have been made, as bidders should have sufficient advance information to assess any risks of liberalising their licence, and delaying could unnecessarily defer the economic benefits that might be gained. On the other hand, we also see no reason why an operator should be prevented from liberalising its licence at a later date should it wish to do so, and there may be some benefit in providing flexibility over when the liberalisation decision could be made. This would, for example, allow an operator to wait for the outcome of the award process (or any other developments it wished to assess) before deciding whether or not to liberalise its licence.

On the basis of the above, we therefore recommend that the MNOs would be allowed to liberalise their existing 2.1 GHz licences at any time from the point at which ComReg publishes its final decisions in relation to this proposed award until the expiry date of the corresponding licence. [17]

### 3.3.3 Competitive implications

*Views of the operators*

In 2014 ComReg received responses from the three MNOs to Consultation 14/65 on liberalisation of the 2.1 GHz spectrum. All three respondents supported the prospect of liberalising their current licences on the basis of the economic and competition benefits it could create, although Meteor and Vodafone both highlighted some concerns about the imbalance in LTE compatible spectrum holdings it could create, in particular due to the 2.1 GHz spectrum available to Three following the merger between Hutchison and O2. However, this was at a time when the future availability of additional spectrum included in the proposed scope of this award was unclear and still some way off.

Liberalising the 2.1 GHz licences in parallel with (or shortly before) this award would mean doing so at a time when a large amount of additional spectrum (350 MHz) is proposed to become available. Furthermore, since those comments were received, the 3.6 GHz band has been awarded to significantly increase the overall supply of LTE compatible spectrum in Ireland and reduce the proportion of the total allocated to Three.

[17] This would seem to be largely in line with NERA's suggestion (in its 2018 report prepared and submitted to ComReg on behalf of Three) that the liberalisation process occurs outside of the auction, allowing liberalised spectrum to be accessed earlier.

Notwithstanding the above, it is important that modifying existing licence terms to allow for liberalisation is carried out in a manner that does not unduly distort competition, among other things.[18] If licences are to be liberalised, then options need to be offered to each licensee setting out what (if any) charges will be applicable for such liberalisation to ensure fairness, and how this will be implemented within the overall award process.

### 3.3.4 Additional payments for liberalisation to 2022

For the 2012 MBSA, ComReg required operators to make a payment in return for liberalising their existing GSM-only rights of use. The amount to be paid was established via the award mechanism (as described above) to reflect the estimated market price of equivalent liberalised rights of use at the time, as revealed by the bids made in the auction. In the case of the 2.1 GHz spectrum for this particular award, the potential for additional payments for liberalisation beyond the licence fees paid (or due to be paid) under the current licence terms is considered over the two key time periods discussed above:

- the period up to 15 October 2022 in relation to all 3G licences (assuming the 2.1 GHz interim rights proposal for Three); and
- the period 16 October 2022 to 11 March 2027 which only applies to Meteor's 3G licence.

*Additional fees for early liberalisation up to 15 October 2022*

For the time period up to 15 October 2022, the available evidence suggests that it is not necessary to apply any additional fees for liberalising the existing 2.1 GHz rights of use. The main reasoning for this is that the fees paid (or to be paid in the case of Meteor) under the current licence terms are likely to be above the current market price of 2.1 GHz spectrum rights. Further, for the reasons set out below, it is impractical to try to set any fees based on an estimate of market price for liberalised rights of two years or less.

The reasons for requiring additional payments on liberalisation are to ensure that operators pay a fair price for being assigned a valuable resource (and, in particular, to incentivise the efficient and optimal use of that valuable resource) and avoid creating potential

[18] We would expect competition concerns to only arise in relation to the mobile market as liberalising licences for spectrum that would most likely be used for providing mobile services should not have any detrimental impact on other spectrum users that do not directly compete with the MNOs. As noted in Section 4, the other operators making use of similar spectrum (in particular Imagine and Airspan, both of which hold rights of use for 3.6 GHz frequencies) can be considered to provide services that fall into different markets to mobile broadband and are not currently in direct competition with the MNOs.

distortions to competition; everything else being equal, the expectation would be that liberalising licences would expand the range of technologies that can be used and so increase the value of the spectrum rights. If an appropriate fee for liberalisation were not charged, an existing licensee would experience a windfall gain. This could be problematic if such gains accrued unequally across operators, leading to competitive distortions.

The benchmarking exercise[19] gives an estimated current market price of spectrum in the 2.1 GHz band in the region of €0.33/MHz/pop for a 15-year licence. However, the 2.1 GHz awards in Ireland in 2002 and 2007 yielded prices in the range of 0.42 – 0.77 €/MHz/pop.[20] On this evidence, the market price of liberalised 2.1 GHz spectrum is likely to be less than the fees for the current 3G licences that were set in 2002/2007. As operators are already potentially paying above current market price estimates for liberalised spectrum, there appears to be no justification for requiring further payment.

For the avoidance of doubt and to pre-empt any potential claims, we would not consider it appropriate to offer any form of refund/discount on the fees paid for the current licences on the basis that these are above current estimates of market price. These licences were acquired by their holders in full knowledge of the fees that would be charged and with the possibility that the asset value of licences could appreciate or depreciate. To re-price usage rights to this spectrum prior to the end of existing licences would undermine the integrity of the previous award process, amount to the State effectively underwriting the risk of overpaying for an asset, and could have a highly undesirable effect on the efficiency of future award processes if payment terms were seen as not being committing for winners.

We also highlight that setting appropriate fees for liberalising licenses in the period up to 15 October 2022 would likely be practically difficult:

- We cannot build a mechanism into the award process for establishing a market price (as in the MBSA process in 2012) since there would be no equivalent generic liberalised 2.1 GHz rights being sold within the process for this time period to use for comparison.

[19] ComReg Document 19/59b

[20] Depending on the type of licence and time of award. Note also that these benchmark data points are for licences including a 5 MHz TDD lot alongside the paired spectrum. The achieved prices were:

- 0.417 €/MHz/pop for the 2x15 MHz A licence (which had restricted coverage) and 5 MHz TDD awarded to Hutchison in 2002;
- 0.772 €/MHz/pop for the 2x15 MHz B licence and 5 MHz of TDD spectrum awarded to each of Vodafone and O2 in 2002; and
- 0.559 €/MHz/pop for the 2x15 MHz licence and 5 MHz of TDD spectrum awarded to Eircom (Meteor) in 2007.

- Benchmarking is often used to form an estimate of the market price of spectrum as input to setting reserve prices. Arguably a similar methodology could be used for determining annual fees based on estimated market prices. However, benchmarking only provides an approximate estimate of likely market prices. Benchmarks are useful for setting reserve prices, as these are typically set conservatively below estimates of market prices. To the extent that benchmarks provide uncertain estimates of likely market prices, reserve prices can be set more conservatively to reflect this. However, such uncertainty is more problematic in the context of trying to set fees for liberalised spectrum intended to reflect a central estimate of market prices.
- A benchmarking approach is also unlikely to be useful as prices paid in other awards are for spectrum licences that span many years, with a major component of the market price relating to the cashflow benefits that spectrum generates for operators in future years. Benchmarking data is therefore likely to have limited relevance for estimating the market price of liberalised licences lasting only two years or less.
- Other more complex methods for determining reasonable fees, such as a business modelling exercises, are not realistically feasible, as ComReg would not have access to the relevant detailed information for estimating the value of the spectrum for operators. In any case, it would not be appropriate to charge an operator the full value gain of liberalising its licence, as the market price of spectrum is determined by the opportunity cost from other potential users who are unable to use the spectrum, not the value of that spectrum to the user itself.

Therefore, we consider it both unnecessary and impractical to try to set any additional fees for liberalisation based on an estimate of the market price for liberalised rights of two year or less for the time period up to 15 October 2022.

Any liberalisation decision should not create a distortion of competition. In the case of the period up to 15 October 2022, we do not envisage any issues of this kind, as all MNOs would be treated the same with regard to the opportunities for liberalising their current rights of use.

On the basis of the discussion set out above, we believe that it would be reasonable and appropriate to allow operators to liberalise their current 2.1 GHz rights of use for the period up to 15 October 2022 without the imposition of additional fees over and above the level of their existing GSM licence fees.

## 3.3.5 Liberalisation of Meteor's licence to 2027

*Early liberalisation for Meteor (16 October 2022 to 11 March 2027)*

Regarding Meteor's current licence, since benchmarking suggests that the fees for the current licences are above the likely market price of the liberalised spectrum, [21] it is arguable that a suitable approach would also be to allow for liberalisation with no additional fees. However, given the different starting positions of the three MNOs in relation to this period and the longer period involved, there are more significant concerns about the potential for unfairness and possible distortion of competition if Meteor were to liberalise its licence but the auction then demonstrated that the market price for liberalised 2.1 GHz spectrum is above Meteor's current licence fees.

We do not consider this scenario likely, but it can be insured against through a potential spectrum liberalisation fee mechanism (discussed below). This would require some payment by Meteor in the event that the market price of 2.1 GHz licences implied by the award outcome were higher than the current fees. Such a mechanism would have the advantage of pre-empting potential arguments about Meteor gaining access to 2.1 GHz on unduly favourable terms.

We first highlight that establishing suitable fees for liberalising Meteor's licence for the period 16 October 2022 – 11 March 2027 through the auction itself is likely to pose challenges. In principle, we could use a similar approach to that applied in the 2012 MBSA; this would require using time slices to create equivalent generic rights of use whose market price could provide a reference point on which to base the fees for liberalisation. However, we cannot use a mechanism that allows Meteor to liberalise its licence for the period up to 15 October 2022 and then choose (e.g. via the award process) whether or not to also liberalise the licence for the remaining period of 16 October 2022 – 11 March 2027. More specifically, it would be unreasonable to have a situation in which Meteor's licence is liberalised for the first period but then 3G-only usage restrictions are reinstated from 16 October 2022 until the licence expires; this would reapply the technology restrictions the EC Decision seeks to remove, and it would likely strongly disincentivise Meteor in making use of the liberalisation freedom in the earlier years. This approach would be contrary to ComReg's objective of efficient spectrum allocation and use.

Therefore, it is an unavoidable feature of allowing a liberalisation option that if Meteor were to liberalise its licence in the period up to 15 October 2022 then that licence would need to stay liberalised for the period 16 October 2022 – 11 March 2027. Meteor's choice to

[21] As with the liberalisation of licences for the earlier time period, we do not consider that this evidence should be considered grounds for applying a refund/discount on current licence fees.

liberalise would necessarily be for the entire residual term of its licence. We take this as an unavoidable constraint on the design of the award process.

*Differences in starting positions*

Due to the different starting dates of their licences, Vodafone and Three are necessarily in a somewhat different situation to Meteor. Both Vodafone and Three could have an early liberalisation option in the period up to 15 October 2022, but would need to acquire new rights from 16 October 2022 onwards, whereas Meteor could have an early liberalisation option to use its current rights (in liberalised form) up to 11 March 2027.

Clearly it is not possible to treat operators in an identical manner with regard to the 2022-2027 period because they are in very different starting situations, with Meteor's existing licence already covering this period. Nevertheless, it is important that this difference does not lead to material distortions of competition. In particular, concerns could arise if Meteor gained access to liberalised 2.1 GHz rights during the period 2022-2027 but paid for that spectrum access at below market price.

*Relevance of the price of 2.1 GHz spectrum in the award for liberalisation terms in the time period 16 October 2022 to 11 March 2027*

While the benchmarking data indicates that the price of the 2.1 GHz liberalised spectrum in the award is likely to be less than the fees for the current 3G licences that were set in 2002/2007, there is of course a degree of uncertainty over the estimates of the current market made prior to the award. It is not impossible, therefore, that the prices for the 2.1 GHz rights in the proposed award will rise beyond the level of the current fees. If auction prices for 2.1. GHz liberalised rights in the same time period were to exceed the current licence fees, not charging additional fees for liberalisation could unduly distort competition. This relates in particular to the liberalisation of Meteor's licences over the period of the first time slice (2022 – 2027). However, in the case that Meteor's licence was liberalised over the first time slice and other operators paid fees for new 2.1 GHz rights over the same period in excess of Meteor's current payments, this could be claimed as potentially giving rise to a distortion to competition.

Given the difference between the benchmarking figures and the current fees paid for the 2.1 GHz licences, we do not consider this situation to be likely. However, to avoid the potential for such distortions to competition to arise, we would recommend having in place a process by which, if the auction price of new 2.1 GHz rights exceeded the level of current fees (of unliberalised licences), there would be a potential spectrum liberalisation fee mechanism that would require Meteor to make a payment that reflected the implied additional market price (above its current fees) of liberalisation.

Without an explicit mechanism, there would remain the possibility that fees for the new 2.1 GHz liberalised rights were higher than existing 2.1 GHz fees and that Meteor was therefore paying below market price for the liberalised spectrum. Therefore, it is impossible

to eliminate the possibility that, in the unlikely event that the prices for the 2.1 GHz licences awarded are higher than the fees for current licences, Meteor may face the risk of additional payments post-award related to the liberalisation process as a result of disputes (e.g. claimed State Aid). This risk would need to be assessed by Meteor when deciding whether or not to liberalise its current licences, with the outcome unknown in advance.

In contrast, with a potential spectrum liberalisation fee mechanism, Meteor would still face some risk of an additional post-auction payment if it were to liberalise its existing licence before the award, but would potentially be better able to assess that risk as the process for determining additional fees would be known in advance. Alternatively, Meteor would be able to make a fully informed decision on whether or not to liberalise immediately after the award, once it knew the extent of any additional costs that would apply.

*Potential spectrum liberalisation fee mechanisms*

The ideal potential spectrum liberalisation fee mechanism would base any liberalisation fees on the extent to which the prices achieved in the award for 2.1 GHz rights in time slice 1 lots exceeded the current fees being paid by Meteor. However, if the award format used is one that allows for package bidding (specifically the CCA, as recommended in Section 7.2 below), there may not be an explicit price for the 2.1 GHz lots that can be used as a basis for the liberalisation fees. This is because winning bidders each pay a single price for a package of lots that potentially includes spectrum from multiple bands/lot categories.

A reasonable solution in this case might be to use the final clock prices to provide an approximation of the relative price per lot for each of the various lot categories. These can then be used to approximate the prices paid by winning bidders for the 2.1 GHz spectrum rights awarded in the auction. This would in turn give a price point for assessing the extent to which prices achieved in the auction for the 2.1 GHz spectrum have exceeded current fees, and the level of additional charges that would be appropriate for liberalisation. This use of final clock prices is similar to the approach taken by ComReg for calculating refunds and adjustments to licence fees for the 3.6 GHz licences awarded in 2016 in the event of delayed access to the spectrum.[22]

A suitable process for determining any additional charges to be paid by Meteor for liberalising its current 2.1 GHz licence(es) in the period 2022-2027 could run as follows:

- Sum the prices paid by each winning bidder to obtain total revenue for the award.
- Allocate the total revenue to each lot category in proportion to final clock prices; this gives an estimate for the auction revenue associated with each of the two 2.1 GHz lot categories.

[22] See Section 2.4.7 of ComReg Document 16/71.

- For the 2.1 GHz spectrum in each of the two time slices, divide the allocated auction revenue by the number of lots in the category sold to give an average auction price per lot for that category. Add these together to give an average auction price for a 2x5 MHz lot running for the full duration over both time slices.
- Add the discounted sum of SUFs for a 2x5 MHz licence (again for the maximum possible licence term) for spectrum in the 2.1 GHz band to the average auction price to give a total price for a 2x5 MHz lot in the award; this is the 'current market price' of 2.1 GHz licences. Using this overall price point covering both time slices (rather than just considering one of the two time slices) helps to avoid creating distortions to bidding due to incentives to push the price of the 2.1 GHz in one time slice or the other to manipulate the liberalisation fees. For discounting the SUFs we propose to use a real discount rate of 7.13% per annum.[23]
- Calculate an equivalent price for a 2x5 MHz block of 2.1 GHz spectrum using the discounted fees (SAFs and SUFs) for Meteor's current 2.1 GHz licences, adjusting for inflation and differences in licence duration – this is the 'previous price'.
- Use the difference between the current market price and previous price to assess whether and the extent to which prices for new 2.1 GHz licences have exceeded Meteor's fees for its current licence.
- Annuitise the difference (using a real discount rate of 7.13% per annum) to give a per year difference between the market price of a liberalised licence and the current fee level for an unliberalised licence.
- Multiply the per year price difference by the number of 2x5 MHz lots Meteor will liberalise (i.e. three) and take the present discounted value (using a real discount rate of 7.13% per annum) over the years for which the early liberalisation is applicable. This is then the one-off premium payable for early liberalisation during the time period 2022-2027.

Finally, we note that this approach – based on allocating the total auction revenue to derive average prices – only uses publicly released information provided at the end of the auction. As an alternative, it is possible to use bidding data (especially losing bids) to create more refined estimates of the market price of spectrum

[23] The discount rate used (7.13%) is based on the estimates provided for the mobile sector WACC in ComReg, 2014, Cost of Capital, Document 14/136 and D15/14: http://www.comreg.ie/_fileupload/publications/ComReg14136.pdf. We estimate the real pre-tax WACC by subtracting the estimated inflation (1.5%) from the estimated nominal pre-tax WACC (8.63%).

bands within a combinatorial auction.[24] However, in the 2012 MBSA, ComReg kept confidential the bid amounts of winning bidders and also losing bids; this was to improve bidding incentives, as this information is likely to be highly informative about bidders' valuations and bid ceilings. In the case of determining a potential fee for liberalised spectrum, we consider that it is important that any process for determining the amount of a potential spectrum liberalisation fee is transparent and only used public data. Therefore, we do not think that the benefits of using more sophisticated methods of estimating the market price of particular bands are appropriate, as they would cut across ComReg's approach to confidentiality of bid data.

*Comments at consultation*

In its response to the consultation on the bands to include, Meteor/Eir stressed that any liberalisation fees should be fair (and arguably that there should be no additional fees due to the implied benefits of liberalisation to society). Meteor said that liberalisation fees should not be linked to prices paid by others seeking to liberalise and renew licences at the same time, when Meteor would only be seeking to renew.

However, we disagree with Meteor's argument, noting that in the case it became necessary to charge liberalisation fees, it would be very difficult to determine suitable fees without looking at the prices paid by others for equivalent spectrum in the award, as these prices would represent the best available estimate of the fair market price of the liberalised spectrum. Indeed, if Meteor were to win 2.1 GHz rights in the award that followed on from its current licences, it would (if its current licences had been liberalised) be acquiring equivalent rights to those (if any) awarded to other MNOs over the full time period.

## 3.4 Time slices

As explained above, the 2012 MBSA awarded spectrum rights over two time slices. This helped with alignment of licence periods and also with the determination of prices for Party-Specific lots as it provided equivalent generic licences for comparison.

We recommend the use of a similar approach for this award, as we consider that there may be benefits in using time slices to aid with licence alignment and providing greater flexibility for accounting for the different expiry dates. More specifically, we propose two time

[24] See DotEcon (2013), "800MHz and 2.6GHz linear reference prices and additional spectrum methodology" prepared for Ofcom. Available at https://www.ofcom.org.uk/__data/assets/pdf_file/0028/71389/linear-reference-prices.pdf

slices for the 2.1 GHz licences, in line with the key periods identified in Section 3.2:

- **Time slice 1 (16 October 2022 – 11 March 2027):** the 2.1 GHz spectrum rights assigned for this period would be for 2x45 MHz currently assigned to Vodafone and Three.
- **Time slice 2 (12 March 2027 – licence expiry (tbd)):** the 2.1 GHz spectrum rights assigned for this period would be for all of the paired spectrum available for the award (i.e. the 2x45 MHz currently assigned to Vodafone and Three as well as the 2x15 MHz currently used by Meteor).

We recommend also awarding the other supra-1 GHz spectrum in two time slices, aligned as much as possible with those set out above for the 2.1 GHz spectrum:

- the first time slice would run from the start date of the 700 MHz, 2.3 GHz and 2.6 GHz licences until 11 March 2027; and
- the second time slice would run from 12 March 2027 to licence expiry (tbd, but this will be the same as for the 2.1 GHz licences)

This would allow for maximum flexibility over switching between the higher frequency lots within the award, which should help to facilitate an efficient assignment.

*Two time slices for all supra-1 GHz bands*

Although 700 MHz spectrum may be an imperfect substitute for the higher frequencies, the difference in propagation characteristics and likely uses of the sub-1 GHz and supra-1 GHz bands mean that they are more likely to be complements; switching between them is less likely to be relevant than between the 2.1 GHz, 2.3 GHz and 2.6 GHz bands, where despite value differences across bands bidders are more likely to switch in response to changes in relative prices. For these reasons, and to maintain simplicity for the award where possible, we do not see any convincing need to award 700 MHz spectrum in two time slices. Therefore, we recommend time slices only for the available 2.1 GHz, 2.3 GHz and 2.6 GHz spectrum.

*Avoiding excessive complexity*

In its response to the ComReg consultation document, Three expressed a concern over the potential number of time slices that might be used, indicating that given the number of different expiry dates of the current licences, this could be up to 5 or 6. Three considers that so many time slices would make the auction unnecessarily complex. We agree that such a large number of time slices would add significant complexity to the award and would be undesirable. Our recommendation above to grant interim 2.1 GHz rights to Three that would expire at the same time as Vodafone's existing licence means that there would only be two time slices required (as set out above); we do not consider this to be overly complex and should address Three's concerns. We note that the proposed approach is less complex than the 2012 MBSA award which also included the use of 'Party-Specific Lots' to facilitate the early liberalisation of the current 900 MHz and 1800 MHz rights of use.

Use of time slices in this way could of course expose bidders to aggregation risk, as operators are likely to have synergies from acquiring spectrum rights of use that span the full period across both time slices.[25] This provides an argument for using an award format that supports packaging bidding, which would protect bidders from winning spectrum in just one time slice but not the other (discussed further below).

## 3.5 Other points raised in the consultation responses

In this subsection we discuss several other points raised in responses to ComReg Document 18/60 in relation to the 2.1 GHz band that could not be suitably addressed above.

### Advantage to existing licence holders

Three claims that the different expiry dates of the current 2.1 GHz licences would "*distort the attractiveness of some of the lots across the range of possible bidders in the long term*". This is because "*an existing licence holder might have an advantage over other bidders for the lots that they hold if the lots do not become available for some time after the award process*". Three highlights that Meteor would have a particular advantage because its licences expire seven years after the date of the award, and "*the value placed on lots that can be used in the short term is always going to be higher than the value to buy lots that cannot be utilised for a period of 7 years into the future*".

We assume that Three's point is made in relation to the scenario where Meteor is able to liberalise its 2.1 GHz lots. However, it is not clear to us why Three considers Meteor to have a particular advantage in bidding for the 2.1 GHz spectrum.

The lots licenced to Meteor up to 2027 would not be available to others until they expire in any case, so Meteor does not have an "advantage" with respect to those lots over any other that goes beyond its rights acquired under the current licence and for which it is paying a fee.

If Three is instead concerned about the lots associated with Meteor's current spectrum when it becomes available from 2027, then again it

[25] As suggested by NERA in Section 3.2 of its report prepared with Three and submitted to ComReg. NERA alternatively suggests that the 2.1 GHz spectrum could be made available with (long) overlapping licence terms; 2x45 MHz would be available as 25-year rights of use starting in 2022, and 2x15 MHz would be available from 2027 with a licence duration of 20 years. This option would be viable, however we do not consider it suitable as it could restrict opportunities for switching.

is unclear to us why Meteor would be considered to have an unfair advantage bidding for those lots in the auction. All bidders would have the opportunity to bid for those lots and we do not see any reason to think that if Meteor were to have the highest value for it this would represent an inefficiency or unfairness through distorted valuations.

## Gaming using bidder-specific lots

Three also seems to have expressed concerns that the use of bidder-specific lots (as in the 2012 MBSA) could allow bidders to hide eligibility and reduce the transparency of the auction. Our understanding is that Three is worried about the possibility for bidders bidding initially for (liberalised) Party-Specific lots but then switching into generally available spectrum later on.

We first highlight that under our current proposals there would be no Party-Specific lots in the award. Therefore, this concern is now beside the point.

In any case, if Party-Specific lots were to be used, a strategy of hiding eligibility before switching demand to other lots later on would only be helpful if the bidder wants to keep its 3G licences with the current restrictive terms, otherwise the bidder would need to bid for the Party-Specific lots with the aim of winning them. If the bidder did not want to liberalise, then making such bids would be a significant risk of winning the Party-Specific lots it did not want, especially in formats such as the CCA where all bids made at any point in the auction are binding.

Furthermore, such a bidding strategy would be counterproductive if the intention of the bidder was to (i) not liberalise and (ii) win generic lots other than Party-Specific lots, as such bids might increase the amount that the bidder would need to bid to win generic lots. This arises because no other bidder can bid for Party-Specific lots. Assuming there are bids from other bidders for the generic lots, for an outcome in which the bidder is awarded the generic lots rather than the Party-Specific lots, it needs to bid enough to beat the outcome in which it is awarded the Party-Specific lots and the generic lots go to another bidder.

We therefore consider there to be a very low risk of such behaviour, even if the same approach as in the 2012 MBSA were used (which is not proposed).

## Payment of fees for spectrum available later

Meteor believes that it would be unfair if it were to win a new 2.1 GHz licence starting in 2027 and have to pay the relevant fees

immediately following the end of the award (in particular when any fees associated with new licences awarded to Vodafone and Three would be made a more reasonable time before the licence start date). Meteor also highlights that in that case it would need to pay for licence renewal eight years in advance of licence expiry (if the upfront fee is due at the end of the auction), when it is still paying for its 3G licences (and will be financially weaker as a result).[26]

In response to Meteor's comments, we first highlight that if it were to win 2.1 GHz spectrum in time slice 2, it would not be paying for a licence *renewal*, but for a new licence (albeit potentially for the same frequencies). There is no reason that payments in regard to new time slice 2 assignments should be treated in different ways for different winners according to what other spectrum licences they currently hold, as in time slice 2 all bidders are in similar positions with all of the available 2.1 GHz spectrum available for award.

In addition, the payment terms faced by Meteor in this situation would be similar to any other operator that was to win 2.1 GHz spectrum in both time slices (whether awarded as two separate licences or one continuous licence); those bidders would also be required to pay in advance for access to the spectrum over the period of time slice 2 and at the same time as paying for access over the first time slice. We therefore do not agree that Meteor would be at any significant disadvantage relative to other operators in this regard, and if we were to defer payments for time slice 2 spectrum rights then this would have to be for all bidders and not just Meteor.

We do acknowledge that allowing for payments to be spread out over time can be beneficial to bidders with limited access to capital and may help to promote an efficient award outcome. However, we highlight that this has already been taken into consideration in the recommended splitting of fees into an upfront spectrum access fee (SAF) and annual spectrum usage fees (SUFs), as set out in Section 6.

For the reasons discussed above, we do not recommend that payments for time slice 2 spectrum for any bidder should be deferred.

[26] We note that NERA also suggests that awarding spectrum so far in advance of the start of the licences makes it harder to value and obliges bidders to pay for the spectrum years before they can use it.

# 4 Measures to safeguard competition

ComReg's statutory objectives broadly require that any process for awarding spectrum usage rights be designed to promote efficient assignment and use of spectrum. In line with this overarching objective, downstream competition in services derived from spectrum should be at minimum safeguarded and, where possible, actively promoted. Therefore, for any spectrum award, it is necessary to consider the potential impact on competition in relevant downstream markets that rely on spectrum as an input.

## 4.1 Which downstream markets are relevant?

As discussed above, the spectrum being considered by ComReg for assignment in this proposed award has all been identified as suitable for 5G WBB ECS. We would expect the 700 MHz band to be important for cost effective wide-area deployment of initial 5G WBB services, with the other available bands offering additional capacity in urban areas and/or traffic hotspots. There may also be demand for the higher frequencies from fixed wireless providers, given the larger amounts of contiguous spectrum available (which is important for providing the required levels of capacity and throughput).

*Competitive impacts in mobile services*

There are currently three MNOs in Ireland (Vodafone, Three and Meteor) all of which operate on a national basis. An efficient mobile network typically uses a combination of sub-1 GHz spectrum to provide coverage and in-building penetration, along with higher frequencies for capacity in high traffic areas; the MNOs are therefore likely to be interested in all of the bands on offer. As discussed in detail below, the assignment of the spectrum available in this proposed award has the potential to impact on downstream competition between the mobile operators, and this will need to be taken into account when determining any requirement for measures to safeguard competition.

In addition to the three MNOs, Imagine, a fixed wireless provider, and Airspan secured spectrum rights of use in the 2016 3.6 GHz award. Airspan appears set to use this for operating a small-cell network for providing wholesale capacity to other operators.[27] This may provide MNOs with an alternative source of capacity and reduce the need for holding spectrum licences directly themselves. It may also provide efficiencies in the deployment of small cells through the sharing of infrastructure. However, this service is as yet undeveloped, and its future impact is uncertain. Furthermore, this business model would sit upstream of the traditional MNOs, so Airspan's entry, although a positive development, does not

[27] See https://www.airspan.com

fundamentally change current conditions of competition in mobile retail markets.

*Competitive impacts in FWA*

In Ireland, FWA services have previously been provided by various regional players using 3.6 GHz spectrum. These licences have expired and a transition process is currently ongoing,[28] with this being a key capacity band for mobile networks. In the recent 3.6 GHz award, the majority of spectrum was won by existing mobile network operators, but Imagine acquired regional spectrum licences which we understand will be used for FWA services in rural Ireland.[29]

The bands above 1 GHz being offered in this proposed award will be licensed by ComReg on a service- and technology-neutral basis. Therefore, there is nothing in principle to prevent these bands from being used for FWA services, either by a specialist FWA provider or by a mobile network operator.

FWA services are distinct to mobile services, as they are used as an alternative to a fixed link to a home or small business in cases where it might be uneconomic to run a wired local loop. Whilst in some cases, mobile services may be an alternative to both FWA and traditional wired access, in rural areas limited mobile coverage and/or lower speeds may mean that general mobile broadband services are not an effective substitute to FWA or traditional wired services. Therefore, FWA is less likely to compete with mobile broadband services in those rural areas.

Specialist FWA providers, therefore, are not in direct competition with mobile operators. Even if there are some customers for whom mobile broadband may be a substitute to fixed connectivity, there are also customer segments – primarily In rural areas - for whom mobile broadband services cannot provide adequate connectivity at a particular fixed location. Any limited substitution is also one-way, in that FWA services are not a good alternative to mobile broadband services by virtue of only being available at a fixed location. In particular, this means that the provision of FWA services in a geographic area is unlikely to impose any material competitive constraint on mobile services through demand-side substitution, even though the pricing of mobile broadband services may to some extent constrain that of FWA services.

We acknowledge that it is possible that mobile network operators might increasingly choose to provide FWA services, not least due to convergence of the underlying technologies. FWA services are expected to increasingly be deployed over LTE-Advanced, creating the potential for scale economies between FWA and WBB provision using some common elements of infrastructure. Converged 4G/5G

[28] https://www.comreg.ie/industry/radio-spectrum/spectrum-awards/3-6ghz-band-spectrum-award/

[29] https://www.comreg.ie/industry/radio-spectrum/spectrum-awards/3-6ghz-band-spectrum-award/

networks can use MIMO for beamforming and are expected to be able to deliver FWA services cost effectively on a common platform with mobile services. However, if such convergence occurred, it would lead to national mobile network operators offering FWA services in particular locations, rather than specialist (and often geographically limited) FWA providers extending their offering into full mobile services. Therefore, even though there may be potential for supply-side substitution, we cannot as a result expect FWA providers to impose any material competitive constraint on pricing of mobile broadband services.

For these reasons, that acquisition of the available spectrum by mobile operators and the impact on competition in mobile telecommunications services (especially mobile broadband) is likely to be the most relevant factor when determining the need for measures to safeguard competition. If spectrum within this proposed award were won by other parties aiming to provide other services, such as FWA, this might well benefit consumers. However, we do not see any compelling evidence to suggest that such other services are as yet relevant for the assessment of downstream competition in mobile telecommunications services. Furthermore, we see no need for special measures to protect non-mobile users (such as specialist FWA providers) by reserving spectrum or through other asymmetric measures to make spectrum available only to them (e.g. individual or collective caps on mobile operators). This could be potentially detrimental to existing and well-established mass-market services provided by the MNOs for a speculative and uncertain benefit in much smaller specialist downstream markets.

## 4.2 Spectrum asymmetries and competition

*Inefficient assignments can be due to anti-competitive valuations*

Highly asymmetric spectrum holdings may distort competition, giving significant competitive advantages to players with more bandwidth. For instance, one party might be able to acquire sufficient spectrum to constrain their rivals, limiting the quality of service they can provide or raising their marginal costs of providing capacity. Therefore, it is potentially possible for participants in an award process to derive some of the value for spectrum from the anticompetitive benefits of denying use of that spectrum to others. This may be detrimental to consumers if the dampening of competition leads to, for example, poorer services and/or higher prices than would have been the case in a more competitive environment.

For these reasons, it is important that an award process avoids assigning spectrum to one user over another purely because of such anticompetitive value. Assigning the spectrum to the user with the highest value in this case would neither create the greatest economic welfare nor be in the interests of consumers, representing an

inefficient award outcome and creating enduring inefficient use of the available frequencies. For these reasons it is common for spectrum caps to be applied to ensure that outcomes are not excessively asymmetric.

*Spectrum measures may be used to promote competition*

In particular cases, where it has been found that downstream competition is currently insufficient, active measures may be taken to create a more competitive downstream market structure. Such measures may include reservations of spectrum for entrants or collective caps on incumbents. Individual caps on incumbent operators may have a similar effect if set tightly enough to carve out spectrum available only to entrants, and/or may help to address concerns over imbalances in spectrum holdings amongst the incumbents.

*Protecting competition does not require symmetric spectrum allocations*

Where downstream markets are adequately competitive prior to a spectrum award, the main concern is with safeguarding existing competition without unduly precluding the potential for new entry. In such cases, spectrum caps are used primarily as a precautionary measure to prevent excessively asymmetric outcomes arising. To achieve this objective, it is not necessary for caps to achieve a tightly symmetric assignment of spectrum amongst incumbent operators. Indeed, there may be valid reasons for the efficient assignment of spectrum to be asymmetric, for example where operators follow different business models. Limited asymmetries in spectrum holdings may be compatible with promotion of downstream competition, with differentiation of services being a benefit to consumers, rather than aimed at dampening price competition; this depends on the specifics of how downstream competition operates and would be affected by the distribution of spectrum.

*Competition measures need to be tailored*

Therefore, the use of competition measures such as spectrum competition caps needs to be tailored to the specifics of an award. In some cases, the distribution of spectrum being awarded may be immaterial to the conduct of downstream competition; in other cases, one bidder cornering the available spectrum could dramatically limit downstream competition. In this proposed award, the primary concern is impacts on the competitiveness of the mobile broadband market.

There is also often a high level of uncertainty about how the distribution of spectrum being awarded will affect downstream outcomes.[30] Because of uncertainty about these linkages, the focus when setting spectrum competition caps should typically be on preventing excessively asymmetric spectrum assignments that risk

[30] Sappington, D and Mayo J (2016) "When do auctions ensure the welfare-maximizing allocation of scarce inputs?", Rand Journal of Industrial Economics, 47(1):186-206.

uncompetitive downstream outcomes, rather than trying to engineer a particular market structure and affect downstream outcomes with any precision.

*ComReg has used competition caps in previous awards*

ComReg used spectrum competition caps[31] in the 2012 MBSA to avoid highly asymmetric outcomes that might lessen the existing level of competition between the MNOs. In that award, ComReg was also mindful of not precluding the possibility of entry, although this was achieved primarily through the choice of auction format and detailed rules that promoted neutral competition between existing and potential new users of spectrum, rather than specific measures to promote entrants (such as a spectrum reservation). More recently, ComReg has applied spectrum competition caps in both the 3.6 GHz auction (2017) and the 26 GHz auction (2018), again to protect against outcomes that might negatively impact downstream competition. The 3.6 GHz auction resulted in the entry of Airspan[32], though caps had been set sufficiently permissively that it would have been possible for the three MNOs to purchase all of the available spectrum in that award.

## 4.3 Current distribution of spectrum amongst MNOs

*We need to consider the potential competitive impact on the mobile telecommunications services market*

The spectrum proposed to be made available in this proposed award has all been identified as suitable for the provision of WBB. On that basis, and as highlighted earlier, we consider that there are a number of potential users likely to be interested in the spectrum, including the MNOs and providers of fixed wireless services. However, we believe that the mobile market is overwhelmingly the relevant one for assessing the potential impact on downstream competition.

As discussed in ComReg document 14/102, additional spectrum provides MNOs with a way of expanding capacity that is an alternative to adding network infrastructure. Therefore, we can expect that access to additional spectrum should tend to reduce the long-run marginal costs to MNOs of expanding network capacity, which in turn should have pro-competitive benefits that should be passed on to consumers. However, if MNOs have access to very different amounts of spectrum and these benefits are enjoyed significantly more by some but not others, this may restrict the ability of those with access to less spectrum to compete in the downstream market (e.g. due to higher marginal costs and/or capacity constraints). This may then be detrimental to consumers if,

[31] Caps on the amount of spectrum that bidders could be assigned in the award. Note that these caps applied only for that specific award process and do not impose any longer-term restrictions on spectrum holdings.

[32] See ComReg 17/46.

for example, the operators with more spectrum face less competitive pressure to pass on the benefits to consumers. On this basis, highly asymmetric spectrum holdings across operators can be undesirable, in particular where there is a limited number of MNOs operating in the market (as in Ireland where there are only three MNOs).

The 700 MHz band is likely to have a central role in the initial delivery of wide-area 5G services, in that it is likely to provide the coverage layer in early 5G deployments (with the 3.6 GHz providing 5G capacity layer and likely to be used first). Furthermore, in the shorter run, MNOs will need to run 2G and 3G services in low band spectrum below 1 GHz, as well as 4G and developing 5G services. This may create a need for operators to hold sufficient spectrum across 700 MHz, 800 MHz and 900 MHz bands to allow for legacy services and transitioning without excessive cost or impact on 4G service quality, which is the current predominant mode of delivering WBB services.

*It is not possible to completely foreclose access to the market for other MNOs…*

In light of these issues, we need to consider the potential impact of the award on the (retail) mobile telecommunications services market. There is a large amount of spectrum available in this proposed award (470 MHz in total), so it is difficult to envisage an outcome in which one or two of the MNOs acquires it all to leave the other(s) with no access to additional spectrum. Furthermore, all of the MNOs have access to frequencies in the 800 MHz, 900 MHz and 1800 MHz bands until 2030, as well as in the 3.6 GHz band until 2032. It is not possible for any of the existing MNOs to be left with an insignificant amount of spectrum at the end of the award (even if they win nothing in this particular award). There will be other existing holdings below 1 GHz, though failure to obtain 700 MHz could adversely impact on an operator's ability to maintain legacy services whilst expanding 4G and 5G capacity. Therefore, there are some risks to downstream competition from asymmetric outcomes, but these are much less severe than if access to the downstream market could be completely foreclosed to one or more operators by denying them spectrum from this proposed award.

*…but highly asymmetric outcomes might still restrict competition*

On the other hand, the large amount of spectrum available does still provide scope for the post-award situation to be highly asymmetric to the extent that competition between the MNOs might be affected. This is exacerbated by the fact that there is already a difference in the current spectrum holdings of MNOs, resulting to some extent from the 2014 merger between Telefónica and

Hutchison 3G (to form Three Ireland). Table 2 shows the current spectrum holdings of the three MNOs.[33][34]

*Table 2: Current MNO spectrum holdings*

| Band | Three | Vodafone | Meteor |
|---|---|---|---|
| 800 MHz | 20 MHz | 20 MHz | 20 MHz |
| 900 MHz | 30 MHz | 20 MHz | 20 MHz |
| **Total sub-1 GHz** | **50 MHz** | **40 MHz** | **40 MHz** |
| 1800 MHz | 70 MHz | 50 MHz | 30 MHz |
| 3.6 GHz* | 100 MHz | 105 MHz | 85 MHz |
| 2.1 GHz FDD | 60 MHz | 30 MHz | 30 MHz |
| **Total supra-1 GHz** | **230 MHz** | **185 MHz** | **145 MHz** |
| **Total** | **280 MHz** | **225 MHz** | **185 MHz** |
| **Total (exc. 2.1 GHz)** | **220 MHz** | **195 MHz** | **155 MHz** |

**We count existing 3.6 GHz holdings as the maximum bandwidth in any region, as holdings vary across regions*

*There is a greater imbalance in supra 1 GHz frequencies*

We can see that Three has access to the most spectrum, followed by Vodafone and then Meteor. The MNOs have similar sub-1 GHz holdings (although Three has slightly more than the other two). The more significant differences are in the operators' access to the higher frequencies, although it is important to note that current 2.1 GHz licences will be expiring in 2022/27, and the associated spectrum

[33] Because there is a mix of FDD and TDD spectrum available, the totals (and notation for the caps below) reference the total amount of spectrum without differentiating between paired or unpaired (i.e. 2x5 MHz = 10 MHz).

[34] In the table of existing holdings and the subsequent analysis we do not include the 5 MHz block of 2.1 GHz TDD spectrum licensed to Three. The 2.1 GHz unpaired band is harmonised at ECC level for DA2GC rather than WBB (and consequently has been identified by ComReg as unsuitable for this proposed award). It is therefore not relevant for competition between MNOs in the mobile market and should not be included in the assessment of competition caps.

is, at this point in time, expected to be included in this upcoming award, allowing scope for some redistribution of current holdings.

*The post-merger asymmetry does not appear to create competition concerns*

In its response to ComReg consultation document 18/60, eir (Meteor) suggests that it is important for ComReg to use this proposed award to address the imbalance between the spectrum holdings of Three and other MNOs, highlighting that "*Three possesses 50% of the 2100MHz spectrum, 47% of the 1800MHz spectrum and 43% of the 900MHz band*".[35] Whilst we agree that there is currently an asymmetry in spectrum holdings across the MNOs, this does not necessarily represent an anticompetitive situation that needs to be rectified, and a degree of asymmetry may well represent an efficient distribution of the spectrum. In its decision on the 2014 merger between Telefónica and H3G, the European Commission considered "*that the change in spectrum holdings resulting from the merger is unlikely to have anticompetitive effects… The fact that, after the merger, there will be a spectrum asymmetry is not, as such, anticompetitive*"[36]

Table 3 shows the markets shares (by revenue) of the mobile operators just before notification of the H3G/Telefónica merger[37] and in the final quarter of 2019, as reported in the relevant quarterly key data reports published by ComReg.[38]

*Table 3: Market shares by total retail revenues for mobile operators*

| Operator | Market share (by revenue) Q3 2013 | Market share (by revenue) Q4 2018 |
|---|---|---|
| Vodafone | 43.5% | 42.5% |
| eircom Group Mobile | 18.2% | 18.5% |
| Three Group[39] | 35.0% | 32.0% |
| Other operators | 3.3% | 7.1% |

*Source: ComReg Document 14/19 and ComReg Document 19/22*

[35] Noting that the pre-award asymmetry in holdings is less severe than suggested by Meteor if we exclude the 2.1 GHz band and consider only currently held spectrum that will not be available for redistribution in the proposed award.

[36] Para 688 of the EC Decision on Case M.6992

[37] The European Commission received notification of the proposed merger on 1st October 2013.

[38] ComReg Document 14/19 and ComReg Document 19/22.

[39] For the 2013 values, Three's market share is calculated as the sum of the market shares of H3G and Telefonica at that time.

We can see from this data that since the notification of the merger:

- the overall revenue distribution in the mobile market has not changed by much;
- there has been a (small) redistribution of revenue share away from the merging MNOs, with Three's revenue share falling by the most amongst the MNOs;
- Vodafone remains the largest player by some margin, and eircom, as the smallest MNO, has maintained its pre-merger revenue share; and
- The HHI[40] (taking all operators other than the MNOs to be a single entity) of the mobile market based on revenue share has fallen slightly from 0.346 to 0.322.

On the basis of this evidence, there does not appear to have been any further concentration within the downstream market after the merger. Combined with the views of the EC above, this would suggest that a post-award spectrum asymmetry *at least* at the same level as after the merger is unlikely to be problematic for competition.

*Increasing supply of spectrum means imbalance may be less important, at least in the medium term*

The differences in supra-1 GHz holdings across MNOs also need to be judged against a background of substantially increasing availability of such spectrum, primarily due to the clearance and release of the 3.6 GHz band. ComReg's auction of spectrum in the 3.6 GHz band in 2017 made 350 MHz available in total and gave operators access to larger contiguous blocks of spectrum. All three MNOs secured in excess of 80 MHz of 3.6 GHz spectrum. Looking forward to the deployment of this spectrum, we would not expect any operator to be at a disadvantage (in terms of facing a higher marginal cost of providing capacity in areas of high traffic density) due to differences in supra-1 GHz spectrum holdings for at least the medium term. In the longer term, continued data traffic growth will in any case need to be met in part through small mmWave cells and offload to fixed networks.

*3.6 GHz allocation to Imagine and Airspan may support competition in the mobile market*

Furthermore, the 3.6 GHz auction also resulted in spectrum being awarded nationally to Airspan and regionally to Imagine. These are positive competitive developments. From publicly available material on their respective websites, we understand that Airspan[41] trading as Dense Air (which is part of the Airspan group[42]) intend to build small cells and offer wholesale capacity to other operators. Whilst it is clearly too early to judge whether this business model will be successful, it might provide an alternative source of network capacity to MNOs and so somewhat diminish concerns about modest spectrum asymmetries in supra 1 GHz holdings.

[40] Herfindahl–Hirschman Index, equal to the sum of the squares of the market shares.

[41] https://www.airspan.com

[42] http://denseair.net/about-dense-air/

*No strong arguments to actively reduce asymmetry or prevent an increase*

For the reasons discussed above, there does not seem to be any particular need or justification to seek to actively reduce the current differences in MNO spectrum holdings on competition grounds. Furthermore, given the background of increasing availability of spectrum, and potential develpoments in small cell networks and/or the FWA market, we do not see any obvious reason why allowing some flexibility for the asymmetry to increase (up to a point) would be detrimental to competition.

## 4.4 Structure of spectrum competition caps

*Competition cap to avoid highly asymmetric allocations*

For the reasons outlined above, it is likely to be prudent to apply one or more spectrum competition caps for this proposed award in order to avoid highly asymmetric outcomes that might impact negatively on competition between MNOs. However, we consider that this should be focused on preventing excessive asymmetries that are materially worse than the current situation. This approach may allow for some limited increase in the asymmetry. We see no justification for active measures intended to reduce the current differences in holdings.

There is little evidence that the current asymmetry in supra 1 GHz holdings will have a material effect on long-run downstream competition. Although Meteor has raised the issue of the current asymmetry, it has not provided any evidence why it would be significantly constrained in competing in the mobile market with its current holdings.

Furthermore, the spectrum above 1 GHz being made available in this multi-band award far exceeds the current asymmetry in supra 1 GHz holdings. This means that it should be enough to set caps on bidders with a view to ensuring that the post-auction spectrum distribution is not too asymmetric, rather than actively intervening to affect downstream market structure through reservations for bidders of particular types.

In particular, there is little justification for effectively reserving spectrum for a non-traditional provider by placing a tight cap on the three MNOs, as suggested by Imagine. Both Imagine and Airspan were able to compete successfully for spectrum in the 3.6 GHz auction without such reservations. Given the high level of uncertainty about the form that non-traditional business models might take and whether they will ultimately be successful, it would be inappropriate for ComReg to make an implicit or explicit reservation of spectrum for such service providers.

We believe that a reasonable approach would be to set caps on all bidders that allow for some asymmetry in outcomes, but to prevent highly asymmetric outcomes given some MNOs have more spectrum at present. Therefore, we propose giving regard to the

current asymmetric situation above 1 GHz by looking at the potential post-auction outcome when selecting the appropriate level of cap. On that basis we consider that any caps applied should take into account existing holdings, since these (in combination with the outcome of the award) will play a part in the post-award competitive landscape.

*We recommend a separate sub-1 GHz cap…*

Given its favourable propagation characteristics, the 700 MHz band is likely to be highly valuable and could therefore impact on downstream competition between the mobile operators. As noted in ComReg document 14/102, the 700 MHz, 800 MHz and 900 MHz bands are all likely to be substitutes for one another in the long run for providing coverage and in-building penetration. However, in the shorter run, MNOs will face challenges in using these bands for 2G and 3G legacy services, whilst maintaining or improving 4G speeds and initially deploying 5G. Running parallel radio access networks to meet these various demands may create significant demand for sub-1 GHz spectrum from MNOs, as distinct from supra-1 GHz spectrum.

Therefore, there is a strong argument for applying a separate cap on the amount of sub-1 GHz spectrum that any operator can have after the award. There is already precedent for a separate sub-1 GHz cap from the 2012 MBSA, and our recommendation is to maintain this approach.

*…alongside an overall cap*

Regarding the rest of the spectrum, the 2.1 GHz, 2.3 GHz and 2.6 GHz bands can all be used to provide WBB and have existing ecosystems with compatible devices. They are likely to be substitutes for one another, as well as for the 1800 MHz and 3.6 GHz bands already licenced, for providing additional capacity particularly in more densely populated urban areas. These capacity bands might also offer an (imperfect) substitute for the 700 MHz spectrum, in the sense that winning more 700 MHz spectrum also provides capacity and might at the margin reduce the need for supra-1 GHz spectrum somewhat. Therefore, we consider that an overall cap on the total post-award spectrum holdings of an operator is appropriate.

Therefore, our recommendation is to set two caps – sub-1 GHz and overall – that include relevant existing spectrum holdings.

## 4.5 Level of spectrum competition caps

We need now to consider the relevant level of competition caps to apply. As discussed above, the recommendation is to allow some asymmetry but also avoid situations in which (absent new entry) the asymmetry in holdings between MNOs is increased beyond a competitively acceptable level.

*Asymmetry metric*

To consider the appropriate level of caps, we look at potential outcomes of the auction given existing spectrum holdings. To judge

which outcomes have too much asymmetry, we first need to define more precisely what we mean by asymmetry.

There are many possible ways of defining metrics of asymmetry (e.g. Herfindahl indices, Gini coefficients and so on). However, we are concerned here with potential effects on downstream market conduct, which should guide the choice of asymmetric metric for spectrum. We cannot expect to have an accurate and detailed understanding of how spectrum distribution affects downstream competition. However, as Meteor raise in their comments, a particular concern given that there are only three MNOs is that no one MNO falls so far behind in spectrum holdings that it cannot compete effectively.

Given this predominant concern, we define a measure of asymmetry between a number of parties as the difference between the greatest amount of spectrum held by any given party, and the minimum held by any party. With this definition, the asymmetry metric for the MNOs' current spectrum holdings is the difference between Three's holdings and Meteor's holdings:

- If we include the 2.1 GHz spectrum, the asymmetry in overall spectrum holdings is 280 MHz – 185 MHz = 95 MHz.
- If we only consider spectrum that will not be included in the upcoming award (i.e. if we ignore the 2.1 GHz licences as this will be re-awarded), the overall asymmetry is 220 MHz – 155 MHz = 65 MHz.[43]

The available spectrum in the award is set out in Table 4. For simplicity we focus on the case that all of the 2.1 GHz spectrum currently licensed is counted as available for re-award, as is appropriate if our concern is the long-run competitive impact of spectrum distribution.

[43] We note that Meteor's 2.1 GHz licence does not expire until 2027 and this will need to be taken into account when establishing the competition caps. The asymmetry shown here represents the "current" holdings after 2027.

*Table 4: Available spectrum in the award*

| Band | Available spectrum |
|---|---|
| 700 MHz | 60 MHz |
| 2.1 GHz | 120 MHz |
| 2.3 GHz | 100 MHz |
| 2.6 GHz FDD | 140 MHz |
| 2.6 GHz TDD | 50 MHz |
| **Total sub-1 GHz** | **60 MHz** |
| **Total supra-1 GHz** | **410 MHz** |
| **Total** | **470 MHz** |

*Sub-1 GHz cap*

We first consider the sub 1-GHz cap. Including existing holdings of 800 MHz and 900 MHz, there is a total of 190 MHz (2x95 MHz) of sub-1 GHz spectrum that could be licenced following the award. Table 5 below sets out the worst-case post-award asymmetries (as defined above) in sub-1 GHz holdings under different competition caps[44] for the sub-1 GHz spectrum. We consider all options ranging from a cap that prevents Three from winning any additional spectrum (50 MHz) to the cap that allows Three to win all of the sub-1 GHz spectrum in the award.

[44] Because the sub-1 GHz spectrum is all awarded as FDD we only consider caps that are multiples of 10 MHz (2x5 MHz) since it is not possible to have holdings where the total amount of paired spectrum (i.e. uplink + downlink) is a multiple of 5 MHz.

*Table 5: Worst-case sub-1 GHz asymmetries under different competition cap options*

| Sub-1 GHz competition cap (MHz) | Three | | Vodafone | | Meteor | | Unsold (MHz) | Asymmetry (MHz) |
|---|---|---|---|---|---|---|---|---|
| | Won in award (MHz) | Total holdings (MHz) | Won in award (MHz) | Total holdings (MHz) | Won in award (MHz) | Total holdings (MHz) | | |
| 50 | 0 | 50 | 10 | 50 | 10 | 50 | 40 | 0 |
| 60 | 10 | 60 | 20 | 60 | 20 | 60 | 10 | 0 |
| 70 | 20 | 70 | 30 | 70 | 10 | 50 | 0 | 20 |
| 80 | 30 | 80 | 30 | 70 | 0 | 40 | 0 | 40 |
| 90 | 40 | 90 | 20 | 60 | 0 | 40 | 0 | 50 |
| 100 | 50 | 100 | 10 | 50 | 0 | 40 | 0 | 60 |
| 110 | 60 | 110 | 0 | 40 | 0 | 40 | 0 | 70 |

We see no reason for a cap of below 70 MHz (2x35 MHz) as this could leave some spectrum inefficiently unsold if there were no demand from other parties. As discussed above, fixed wireless providers are likely to be more interested in the other available bands; although it is not implausible that there would be demand for 700 MHz spectrum beyond that of the MNOs, there does not seem to be any clear benefit in setting a cap that is so tight that it could restrict competition in the auction, and potentially leave some highly valuable spectrum unassigned or inefficiently allocated to other users. On the other hand, a cap of over 70 MHz could result in an outcome where Three has double the sub-1 GHz spectrum of Meteor. On this basis, we consider that a competition cap of 70 MHz on the sub-1 GHz spectrum would strike an appropriate balance, which allows for a maximum sub-1 GHz asymmetry of 20 MHz after the award.

Note that, due to the granularity of the spectrum packaging and the limited amount of 700 MHz available, it is not possible to set a cap that precludes the possibility of a greater imbalance in sub-1 GHz holdings than at present (asymmetry based on current holdings is 10 MHz) without potentially leaving some of the spectrum inefficiently unsold. We do not consider this to be a problem as concerns about asymmetric spectrum holdings are due much more to differences in overall holdings, rather than modest differences in sub-1 GHz spectrum alone. Therefore, the possibility of a modest increase in the asymmetry of sub-1 GHz holdings is not of concern provided that there are sufficient limits on the asymmetry of total spectrum holdings enforced by the overall cap.

*The overall cap*

Table 6 sets out a range of options for the overall cap, on the assumptions that a sub-1 GHz competition cap of 70 MHz will be applied and that all of the 700 MHz is allocated (where possible).[45]

[45] There are many other options for the level of the overall cap, but these either risk unsold spectrum or imbalances that exceed the current asymmetry across MNOs and would therefore not be considered as viable options.

*Table 6: Worst-case asymmetries under different overall competition cap options*

| Overall competition cap (MHz) | Three | | Vodafone | | Meteor | | Unsold (MHz) | Asymmetry (MHz) | Asymmetry as % of total spectrum available to MNOs |
|---|---|---|---|---|---|---|---|---|---|
| | Won in award (MHz) | Total holdings (MHz) | Won in award (MHz) | Total holdings (MHz) | Won in award (MHz) | Total holdings (MHz) | | | |
| 340 | 120 | 340 | 145 | 340 | 185 | 340 | 20 | 0 | 0.00% |
| 345 | 125 | 345 | 150 | 345 | 190 | 345 | 5 | 0 | 0.00% |
| 350 | 130 | 350 | 155 | 350 | 185 | 340 | 0 | 10 | 0.96% |
| 355 | 135 | 355 | 160 | 355 | 175 | 330 | 0 | 25 | 2.40% |
| 360 | 140 | 360 | 165 | 360 | 165 | 320 | 0 | 40 | 3.85% |
| 365 | 145 | 365 | 170 | 365 | 155 | 310 | 0 | 55 | 5.29% |
| 370 | 150 | 370 | 175 | 370 | 145 | 300 | 0 | 70 | 6.73% |
| 375 | 155 | 375 | 180 | 375 | 135 | 290 | 0 | 85 | 8.17% |
| 380 | 160 | 380 | 185 | 380 | 125 | 280 | 0 | 100 | 9.62% |
| 385 | 165 | 385 | 190 | 385 | 115 | 270 | 0 | 115 | 11.06% |
| 390 | 170 | 390 | 195 | 390 | 105 | 260 | 0 | 130 | 12.50% |
| 395 | 175 | 395 | 200 | 395 | 95 | 250 | 0 | 145 | 13.94% |
| 400 | 180 | 400 | 205 | 400 | 85 | 240 | 0 | 160 | 15.38% |
| 405 | 185 | 405 | 210 | 405 | 75 | 230 | 0 | 175 | 16.83% |
| 410 | 190 | 410 | 215 | 410 | 65 | 220 | 0 | 190 | 18.27% |
| 415 | 195 | 415 | 220 | 415 | 55 | 210 | 0 | 205 | 19.71% |
| 420 | 200 | 420 | 225 | 420 | 45 | 200 | 0 | 220 | 21.15% |

A cap of below 350 MHz limits the extent of feasible competition for spectrum within the auction between the MNOs and could lead to unsold spectrum in the event that there is no demand from other parties. Therefore, an overall cap of below 350 MHz would not be appropriate as it risks leaving spectrum inefficiently unsold if there is not demand other than from the three existing MNOs.

The current level of asymmetry between the MNOs is 95 MHz (including current 2.1 GHz FDD holdings). This asymmetry would be maintained with a cap of between 375 MHz and 380 MHz. With spectrum awarded in 5 MHz blocks, a cap of at most 375 MHz (with an associated asymmetry measure of 85 MHz) would therefore be required to ensure the asymmetry did not increase, in absolute terms, relative to the current situation (under the assumptions used for calculation of the 'worst-case' scenarios).

As discussed above, there should be no concerns about an outcome in which the asymmetry is maintained, and there is no clear reason to believe that a greater difference in holdings would be problematic. Furthermore, as more spectrum will be available in total, a given absolute difference in spectrum holdings may be relatively less important.[46]

On that basis there are arguments to suggest that a cap of above 375 MHz would not be unreasonable, and we consider that **a cap of between 375 MHz and 420 MHz might be appropriate** for avoiding excessively asymmetric post-award holdings but not unduly restricting bidders in the auction. At the upper end of this range, the associated asymmetry measure (220 MHz) is approximately 21% of the total spectrum that would be available to the MNOs, which is similar to the post-merger asymmetry relative to total spectrum holdings at that time.

As a final point on determining the appropriate level of the caps, we recognise that it is of course possible that some of the available spectrum is assigned to parties other than the MNOs, such as Imagine, Airspan, or a new entrant. In this scenario the worst-case asymmetries presented above would not necessarily hold, and the imbalance in spectrum holdings across the MNOs after the award could be greater (e.g. if Three and Vodafone were to win the maximum possible, but Meteor won less than it could have due to competition from another bidder).

The role of the competition caps we have recommended is to prevent excessively asymmetric holdings that could distort competition, and to provide reasonable opportunities for bidders to compete for spectrum in the award without being denied access purely for anti-competitive purposes. However, they should not

[46] The asymmetry in current holdings (100 MHz) represents 16.3% of the total bandwidth licenced to the MNOs (615 MHz), but is only 9.6% of the total amount of spectrum that could be assigned to the MNOs following the award (1040 MHz).

unduly constrain attempts to increase spectrum holdings for legitimate (i.e. not anti-competitive) business reasons or restrict competition in order to establish a specific predetermined award outcome. It would be inappropriate for ComReg to set competition caps that would prevent a user from acquiring additional spectrum that could be used effectively for improving services to consumers simply because another bidder might not be able or willing to effectively compete in the auction with all other interested parties on the merits.

# 5 Lot structure

## 5.1 Lot size

In order to award rights of use for spectrum on a technologically neutral basis, it is recommended to, where possible, offer lots consisting of small frequency blocks that bidders can then aggregate into a bandwidth that meets their requirements. This provides maximum flexibility for bidders to acquire bandwidths in line with their specific usage requirements, supports efficient assignment of the frequencies, and avoids arbitrary administrative decisions.

*EU/CEPT guidance on block size*

Guidance on the block size for each of the bands is provided in various CEPT and EU harmonisation documents. In general, the recommendations are to assign the spectrum in 5 MHz blocks, which is widely regarded as a suitable building block that is compatible with bandwidths suitable for a wide range of users:

- The EU implementing Decision (EU) 2016/687 of 28 April 2016 sets out that "…within the 703-733 MHz and 758-788 MHz frequency bands…**the assigned block sizes shall be in multiples of 5 MHz**";
- The frequency arrangement for the 2.1 GHz paired spectrum is set out in ECC Decision (06)01 which states that "[f]or licensing purposes, the bands 1920-1980 MHz and 2110-2170 MHz, are divided into twelve paired blocks and **the minimum block size should be in the range 4.8 MHz to 5.0 MHz**";
- ECC Decision (14)02 sets out the EC recommended blocks size for the 2.3 GHz band, stating that the "[f]requency arrangement should be based on **20 blocks of 5 MHz**"; and
- ECC Decision (05)05 and Commission Decision 2008/477/EC set out the block size for the 2.6 GHz band, with the recommendation that "**[a]ssigned blocks shall be in multiple of 5.0 MHz**".

Our understanding is that ComReg intends to make the majority of the spectrum available in 5 MHz blocks for each of the frequency bands to be included in this proposed award, in line with European standards. We are not aware of any reason to deviate from this approach and believe it to be the most appropriate approach to determining the lot size i.e. paired spectrum would be made available as 2x5 MHz lots, and unpaired spectrum as 5 MHz lots. The only exception to this may be with regard to the top 10 MHz and the bottom 30 MHz of the 2.3 GHz band, where there are potential benefits to making these blocks available as single (larger) lots (discussed further in Section 5.3 below).

*Number of lots available*

This approach of using 2x5 MHz lots for all paired spectrum, 5 MHz lots for all unpaired spectrum, excepting one 10 MHz and one

30 MHz lot in the 2.3 GHz band, would yield a total of **103 distinct lots** available in the auction. This assumes that the 2.1 GHz, 2.3 GHz and 2.6 GHz bands would each be made available in two time slices. The breakdown of lots across bands and time slices is presented in the table below.

*Table 7: Number of blocks per band and time slice*

| Band | Time slice | Available bandwidth | Lot size | Number of lots |
|---|---|---|---|---|
| 700 MHz | NA | 2x30 MHz | 2x5 MHz | 6 |
| 2.1 GHz | 1 | 2x45 MHz | 2x5 MHz | 9 |
| 2.1 GHz | 2 | 2x60 MHz | 2x5 MHz | 12 |
| 2.3 GHz | 1 | 100 MHz | 5/10/30 MHz | 14 |
| 2.3 GHz | 2 | 100 MHz | 5/10/30 MHz | 14 |
| 2.6 GHz paired | 1 | 2x70 MHz | 2x5 MHz | 14 |
| 2.6 GHz paired | 2 | 2x70 MHz | 2x5 MHz | 14 |
| 2.6 GHz unpaired | 1 | 50 MHz | 5 MHz | 10 |
| 2.6 GHz unpaired | 2 | 50 MHz | 5 MHz | 10 |
| **Total** | | | | **103** |

## 5.2 Frequency specific vs frequency generic lots

There are significant benefits from initially offering spectrum as frequency-generic lots to determine the total bandwidth that needs to be assigned to each bidder, within contiguous blocks of spectrum of similar value, before determining the assignment of specific frequencies for each winner:

- there are efficiency benefits from assigning contiguous spectrum to each user, as this makes it possible to improve spectrum use of a given bandwidth through the use of fewer large channels rather than a greater number of small channels;
- offering the spectrum in categories of identical lots can reduce bidding complexity relative to offering each spectrum block as an individual lot, as this might reduce the total number of different lot combinations that bidders may need to consider when determining their bids.

We are therefore of the view that the spectrum should be allocated (initially) as frequency-generic lots where possible, but with as far as possible bidders having a guarantee that lots won in the same band will be assigned as contiguous frequencies (subject to the limitations imposed by the frequency-specific lots proposed for the 2.3 GHz and unpaired 2.6 GHz bands).

However, when deciding whether to use frequency-generic or frequency specific lots we need to assess the extent to which frequencies within a particular band may differ in value, and whether the need to use frequency-specific lots to account for those differences outweighs the benefits of using frequency-generic lots.

## 5.3 Lot categories

When awarding spectrum as frequency-generic lots, the typical approach would be to define a number of 'lot categories' to group lots according to their value and/or other parameters.[47] The intention is to categorise lots such that all lots within a given category can be considered largely identical, and therefore close substitutes. In the first stage of the award, bidders would specify the number of generic lots they wish to acquire in each lot category, before specific frequency assignments are decided in a later stage.

The first step in defining lot categories would be to partition the lots by band. We also need to recognise that, for bands being made available separately in the two time slices, each specific frequency block would need to be included in two lot categories, one for each of the time slices i.e. a spectrum right for a specific 2x5 MHz block in the 2.1 GHz band covering time slice 1 cannot be viewed as a substitute for rights to use the same frequencies in time slice 2, and bidders will need to be able to bid for these separately.

We would then need to consider whether there are any other factors that would require a further split of the available rights of use into more lot categories.

At present, for the 700 MHz and 2.6 GHz paired bands, we are not aware of any material, systematic differences in the characteristics/value of the different blocks available (within each of those bands).

Regarding the 2.1 GHz band, we note that Meteor's current licence will run for the duration of the first time slice, and the associated spectrum rights split the remaining 2.1 GHz frequencies into two non-contiguous blocks. If Meteor's current assignment were to remain in that position within the band then it would be necessary to split the 2.1 GHz lots into two lot categories for time slice 1: one

[47] Where a frequency-specific lot is required, this could be made available as a separate lot category including just a single lot.

category including the three 2x5 MHz blocks below Meteor's frequencies, and another category including the remaining six 2x5 MHz blocks above. This would ensure that bidders would know, when placing their bids, whether any 2.1 GHz time slice 1 lots they win would be assigned as one contiguous block or split across the two parts of the band either side of Meteor's frequencies. However, this solution creates additional complexity for the award (with an increased number of lot categories) and limits the scope for assigning larger blocks of contiguous spectrum within the band.

It would be preferable for Meteor's current spectrum rights to be moveable within the band, which would allow for all of the available spectrum to be awarded as a single lot category (in each time slice) and for all winners of lots in the 2.1 GHz band in time slice 1 to be guaranteed contiguous frequencies. Similar to the approach used in the 2012 MBSA and in the interests of an efficient assignment, our recommendation is to require the existing licensee (Meteor) to relocate its current spectrum holdings[48] to accommodate contiguous assignments for all winners as a condition of participating in the award. This could be subject to some form of rebate to cover any reasonable costs of relocation that are incurred by the operator. It is our understanding that ComReg is proposing to take this approach, and for the remainder of this report we assume that this will be case.

We understand also that there are two potential sources of value difference within the 2.3 GHz band:

- the frequencies 2390 – 2400 MHz have a lower in block EIRP limit than other parts of the 2.3 GHz band, which could reduce the value of that spectrum relative to the rest of the band; and
- Eir is currently using frequencies in the 2307 – 2327 MHz range to provide fixed telephony via its Rurtel service in rural parts of Kerry, Galway and Donegal.

Regarding the 2390 – 2400 MHz block, if power limits mean that the potential uses of the band are more limited (which may result in the value of this spectrum being lower than the value of other 2.3 GHz spectrum with less restrictive technical constraints) there may be an argument for allowing bidders to bid for those frequencies separately to the rest of the band. The restricted frequencies could be made available as a single 10 MHz lot, as two generic 5 MHz lots, or as two frequency-specific 5 MHz lots. Our preliminary view is that offering these frequencies as a single 10 MHz lot is preferable, as we do not envisage any demand for the 2395 – 2400 MHz block in isolation, but only as part of a larger frequency range that would include the 2390 – 2395 MHz block and possibly additional blocks below this. Offering these frequencies as a single lot also makes it

[48] We anticipate that in this case Meteor would participate in the assignment stage and would be given an opportunity to express its preferences over different locations within the band. This would also allow for any additional 2.1 GHz lots won by Meteor in the 2.1 GHz band to be allocated contiguous to its current holdings.

possible to guarantee that any bidder who wins this lot alongside additional lots in the 2300 – 2390 MHz range can be assigned all this spectrum contiguously (subject to the contraints relating to the potential for awarding the 2300 – 2330 MHz part of the band in a separate lot category, as set out below.

In terms of the 2307 – 2327 MHz range, it is unclear at present whether Rurtel will still be operating in the 2.3 GHz band at the time of award, or if it will migrate to alternative frequencies. If Rurtel were to largely vacate the band then there would be limited issues regarding these frequencies, which could then be included as frequency-generic lots with the rest of the 2.3 GHz band (other than possibly the top 10 MHz).

If Rurtel were to largely stay in the band it would be using frequencies in five of the proposed 5 MHz lots, from 2305 MHz to 2330 MHz. As mentioned by ComReg in Document 18/60, it may be possible to assign spectrum rights for these frequencies with temporary coordination zones to fit around Rurtel's licences. The extent to which these restrictions would affect the value of the frequencies is somewhat uncertain.

In Document 19/59d, Plum Consulting set out the coordination areas that would need to apply for each of the Rurtel deployments in counties Kerry, Galway and Donegal. The geographic areas are large and in particular currently include the cities of Galway and Cork. Plum Consulting estimates that the coordination zones required based on current Rurtel operations would reduce the population that could be served using new 2.3 GHz rights of use for the corresponding frequencies by approximately 1.3 million. DotEcon understands from ComReg that the extent of the Rurtel system could reduce over time as alternative solutions become available[49]. If the geographic extent of the coordination zones reduced, in particular to not include the cities where 2.3 GHz spectrum would be particularly suited, then it may be the case that the value differences will be small. In this case it would still be feasible to include the 2305 – 2330 MHz blocks as frequency-generic lots alongside the rest of the band, allowing the assignment stage to resolve any minor preferences for specific frequencies.

On the other hand, if the Rurtel licences are considered to have a large impact on value it may be appropriate to treat these frequencies separately to the rest of the band in order to allow bidders certainty over whether they would be bidding for restricted or unrestricted spectrum rights. In this case, there would also be an isolated 5 MHz unrestricted use block at the bottom of the band (i.e. 2300 – 2305 MHz). On the expectation that there is unlikely to be demand for this 5 MHz block on its own, if assigned it would be allocated alongside the adjacent restricted use frequencies and use

[49] E.g. fixed cellular solutions, and we understand the NBP is likely to provide an alternative solution for the USO.

of the lot would likely be *implicitly* subject to the same restrictions. On this basis, we believe that it would be appropriate to include the 2300 – 2305 MHz block in the same lot category as the restricted use frequencies currently occupied by Rurtel. There would then seem to be two options with regard to these frequencies:

- the 2300 – 2330 MHz spectrum could be made available in a separate lot category as six frequency-generic lots at the bottom of the 2.3 GHz band; or
- the 2300 – 2330 MHz spectrum could be offered as a single frequency-specific 30 MHz lot.

The first option would provide more flexibility for bidders to express demand for different spectrum portfolios. However, it could also create complexity for bidders through the risk of fragmented assignments. If, for example, there were multiple winners of restricted use spectrum that also won frequency-generic lots in the rest of the band, at most one of those bidders could be assigned contiguous frequencies, with the rest getting spectrum in two non-contiguous blocks (but having to bid without knowing this in advance).

The second option of assigning the lowest 30 MHz as a single (frequency-specific) lot would remove this risk. There could be only one winner of that lot, and if that bidder were to also win additional frequency-generic 2.3 GHz lots then it would always be possible to give this bidder a contiguous assignment at the bottom of the band. For these reasons, we are of the view that this second option is likely to be preferable if the Rurtel licences significantly affect the value of the 2300 – 2330 MHz frequencies.

Note that under either of these options it would not be possible to assign a single contiguous frequency block within the band to a bidder that wins the top 10 MHz frequency-specific lot, some or all of the spectrum in the 2300 – 2330 MHz range, and some (but not all) of the frequency-generic lots in between; this would need to be taken into account by bidders when choosing which packages to bid for.

We understand that ComReg is seeking input from stakeholders on this issue and the extent to which the value of the restricted spectrum rights might differ from the value of lots in the rest of the band, and we expect to make a further assessment on this matter when more information is available. For the remainder of this report, our working assumption is that the Rurtel licences will have an impact on the value of the associated spectrum, and that the 2300 – 2330 MHz range should therefore be considered separately to the rest of the band and included in the award as a 30 MHz frequency-specific lot.

Regarding the 2.6 GHz Duplex Gap, we understand that the top and bottom 5 MHz blocks (2570 – 2575 MHz and 2615 – 2620 MHz) will be subject to more restrictive power limits than the rest of the band. If these power limits mean that the affected lots have a lower value

than the rest of the band, there may be a benefit in making these available separately as frequency-specific lots, so that bidders can be sure of whether the bids they submit are for higher or lower value frequencies. Our working assumption is that the value differences created by the power limits will be large enough to justify this approach. This would of course mean that a contiguous assignment within the 2.6 GHz Duplex Gap could not be assigned to a winner of both frequency-specific lots alongside some (but not all) of the spectrum in between, but this could be accounted for by bidders when submitting their bids. A winner of only one of the frequency-specific lots could always be guaranteed that any additional frequency-generic 2.6 GHz unpaired lots it wins are placed next to the relevant frequency-specific lot.

To summarise, we are currently of the view that:

- spectrum in the 700 MHz, 2.1 GHz, and 2.6 GHz paired bands can be allocated as frequency-generic lots within each of the bands;
- the top 10 MHz of the 2.3 GHz band is subject to power restrictions and cannot be considered as a direct substitute for other 2.3 GHz lots, so should be allocated as a single frequency-specific lot in the award;
- the bottom 30 MHz of the 2.3 GHz band is likely to be affected by the current (regional) Rurtel licences and cannot be considered a direct substitute for other frequencies in the band, so should be included in the award as a frequency-specific lot;
- the remaining 60 MHz in the 2.3 GHz band can be allocated as frequency-generic lots within the range 2330 – 2390 MHz;
- the top and bottom 5 MHz blocks in the 2.6 GHz unpaired band are subject to power restrictions and should be awarded separately to the rest of the band as two frequency-specific lots (2570 – 2575 MHz and 2615 – 2620 MHz); and
- the remaining 40 MHz in the 2.6 GHz unpaired band should be made available as frequency-generic lots within the range 2575 – 2615 MHz.

Based on the discussions and recommendations above, Table 8 sets out our current expectations on the lot categories that would be appropriate for this proposed award.

*Table 8: Potential lot categories*

| Cat. ID | Band | Frequency range | Time slice | Lot size | No. generic lots |
|---|---|---|---|---|---|
| 1 | 700 MHz | 703 – 733 MHz / 758 – 788 MHz | 1 | 2x5 MHz | 6 |
| 2 | 2.1 GHz | 1920 – 1980 MHz / 2110 - 2170 MHz | 1 | 2x5 MHz | 9 |
| 3 | 2.1 GHz | 1920 – 1980 MHz / 2110 - 2170 MHz | 2 | 2x5 MHz | 12 |
| 4 | 2.3 GHz | 2300 – 2330 MHz | 1 | 30 MHz | 1 |
| 5 | 2.3 GHz | 2300 – 2330 MHz | 2 | 30 MHz | 1 |
| 6 | 2.3 GHz | 2330 – 2390 MHz | 1 | 5 MHz | 12 |
| 7 | 2.3 GHz | 2330 – 2390 MHz | 2 | 5 MHz | 12 |
| 8 | 2.3 GHz | 2390 – 2400 MHz | 1 | 10 MHz | 1 |
| 9 | 2.3 GHz | 2390 – 2400 MHz | 2 | 10 MHz | 1 |
| 10 | 2.6 GHz paired | 2500 – 2570 MHz / 2620 – 2690 MHz | 1 | 2x5 MHz | 14 |
| 11 | 2.6 GHz paired | 2500 – 2570 MHz / 2620 – 2690 MHz | 2 | 2x5 MHz | 14 |
| 12 | 2.6 GHz unpaired | 2570 – 2575 MHz | 1 | 5 MHz | 1 |
| 13 | 2.6 GHz unpaired | 2570 – 2575 MHz | 2 | 5 MHz | 1 |
| 14 | 2.6 GHz unpaired | 2575 – 2615 MHz | 1 | 5 MHz | 8 |
| 15 | 2.6 GHz unpaired | 2575 – 2615 MHz | 2 | 5 MHz | 8 |
| 16 | 2.6 GHz unpaired | 2615 – 2620 MHz | 1 | 5 MHz | 1 |
| 17 | 2.6 GHz unpaired | 2615 – 2620 MHz | 2 | 5 MHz | 1 |

# 6 Spectrum fees and minimum prices

*Structure of spectrum fees*

ComReg typically splits the fees that apply to spectrum licences between:

- a **spectrum access fee** (SAF) – a one-off fee established during the award process (e.g. determined by auction) payable soon after the allocation of licences; and
- ongoing **spectrum usage fees** (SUFs), paid annually during the licence term.

Structuring the fees in this way helps to support efficient use of the spectrum over the licence term as it provides incentives for returning the spectrum to ComReg (in which case the licensee would no longer be liable for the annual fees) if it is not being efficiently used - in this case the spectrum could then be reallocated to another user that would be able to make better use of it. In a similar way, it also serves to protect bidders where there is a degree of uncertainty over the future value of the spectrum i.e. the spectrum can be returned if it is ultimately less useful/valuable than envisaged at the time of award, in which case the losses to which the bidder is exposed are lower than if it had to pay all of the fees upfront. In addition, allowing the overall spectrum fees to be paid over time can support/enable participation in the award by bidders with more limited access to capital in the short term (such as new entrants), allowing them to raise the necessary funds over a greater length of time. This can help to promote an efficient award outcome and potentially improve competition and services in the downstream market.

On the basis of the above, we consider that splitting the fees for a licence between an upfront SAF and ongoing SUFs is in general a good approach, and we do not see any need to deviate from that for this proposed award.

*Need for minimum prices*

The **minimum price** for a lot comprises both the minimum possible SAF (set by the reserve price for the auction) and the ongoing SUFs (indexed by inflation) that licensees can anticipate paying.

There are good reasons for setting minimum prices in an auction, as these reduce incentives for:

- strategic behaviour within an auction aimed at decreasing the price paid (including both tacit collusion within an auction and also arrangements entered into prior to an auction aimed at decreasing competition within the subsequent auction); and
- speculative bidding e.g. attempting to acquire the spectrum at a low price without a genuine business plan for using the frequencies but in the hopes that the value will increase in the future and the spectrum can be sold on at a profit.

We believe that these arguments are applicable for the spectrum available in this proposed award, and for these reasons we recommend that ComReg applies a minimum price for each of the available lots.

*Split of minimum price between SAF and SUF*

The split of the minimum price between the minimum SAF (reserve price) and the SUFs should be set to balance the need to impose a sufficiently high upfront fee to deter non-serious bidders and strategic bidding, and the benefits of spreading a proportion of the fees across the licence term, as discussed above. For the 2012 MBSA, ComReg applied a 50:50 split of the minimum prices between the minimum SAF and the SUFs. However, for the 3.6 GHz award in 2016 it revised its approach and instead used a 40:60 split, recognising that some potential participants were small regional FWALA operators that may have more limited access to capital in the short term.

In its response to the consultation on included spectrum, Imagine highlighted that it believes putting all of the auction price increase over the reserve price into the SAF makes it difficult for smaller bidders (that would find it difficult to raise such large amounts of capital in the short term) to compete. Imagine would prefer an alternative approach that allows for some of the difference between the auction price and the reserve price to be paid in annual instalments.

We acknowledge Imagine's comments and accept that higher upfront fees might in some cases disadvantage smaller bidders. This is one of the reasons why we recommend (and ComReg typically uses) the approach of deferring some of the fees into annual payments (the SUFs). We note also that ComReg is generally mindful of the impact of the SAF/SUF split on bidders and the potential award outcome (as demonstrated by its decision to put more weight on the SUFs for the 3.6 GHz award).

The proportion of the overall auction price that is deferred through fixed SUFs depends on the extent to which the auction price increases above the reserve price (i.e. the minimum SAF). Minimum prices (i.e. the discounted sum of the SUFs and the minimum SAF) are set below estimates of the likely market price of spectrum, but nevertheless represent a material proportion of likely market prices. Therefore, unless auction prices increase far above reserve prices, SUFs represent a significant deferment of payments. For example, with a 50:50 split of a minimum price between SUFs and a minimum SAF, if the auction price were to increase to double the minimum SAF, it is still the case that one-third of the overall total payment is deferred; if the auction price were triple the minimum SAF, then one-quarter of the total auction price would be deferred.

In our view it is appropriate that the proportion of the overall payments that is deferred should decrease as the auction price increases above reserve. This is necessary to deter non-serious,

vexatious, or speculative bidding. In particular, there is a danger that deferring the *increase* in the auction price above reserve encourages bids that may not be securely financed and might even be at risk of default. We also note that licence winners will typically need to undertake significant network investments to make use of spectrum and efficient use of spectrum may be compromised if licensees are won by parties who might struggle to raise necessary financing. These issues are of greater concern when the available spectrum is expected to be particularly valuable and/or important for the downstream market (since there may be greater incentives to engage in anti-competitive vexatious bidding, the potential for larger gains in the secondary market, and a greater impact on consumers in the case of inefficiently used spectrum).

In our view Imagine's concern is best addressed by ensuring that the minimum price is not set too low (subject to the limitation that a risk of inefficiently unsold lots is created). In particular, if the minimum price is set higher, then SUFs will be set higher. This will be reflected in bidders lowering their spectrum valuations correspondingly, and the auction price being lower. Therefore, the overall effect of higher SUFs is not to increase the overall amount that bidders pay (on a discounted basis), but rather to defer a greater amount of that overall payment. It is not necessary to link SUFs to the auction price itself to achieve a reasonable amount of payment deferment and, in any case, it is reasonable that proportion of the payment that is deferred should decrease as the auction price increases.

We note also that putting some of the auction price into the SUFs would potentially mean applying different annual fees per MHz for each licensee (since auction prices are non-linear), which could distort post-auction incentives across operators for returning spectrum to ComReg and complicate secondary trading. This is a significant complication and, therefore, we do not recommend an approach that allows for some of the auction price to be deferred across the duration of the licences by increasing the SUFs.

For these reasons, we recommend maintain ComReg's standard approach of charging the full auction price as an upfront fee at the end of the award, with fixed, pre-determined SUFs payable annually throughout the licence term.

Regarding the split of the minimum price between the minimum SAF and the SUFs, we believe that a 40:60 ratio would he appropriate. Given the likely importance of the available spectrum in this proposed award for the downstream market, it is important that the minimum SAF is set high enough to defer speculative or strategic bidding. However, we also recognise that there is potential for the available spectrum to be utilised for FWA and/or small-cell services, implying possible participation from entities other than the MNOs, potentially with more limited access to short term capital. With these considerations in mind, we believe that a 40:60 split would be appropriate, in order to ensure non-serious/vexatious bidders are

sufficiently deterred whilst also supporting participation by smaller bidders. This appears to have worked well for the 3.6 GHz award, noting that spectrum was awarded to two bidders other than the MNOs (Airspan and Imagine), and we recommend the same approach for this proposed award.

# 7 Award Format

In line with ComReg's approach for other recent spectrum awards, and with ComReg's initial assessment for this proposed award, we recommend using an auction process. The general advantages from using an auction process over using an administrative process have been discussed at length in previous reports[50], and include greater transparency and efficiency, and a reduced burden for the regulator in making key decisions that could lead to regulatory failure. In the context of this proposed award, we do not have any reason to suspect a potential market failure arising from the use of an auction process, and thus we do not see any reason to prefer an administrative process.

Our working assumption for this section is that the available frequencies will first be assigned to the greatest extent possible as frequency-generic lots, grouped into lot categories as set out in Section 5.3.

We start this section by discussing some key considerations for auction design. We then discuss the appropriate auction format for the assignment of frequency-generic lots. Finally, we discuss the appropriate auction format for the assignment of specific frequencies for winners of frequency-generic lots.

## 7.1 Key considerations for auction design

### 7.1.1 Mitigating bidder risks

*Aggregation risk*

Offering the available frequencies in small blocks implies that bidders are likely to bid for multiple lots in order to obtain the bandwidth they require. In this context, auction processes where bidders place a number of bids for individual lots can expose bidders to so-called **aggregation risk**, which is the risk that a bidder who is bidding for a number of lots might win some but not all of these lots. Whilst aggregation risk is not an issue when bidder's valuations for additional lots are decreasing, they are problematic when there are synergies across lots (i.e. when the value of multiple lots together is greater than the sum of the individual value of the lots) – in this case, winning fewer than that number of lots would result in the bidder paying for something that is worth less than the price (and potentially nothing).

Whether aggregation risk exists and poses a problem depends on the structure of demand, the lots offered in the auction and the specific

[50] For example, in ComReg Document 11/58.

auction rules. Where there are no synergies across lots, we do not need to be worried about aggregation risk. However, synergies across lots are plausible when the spectrum is offered in small blocks and bidders are expected to acquire multiple lots; for instance:

- bidders may have a minimum bandwidth requirement that is only achieved with several lots, so that winning fewer lots than they bid for is useless;
- some bidders might want to increase their bandwidth in steps greater than the lot size;
- there may be technical efficiencies from larger bandwidths that may give rise to increasing returns to scale from acquiring additional lots (at least for some bandwidths); or
- bidders may wish only to acquire spectrum if they can obtain a portfolio that includes spectrum in different bands, for instance to provide support to different devices or to obtain a combination of low frequencies for a coverage layer and high frequencies for additional capacity – this might be particularly relevant for new entrants.

Aggregation risk is removed by accepting 'package bids', where bidders can bid for a package of lots with a single bid amount, rather than being required to place separate bids for the individual lots that form the package. If the bid is selected as a winning bid, the bidder will be assigned all of the lots in the package and is not exposed to winning only a subset of the lots in the package (unless they separately bid for such a subset).

Regarding the spectrum available in this proposed award, we consider that it is very likely that lots will be complementary which could lead to aggregation risks for at least some bidders (or potential bidders):

- The proposed lot size (mostly 5 MHz or 2x5 MHz) represents the *smallest* building block suitable for the range of likely uses, and in reality we would expect operators to want/need larger blocks of contiguous spectrum to support higher speeds and capacity requirements. We therefore expect there to be synergies across lots within a given band, and measures to protect bidders against winning a smaller bandwidth than required are likely to be beneficial.
- Similarly, it is likely that some or all bidders will wish to acquire a mix of lots across different bands, and that holdings in these bands may be complementary. In particular, any new mobile entrant who does not already hold spectrum in other bands might wish to acquire a combination of sub-1 GHz frequencies (for coverage and in-building penetration) and higher frequencies (for additional capacity in high traffic areas). Without protective measures in place, there would be a risk to a bidder that it would acquire the spectrum it needed in one band, but not in another (rendering the lots it did win less valuable than if the bidder had also acquired lots in the other band).

Therefore, mitigating aggregation risks across bands may be important not to disadvantage and/or discourage potential entrants.

- Finally, it is likely that there will also be strong synergies arising from having access to the spectrum over the course of both time slices. For example, acquiring spectrum rights of use for time slice 1 only may not be of much use if the operator then became capacity constrained and had to reduce/compromise services accordingly when those licences expired. On the other hand, an operator might struggle in the downstream market if it acquired licences for time slice 2 only and had to wait for those to come into force before it was able to effectively compete with other operators that were able to take advantage of the spectrum much earlier.

Given this, we consider that synergies across lots are likely, and might justify the use an auction format that supports package bidding, in order to avoid exposing bidders to aggregation risks.

*Substitution risk*

Further complications can arise when the lots offered are substitutable, i.e. a bidder might be willing to acquire one lot or the other, or one combination of lots or another, depending on their relative price.[51] In this case, bidders may be exposed to the risk of winning a combination of lots that is not their preferred one given the final auction prices. We call this **substitution risk**.

Substitution risk arises, for example, when there are frictions in switching across substitutable lots, which may prevent bidders from bidding on their preferred combination of lots. Such frictions are typically a result of activity rules in multiple round auctions, which narrow the options available to a bidder as the auction progresses.

When there are also complementarities between lots, bidders might be willing to switch their demand across lot categories in response to price differentials, but not on an individual lot basis, rather switching between groups of lots. In such cases, aggregation risk and switching impediments can interact adversely if bidders are unable to shift their demand across different aggregations cleanly in one move.

Efficiency requires that the lots available are assigned in line with relative valuations, so that at final prices each bidder prefers the lots it has won to those won by others. Therefore, to promote efficiency bidders should be able, and have incentives, to reveal their relative valuations across different lots or combinations of lots, and mitigate

[51] In the extreme case of perfect substitutes, a bidder would prefer whichever lot is the cheapest by even an infinitesimally small amount. This may be the case where we are dealing with frequency-generic blocks, where initially all blocks are absolutely identical. Substitutability may also be imperfect, i.e. bidders may attribute different values to different lots, and thus may only want to acquire the lot with lower value if there is a sufficiently large price difference between the two lots. However, even then, any small deviation from this price difference would then cause the bidder to prefer one lot or the other.

substitution risk. If substitution risk is not addressed, this may also result in inefficiently unsold lots, if bidders who would want to acquire these lots were simply unable to express their willingness to do so through their bids.

In multi-round auctions, substitution risk can be mitigated by allowing bidders to switch between combinations of lots in response to price signals. Otherwise, bidders might end up locked with bids on lots that are not their preferred ones at final prices.

Substitution risk can be addressed more generally by offering bidders the option to bid for alternative packages and adopting a winner and price determination mechanism that maximises bidder surplus given the bids received. This means that a bidder can express its valuations for a number of alternatives, and then rely on the auction mechanism to select the most preferred outcome against those valuations. The CCA, combinatorial multiple round ascending auction (CMRA) and the sealed-bid combinatorial auction (SBCA) all adopt this approach.

However, substitution risk does not only arise due to switching impediments inherent in the auction mechanics. For instance, bidders may face practical limitations when there are many lots on offer and they have a wide range of packages of potential interest; in this case it may be difficult to prepare a consistent set of bids that reflects their valuations for all packages of interest. Even if bidders are able to submit a large set of bids for alternative packages, other factors may still limit the extent to which they are able to express their relative valuations. For example, if a budget constrained bidder is unable to predict what they may be able to win within their budget, then they may face complex bidding decisions when trying to optimise their chances of winning the best combination of lots given their available funds.

*Strategic complexity*

Both substitution risk and aggregation risk introduce strategic complexity, as bidders will typically bid on the basis of their expectations over the final auction prices and outcome, in order to mitigate the risk that they end with an unwanted combination of lots given the end prices. For instance, a bidder who anticipates switching impediments in an open auction may need to consider the risk of being stuck with a choice made early in the auction when deciding whether to switch.

### 7.1.2 Open rounds versus sealed bid

*Sealed bid auctions*

Sealed bid auctions are fairly simple and quick to run, and they are robust against gaming and tacit collusion. However, they can expose bidders to a relatively high degree of uncertainty about the likely outcome, as they do not have an opportunity to gauge the degree of competition in the auction or to revise their bids if they are unhappy with the outcome. Furthermore, where a large number of lots are

available in the award, it may not be feasible or practical for bidders to express accurately their demand for every combination of lots for which they might be interested, and a decision would be required as to how to focus their bids. With a sealed bid auction, this is very difficult and risks inefficiencies (and possibly unsold lots) as bidders would have a very limited idea about which combinations of lots they would have a chance of winning (given the demand of other bidders). However, where there are only limited options, or when there is little uncertainty, a sealed-bid auction might work well.

*Auctions with an open stage*

Conversely, open (multi-round) auctions disclose some information about the level of competition, allowing bidders to update expectations and estimates of competitors' behaviour and to adjust their valuations and bids accordingly. This will help to reduce the risk from inefficiencies that could arise from bidder information deficits or uncertainty, for instance in relation to the existing conflicts in demand, or common value uncertainty. Of particular relevance for this proposed award, when there are many lots available an open stage can help bidders to reduce uncertainty about what they may be able to win, and thus reduce the number of bids they need make to have a good chance of a satisfactory outcome.[52] Furthermore, the iterative nature of open processes mitigates the scope for inefficiencies arising from bidder errors when submitting their bids. Therefore, although open auctions are more complex to run, and take a longer time to resolve, the possibility to learn from the demand expressed by others means that they are less prone to inefficient outcomes. Open auctions do provide greater scope for tacit collusion or other gaming strategies, although this does depend on the specific rules used for the auction and the risks can usually be effectively managed with suitable measures in place.

*Common value uncertainty*

Common value uncertainty is likely to be more of an issue with respect to the assignment of frequency-generic lots, rather than the assignment of specific frequencies (given that we are not aware of any issues affecting specific frequencies within the bands available, other than as set out above). We believe that common value uncertainty is likely to be less relevant in the proposed award than the 2012 MBSA, as:

- a significant amount of the valuation for the spectrum is likely to come from current operators being able to use it for

[52] For instance, in the case of a CCA, whilst bidders might be interested in a very large set of potential alternative packages in principle, bidders are not exposed to the degree of uncertainty they would face in a combinatorial sealed bid auction, as the clock stage will disclose information that helps bidders in identifying the packages they may realistically expect to have a chance of winning, allowing them to focus only on these packages rather than having to consider submitting bids for all possible packages of interest.

improving/continuing existing services, which would be subject to less uncertainty and would in any case be operator-specific; and

- where there are potentially different uses of the spectrum with varying business models (as we might expect in this proposed award, in particular for the higher frequency bands), it can be difficult for a bidder to separate out the information that is relevant to its particular use case.[53]

However, there still may be a certain degree of common value uncertainty in this proposed award, in particular due to the potential for the spectrum to be used for 5G services where the technology and use cases are still relatively novel or in relation to the relative value of substitutable bands (e.g. the relative value of 2.1 GHz, 2.3 GHz and 2.6 GHz), which could be mitigated through the use of an open auction for the assignment of frequency-generic lots.

*Resolving conflicts in demand*

Given the large amount of spectrum available, there are likely to be benefits from using an open process for determining the assignment of frequency-generic lots, as this may help bidders in identifying what they may reasonably expect to win, and in which categories their demand may fit with that of competitors. In particular, given the number of lots available and their possible combinations, it is likely to be impractical for bidders to express accurately their demand for all combinations of frequency-generic lots in a one-shot sealed bid process, because this might require considering and valuing too many packages. However, if bidders bid for only a selection of the packages they might be willing to acquire with little information about the demand from competitors there is a risk that the bids submitted by different bidders might clash. We might not be able to accommodate the demand from both bidders, simply because bidders have not bid for alternative packages which might still have been of interest and which could have been accommodated alongside the bids submitted by competitors. An auction format with an open stage allows greater scope for these conflicts in demand to be resolved in a way that achieves a better and more efficient assignment.

*Potential for bidder errors*

Finally, although bidders in this proposed award are likely to be well informed regarding the auction rules and their own valuations, an open auction format could also still help to reduce the risk of an inefficient outcome due to bidder error, as it provides opportunities to recover (subject to activity rules) from any mistakes (unlike a sealed bid auction).

[53] Unless information about demand from individual bidders is provided, although this would typically not be recommended as it makes tacit collusion much easier.

## 7.2 Auction format for the assignment of frequency-generic lots

In this sub-section we consider alternative auction formats frequently used for spectrum auctions, and consider their suitability for the assignment of frequency-generic lots in this proposed award. We start from a relatively wide list of alternative auction formats that have been designed and used for spectrum auction, which includes:

- the combinatorial clock auction (CCA);
- the combinatorial multiple round ascending auction (CMRA);
- the sealed bid combinatorial auction (SBCA);
- the simple clock auction (SCA); and
- the simultaneous multiple round ascending auction (SMRA);

We first make some choices in relation to features that we consider necessary for the auction, based on the key issues for this particular award. These choices allow us to make a shortlist of auction formats which we consider may work for this proposed award. We then provide a detailed assessment for the shortlisted formats, in order to recommend the format that we consider most appropriate for this proposed award.

### 7.2.1 Shortlisting of candidate auction formats

In the previous section we discussed some key considerations in relation to auction design. In light of these, we identify two key questions in relation to the desirable features of the auction, which help us to shortlist or eliminate the different auction formats considered.

*Do we require a combinatorial auction, or can we use a mechanically simpler format?*

The first key question is whether it is preferable to adopt a combinatorial auction or not.

Combinatorial auctions allow bidders to make bids without facing aggregation risk, and can include provisions to allow bidders to submit mutually exclusive bids for alternative packages, which mitigates substitution risk. Therefore, in terms of allowing bidders to express their demand, combinatorial auctions provide a more flexible framework than non-combinatorial auctions.

However, combinatorial auctions are typically mechanically more complex than non-combinatorial auctions, both in terms of the evaluation of bids (and determination of prices if a second-price rule is used), and in terms of activity rules in the case of open, multi-round combinatorial auctions. Such mechanical complexity may discourage inexperienced bidders, and could lead to mistakes by bidders if they fail to anticipate the consequences of their bids.

Therefore, the case for using a combinatorial format depends strongly on the extent to which bidders could be exposed to a aggregation and substitution risk under a non-combinatorial format, and thus the extent to which there are complementarities between lots, and substitution possibilities that might be difficult under simple activity rules.

Typically, if there are material complementarities across lots, as is the case for the present award (as discussed in Section 7.1), non-combinatorial auction formats will present a risk of an inefficient outcome, and thus the additional complexity from using a combinatorial auction format is justified on the grounds that its greater efficiency is likely to offset any drawbacks from the additional mechanical complexity.

Given this, we recommend using a combinatorial auction for this proposed award.[54]

This would suggest discarding SMRA-based formats and simple clock auctions. In particular, we consider that these formats are not suitable for this proposed award due to the following key reasons:

- SMRA-based formats are not appropriate for this proposed award, as these would be likely to expose bidders to material aggregation risk and create impediments for bidders to switch across different portfolios of interest in response to price changes; and
- although the simple clock format can support package bidding to mitigate aggregation risk, this is at the cost of an increased risk that lots might go inefficiently unsold due to demand for those lots being suppressed at final clock prices; furthermore, when there are different lot categories (as for this proposed award) the simple clock auction may expose bidders to substitution risk (if the activity rules limit the extent to which bidders can switch between alternative portfolios of interest), and provides opportunities for undesirable price-driving strategies at a low risk of winning unwanted lots (which may also increase the risk of unsold lots).

[54] In its 2018 report submitted on behalf of Three ('*Preparing for the 2019 Irish multi-band spectrum award*'), NERA Economic Consulting suggests that MNOs (who already hold spectrum) are unlikely to be exposed to aggregation risks in relation to bandwidth other than those related to achieving a relatively modest minimum bandwidth requirement, which it argues could be addressed through offering the spectrum in larger lots and setting sufficiently tight spectrum caps. However, this is not necessarily true for other potential bidders who do not already hold spectrum and may only be willing to acquire spectrum if they can achieve a greater bandwidth. Furthermore, aggregation risks would remain in relation to acquiring spectrum in the two time slices. Therefore, simply offering the spectrum in larger lots and under tighter caps does not resolve aggregation risks in general, whilst at the same time might disadvantage particular bidders and reduce flexibility in determining the winning outcome. Conversely, using a format that supports package bidding should eliminate aggregation risks in general without necessarily reducing the range of possible packages for which bidders can bid.

Accordingly, these formats are not considered further in this section. A more detailed assessment of the suitability of these formats for this proposed award is provided separately in Annex A .

*Do we require an open, multi-round auction?*

A second key choice is whether to use a sealed bid process or an open combinatorial format.

Undoubtedly, a sealed bid process is mechanically much simpler and easier to run, as bidders only need to submit their bids once, and do not have to worry about activity rules and the mechanics and constraints associated with bidding in subsequent rounds. However, where bidders may face any uncertainty about demand, their chances to win specific spectrum portfolios, and the likely competitive prices, then a sealed bid auction can be strategically very complex.

Conversely, whilst open multi-round auctions are more complex, and take longer to complete, they provide opportunities for bidders to pool information through the bidding process to mitigate any common uncertainties, narrow down the options they may realistically hope to win, and refine their expectations on the likely competitive prices (which is particularly relevant for assisting with internal governance, and for budget-constrained bidders deciding how to bid).

The efficiency of a combinatorial auction depends on its ability to collect relevant demand information from bidders. In the case of a sealed bid process, the performance of the format critically depends on bidders expressing a sufficiently rich range of preferences over spectrum portfolios that they believe might form part of a market-clearing outcome. However, there are a number of reasons why the bids received may fail to provide the necessary information to identify an efficient outcome, especially given the large number of lots and potential portfolios of interest:

- making a large set of bids for all relevant packages without the package discovery functionality within a multi-round process is challenging, and mistakes can easily be made;
- bidders might be unable to bid for all the portfolios of interest at their absolute valuation, as this can create substantial governance issues, and thus might struggle to determine an appropriate bid level in the absence of any indication of likely end prices;
- bidders who have to manage budget constraints would face further challenges, as it is difficult to optimise bid strategy without any knowledge about likely end prices to gauge what portfolios they may realistically hope to win within their budget; and
- if a first price rule were used, there is additional complexity for bidders in identifying an optimal bid amount that maximises their expected surplus, as lower bids increase surplus in case of winning, but reduce the chances of winning.

Given this, we believe that a sealed bid process would not be suitable for this proposed award, as the very large number of lots means that bidders would be exposed to substantial uncertainty, and might be unable to make a sufficiently wide set of bids that provide all the demand information that would be necessary for the auction to yield an efficient outcome. Therefore, we recommend the use of an open auction format for the assignment of frequency-generic lots, as we believe that the benefits from having an open stage in terms of mitigating the uncertainties faced by bidders justify the additional complexity and time associated with using an open process instead of a sealed bid auction. Given this, we exclude the SBCA from further analysis in this section – however, we provide a more detailed assessment of the SBCA in Annex A .

*Shortlisted auction formats*

Given our recommendation for using a combinatorial, open format, we shortlist the CCA and the CMRA as candidate formats for this proposed award.

In the next subsections we assess their suitability in turn.

### 7.2.2 Combinatorial Clock Auction (CCA)

The CCA is a combinatorial auction format that allows bidders to submit bids for alternative, mutually exclusive packages. Winners are determined at the end of the process on the basis of all the bids received. Once the winning outcome has been calculated, bidders do not have an opportunity to revise their bids. However, the CCA features an open stage that allows bidders to assess the demand from competitors and potential end prices.

#### Basic structure

The CCA consists of a clock auction bidding process (the clock stage) followed by a final round in which bidders can submit a number of mutually exclusive, package bids (the supplementary bids round).

The clock stage evolves over a number of rounds. For each round, the auctioneer announces a round price for each lot category. During the round, bidders specify the number lots they would like to acquire in each category at these prices. No information about demand from other bidders at the current round prices is provided to bidders while the round is in progress. At the end of the round, if the demand from all bidders can be accommodated with the lots available, then the clock rounds end. Otherwise, a new round will be required, for which the price for lot categories with excess demand is increased. Bidding during the clock stage is subject to activity rules that prevent bidders from increasing their demand for lots for which (relative) prices increase, and will constrain the bids the bidder can make in the supplementary bids round.

In the supplementary bids round, bidders can make their final offers for alternative, mutually exclusive packages. The bids that each bidder may submit in the supplementary bids round are subject to constraints arising from the bids it submitted during the clock stage. These constraints essentially require that the final set of bids submitted by the bidder must be consistent with the demand profile that can be inferred from the bids it submitted during the clock stage.

After the supplementary bids round, winners and prices are determined using a combinatorial approach, taking into account all bids submitted during the auction (including both the clock stage and the supplementary bids round). The winning bids are those that generate the highest total value, subject to selecting at most one bid from each bidder and ensuring that all bidders can be assigned the lots specified in their winning bids given the lots available.

## Pricing

The CCA adopts a pricing rule that requires winners to pay a price for their lots that is at least as high as the value that could be obtained from assigning these lots amongst the other bidders. However, subject to the condition above, the CCA will minimise the total sum of prices paid in the auction. This rule reduces the scope for a bidder to affect its own price by reducing its bid, and thus largely removes the incentives to bid below the level that reflects its maximum willingness to pay for each package. Encouraging bidders to reflect their maximum willingness is desirable, as this information allows the auction mechanism to make a better assessment of how to assign the lots amongst bidders and supports an efficient award outcome.

## Activity Rules

The activity rules apply restrictions on the bids that can be submitted by a bidder on the basis of the bids it submits in (some) earlier rounds. This is to ensure that bidding is progressive (demand falls as prices increase) and to create incentives for bidders to bid truthfully according to valuation (to ensure information revealed in the clock rounds is meaningful and to maximise the likelihood of an efficient outcome).

For this proposed award, we recommend that the activity rules would be the same as those used in the multi-band award in 2012 and 3.6 GHz award in 2016, and would need to be applied separately for each time slice.

Each lot would be assigned a number of '**eligibility points**', where every lot within a particular lot category would have the same

number of eligibility points. The eligibility points are effectively weights applied to each lot category to reflect an allowed rate of switching between different lot categories. Therefore, assuming that bidders will seek a given bandwidth and consider switching across different bands but pursing in principle the same bandwidth, we would recommend that lots are given a number of eligibility points that reflect the MHz included in the lot. However, if there are good reasons to believe that bidders would be more likely to adjust the bandwidth when switching between bands (e.g. if alternative packages were to use different technology and channel width, due to different total availability of spectrum in the different bands, or for example in the case of regional lots reflecting the population covered in different regions), then it may be reasonable to set eligibility points that are not strictly proportional to the bandwidth of lots. Nevertheless, under the relaxed activity rules proposed for the award the choice of specific eligibility points is not crucial, as bidders will be able to switch back and forth between packages with different eligibility points provided that this is consistent with revealed preference.

For each time slice, at the start of any round a bidder would have an '**eligibility level**' to bid for lots within that time slice. The '**activity**' of a bidder in a round for a particular time slice is the sum of the eligibility points of the lots in that time slice the bidder actually bid for (as part of the package bid submitted). Before the first round, the bidder's (initial) eligibility level for each time slice would be set in accordance with some qualifying criteria (e.g. lots bid for on the application form, amount of deposit submitted). For subsequent rounds, the bidder's eligibility level for a time slice will be set with respect to the bidder's eligibility and activity in the preceding round; specifically, the bidder's eligibility in a given time slice will be equal to the lower of:

- its eligibility in that time slice at the beginning of the preceding round; and
- its activity in that time slice in the preceding round.

Therefore, if the bidder's activity in that time slice falls below its eligibility in a given round, then this level of activity will define the eligibility level for the bidder in the following round. However, if under the activity rules the bidder makes bids with an activity that exceeds its eligibility level in the round, then its eligibility level will remain the same for the following round.

A bidder is allowed to bid for any package with associated activity less than or equal to the bidder's current eligibility level in each of the time slices.[55] However, the activity rules in the CCA narrow the bidding possibilities available to a bidder on the basis of the bids it

[55] It is important to note that eligibility points are not transferable across time slices i.e. it would not be possible to increase demand in one time slice by decreasing demand in the other.

submits in rounds in which the bidder's activity is less than its eligibility level for one or both of the time slices.

Specifically, suppose that the bidder reduces its eligibility level in one or both of the time slices by bidding for package X in round *n*. Any package Y with associated activity greater than that for package X in either or both time slices, but for which the bidder had sufficient eligibility to bid in round *n*, would be subject to a constraint. This constraint will limit the amount that the bidder can offer for Y in relation to the amount that the bidder offers for X. Specifically, the bidder's bid for Y cannot exceed its bid for X plus the difference in the price of these packages in round *n*. The rationale for this is that the bidder could have bid for Y when the price difference between Y and X was below this; however, by bidding on X, the bidder indicated that it was not willing to pay this difference to obtain Y instead of X.

These constraints reduce the bidding options for the bidder to ensure they are consistent with revealed preference implied by its previous bids, both during the clock stage and the supplementary bids round. During the clock stage, the bidder will only be able to bid for Y if the price difference between X and Y does not increase (relative to the price difference in round *n*), and provided that it updates its bid for X if necessary to ensure that its bids are consistent with the constraints. During the supplementary bids round, the bidder's final set of bids will also need to satisfy all of these constraints, which may require increasing the bids for some packages that the bidder bid for during the clock stage.

## Guarantees offered to bidders

The CCA removes aggregation risks by supporting package bidding, which provides a guarantee that a bidder will win a whole package it bid for or nothing at all. The CCA also suppresses substitution risk by allowing bidders to bid for alternative, mutually exclusive packages with a guarantee that the winner determination mechanism will select that which would provide the greatest surplus to the bidder (in terms of the difference between the bid submitted by the bidder and the price it would need to pay for each package). This property, in combination with the pricing rule, limits incentives to reduce demand early in order to keep clock prices low (so-called strategic demand reduction), as the bidder should obtain at least the same surplus by bidding straightforwardly according to valuations (assuming that competitors' bids were unaffected by the bidder's bid during the clock rounds).

The CCA allows bidders to calculate the maximum price they may need to pay for their final package (especially when the relaxed activity rules are used, under which an upper bound for this can be obtained with a simple calculation). If the bidder makes a bid at this maximum price, then the bidder is guaranteed to win with one of its

bids. Where such price is below a bidder's valuation for the final package, then the bidder can make a bid for the final package at this price and adjust its bids for other packages to reflect the difference in value between the corresponding package and the final package, with a guarantee that the bidder will win with one of its bids.

## Guarantees offered to the auctioneer

Provided that each bidder submits a set of bids that reflects its full demand profile, the CCA will assign lots efficiently. As a consequence, lots will only go unsold when it would not have been possible to generate additional value from assigning them (on the basis of bids received).

## Gaming opportunities and incentives

The CCA considers all bids submitted during the auction and in the application in determination of winning bids and prices. Bids submitted in the clock rounds remain eligible to become winning bids (mitigating incentives to bid for unwanted packages), and where they lead to a reduction in eligibility will also set constraints on the bids that a bidder can submit in other clock rounds and in the supplementary bids round. Bidding in a non-straightforward way with the aim of steering the auction outcome entails a higher risk of not being able to express demand. For this reason, the CCA provides good incentives for bidders to bid straightforwardly according to valuations.

Some commentators have criticised the CCA on the grounds that it provides incentives for overbidding in order to impose higher prices on competitors, and that if bidders overbid too much they may end overpaying for the spectrum that they win. These concerns are unlikely to be material in practice. It is true that bidding incentives in a CCA are rather different to those in other open formats such as SMRAs due to the fact that losing bids do not affect bidders' own prices, but may set competitors' prices. However, this has the benefit that it encourages bidders to compete for additional lots. To the extent that the CCA may provide incentives to bid for packages that the bidder does not expect to win, these are limited by the risk of ending up with an unwanted package or a price that exceeds valuation. This risk should have a desirable disciplinary effect and discourage such behaviour. Furthermore, with spectrum caps set at reasonable levels, it should be the case that most packages that bidders can bid for at potential winning packages under some scenario for rival bids.

The CCA provides a clear framework in which bidders can avoid overpaying for any package by making bids in line with valuations.

Therefore, the critique of the CCA might be more related to the fact that competition for additional lots is likely to be stronger than in other formats where there might be strong incentives for strategic demand reduction or that might be more susceptible to tacit collusion.

In a CCA, losing bids for larger packages do not affect a bidder's price in the event that it wins a smaller package. As a result, the CCA is more effective in eliciting demand from bidders as they have good reason to compete for larger packages of lots up to valuation even if these bids prove ultimately unsuccessful.

The CCA destabilises tacit collusion by providing an opportunity for bidders to deviate from any tacit agreement in the supplementary bids round without the risk of retaliation by competitors. In a one-shot situation, deviating from any tacit agreement cannot disadvantage bidders who deviate, especially if bidders cannot verify competitors' behaviour (e.g. if all bids are kept confidential). Therefore, bidders have little incentive to stick to such an agreement. Furthermore, there may be benefits from deviating, for example by making supplementary bids for larger packages, as a bidder might then have some chance of winning one of these. As a consequence, while still possible, collusion in a CCA may be difficult to sustain.

Setting prices on the basis of the demand displaced by each winner can also lead to material price asymmetries when only some winners have unsatisfied demand for additional lots beyond what they have won. This could yield superficially counterintuitive results when bidders are highly asymmetric in terms of the bids they have made. For instance, consider a simple scenario in which we have eight lots, a 'strong' bidder with flexible demand between four and eight lots, and a 'weak' bidder with demand for four lots. Suppose that the weak bidder manages to outbid the strong bidder on four lots, so that both bidders win four lots each. In this case, the weak bidder will need to pay the amount that the strong bidder offered for four additional lots; conversely, the strong bidder will only have to pay the reserve price, as the weak bidder did not express demand for more lots than it wins. Therefore, despite the fact that both bidders win the same package, the strong bidder would emerge from the auction with a better deal as it faced weaker competition. This occurs because the lots assigned to the weak bidder were contested, while the lots assigned to the strong bidder were not.[56]

Such outcomes may raise concern about the 'fairness' of the pricing rule, for instance on the basis that the demand for additional lots

[56] Asymmetric spectrum competition caps may lead to similar results, as they limit the extent to which capped bidders can express demand for additional lots.

from weak bidders may be limited by their budget.[57] However, in judging fairness we must also acknowledge that the bidders are not in symmetric positions. In particular, the weaker bidder faces more competition than the stronger bidder and the outturn prices reflect this. If bidders are in broadly symmetric positions, then prices will be broadly symmetric.

Our main concern in designing the auction is to ensure an efficient assignment, which opportunity-cost pricing achieves. Indeed, if prices for winners did not reflect the extent of competition that they individually faced, then the auction outcome would not be efficient. Imposing a requirement for symmetric pricing – that bidders winning the same pay the same - may fail to yield an efficient outcome when spectrum valuations are synergistic.[58]

Other arguments made against the CCA relate to potential situations in which strong bidders with predictable demand might be at the mercy of weaker bidders that can inflict high prices to force strong operators to reduce demand. Arguably, this would require weaker bidders to have a high degree of certainty over the demand from strong bidders to know to what extent they could drive prices paid by stronger bidders without winning themselves. Therefore, these concerns are mitigated in this auction by the large supply of spectrum, and the fact that demand from competitors might be highly uncertain. Moreover, under the informational assumptions necessary to support this argument, this would be a potential issue under most auction formats, so it is not a specific problem with a CCA.

## Complications

Complications in the CCA arise when bidders may be unable to express their demand fully – including their preferences across different packages of lots – through their bids. This can happen for various reasons:

[57] For instance, NERA comments on this issue in its 2018 report submitted to ComReg on behalf of Three, arguing that the CCA can lead to price asymmetries that can be 'grossly unfair'.

[58] For instance, if lots are complementary and there is insufficient demand to accommodate the preferred package from all bidders, then a simple clock auction or an SMRA, as proposed by NERA (in its 2018 report submitted to ComReg on behalf of Three), can easily lead to lots remaining inefficiently unsold (if there would have been demand for those lots at a lower price, but not at the market clearing linear price), or bidders paying a price for lots they win that exceeds their valuation (due to aggregation risks). Thus, when valuations are synergistic, the outcomes obtained with these simpler formats might be inefficient and/or 'unfair'.

- Some bidders may have a budget constraint that is below their highest valuation for a combination of lots, and so may not be able to bid at value for all possible packages. In particular, this may mean that a bidder cannot express its valuation differential between a larger and a smaller package of lots.[59] The bidder would have a choice between bidding less for the smaller package in order to bid for the large package at its budget, if it thought this would likely win the large package, or alternatively if it was unlikely to win the large package at its budget, bid for the small package at value, but then understate its valuation differential.
- If there is a restriction on the maximum number of packages that bidders can bid for, this may limit the extent to which a bidder can express its demand profile by means of alternative options, even if it had sufficient budget for all options. The bidder would need to select relevant packages that it thought it would have some chance of winning.

The CCA mitigates these problems by disclosing demand information during the clock stage that helps to assess what the bidder could realistically win.

In terms of the first point, this demand information may allow bidders to calculate an upper bound on the price they may need to pay for the package they bid for in the final clock round, especially under the relaxed activity rules adopted for the MBSA and 3.6 GHz award. On the basis of this information, the bidder is able to assess the extent to which it could reduce its bids without risk of undermining its chances of winning. However, bidders operating under a tight budget constraint may still be unable to express their demand profile within their budget; such bidders may need to further adjust their bids to maximise their chances of winning on the basis of their expectations on what they might be able to win.

Even if bidders may be able to have access to sufficient budget, it is often challenging to get approval to submit a bid at a much higher level than the expected price for the package. This may create governance issues for some bidders. However, this problem is also mitigated by the relaxed activity rule adopted for the MBSA, which provides better information to calculate an upper bound on the price for the package a bidder bid for in the final clock round and thus may limit the extent to which the bidder needs to bid above likely end prices.

[59] If the bid for the larger package is limited by budget, then the bidder will need to consider whether to make a bid for the smaller package which reflects its value (in which case the difference between bids for the large and small package will not reflect the difference in value, as the bid for the larger package is lower than its value), or to make a lower bid for the smaller package, so that the difference between bids reflects the value difference (but in this case both bids will be below valuation, which reduces their chances of becoming winning bids).

Regarding the second point, the information released about the demand of others would help bidders to form an assessment of the packages that it would likely stand a chance of winning. The bidder could then focus its supplementary bids on these packages, ensuring that its limited number of supplementary bids were used to make meaningful offers rather than wasting them on packages it would never stand a chance of winning.

These complications could be magnified in a multi-band setting if bidders were able to switch between lot categories to distort clearing prices without consequences for the final bids they can submit. This could allow some bidders to distort relative prices at the end of the clock stage and create excess supply at those prices, which would limit the extent to which bidders can use the information from the clock stage when determining their final set of bids; when the value of lots in excess supply in the final clock round is significant, the maximum price that a bidder might possibly need to pay for some packages may be materially above final clock prices. However, the activity rules (set out above, as used for the MBSA and 3.6 GHz award) reduce the extent to which final prices might exceed the clock prices at the end of the clock stage, and also the scope for bidders to artificially create situations of excess supply in the final clock round without facing adverse constraints when submitting their final set of bids in the supplementary bids round.

## Support to bidders to reduce risk of errors

The activity rules and the process for determining winners and prices in the CCA are often perceived as complex. This could discourage some bidders, and possibly disadvantage those who fail to understand the rules if they then fail to understand the consequences of their bids. This issue may be mitigated by providing appropriate guidance and training to bidders. For instance, as in previous awards, it may be worth offering a bidder training programme including mock auctions, the possibility for bidders to use the system to run their own simulations and get familiarised with the rules and auction system, or access to a server to run winner and price determination software, which allows bidders to calculate prices paid for a given set of winning bids. This may somewhat increase the work needed when preparing for the auction, but will increase the probability of an efficient and satisfactory outcome.

## Overall assessment

A CCA provides a good framework for bidders to be able to compete for diverse footprints and bandwidths, as:

- by supporting package bidding, the CCA provides a framework for bidders to bid without aggregation risks;
- at the same time, by using generic lot categories and providing an opportunity for bidders to submit mutually exclusive bids for alternative packages, the CCA provides a framework for bidders to bid without substitution risks; and
- finally, by selecting bids so that the difference between bid amounts and prices are jointly maximised it ensures that bidders who submit a set of bids that reflects their preferences should win with their preferred bid (as a consequence, the CCA has the advantage that it eliminates incentives for strategic demand reduction and promotes competition for additional lots).

Provided that bidders can suitably reflect their valuations in their bids, the CCA is likely to perform well under any demand profile.[60]

These properties make the CCA a good choice for this auction, where complementarities between lots are to be expected. However, despite suppressing bidder aggregation and substitution risks, the CCA can present some challenges for bidders.

Table 9 provides a summary of key advantages and limitation of the CCA for this proposed award.

*Table 9: Advantages and disadvantages of the CCA*

| **Key advantages** | **Key limitations** |
|---|---|
| • Bidders do not face any aggregation risks<br>• There is no risk of overshoot or lots going inefficiently unsold due to lumpy demand<br>• Provided that bidders submit a final set of bids that reflects their valuations, the CCA yields an efficient outcome without requiring any specific assumptions to be made about the structure of demand | • Potential difference between valuations and likely prices may create governance issues for bidders seeking approval of bid ceilings<br>• Opportunity cost pricing may lead to price asymmetries, in that smaller bidders may create little pricing pressure on larger bidders, but may have to pay dearly to outbid them (though this issue is mitigated given the large amount of |

[60] In some cases bidders may be unable to express their demand profile by means of a complete set of value-reflecting bids. This can occur when there are significant limitations on the bids that bidders can submit (as for instance a significant reduction on the total number of packages that each bidder can bid for) or if bidders' valuations are materially above their budget. Notwithstanding this, the CCA can assist bidders in identifying which packages they are likely to win within their budget, especially under the activity rules adopted for the MBSA and 3.6 GHz award. This allows bidders to focus on these packages and adjust bids to improve their chances of winning their preferred affordable package.

| | |
|---|---|
| • Price differences across packages reflect complementarities between lots and opportunity costs, so both winners and losers should be 'happy' if their bids reflect their valuations<br>• Incentives to engage in strategic demand reduction are greatly reduced by not requiring a uniform price per lot, which allows bidders to compete for a large package without pushing up the price they might have to pay to win smaller packages<br>• With many lot categories the clock rounds can discover an outcome in which bidders have mutually compatible demand, which can then inform the selection of packages to be subject to supplementary bids<br>• Bidders need to focus on valuing packages prior to the auction and the gains from gaming behaviour are relatively modest. | spectrum available here and uncertainty about competitors' demand) |

### 7.2.3 Combinatorial Multi-Round Ascending Auction (CMRA)

The CMRA builds on the CCA with relaxed activity rules for the clock auction phase, adding some of the combinatorial elements of the CCA, whilst keeping a clock structure. In particular, the CMRA:

- does not have a final sealed bid round – instead, it allows bidders to make multiple bids in each clock round (subject to the constraints that would apply to the supplementary bids round of the CCA) and runs a combinatorial evaluation of bids at the end of each round;
- does not expose bidders to the risk of not winning any spectrum unless they explicitly stop making bids at round prices, as in the simpler clock auction; and
- uses a pay-your-bid rule instead of the opportunity cost based pricing rule used in the CCA, but allowing bidders to only

increase their bids progressively, always capped by round prices and any supplementary caps that might have arisen from the bids made by the bidder in earlier rounds.

## Basic structure

The process follows the multi-round structure of a clock auction, in that:

- identical lots are grouped together into lot categories;
- the auctioneer announces the price for each lot category in a round, and bidders specify the number of lots in each category they wish to acquire at the prices announced by the auctioneer – this constitutes the *headline bid* of the bidder in that round.

Bidders can also make *additional bids* (i.e. in addition to the headline bid, for other packages) in each round, submitted alongside their headline bid for the round, subject to the constraints that:

- none of these bids can exceed the round price; and
- that relative caps that arise from previous headline bids are satisfied (the relative caps arise when a bidder reduces its eligibility by bidding on a headline bid with less eligibility than its preceding one, following the same approach as in a CCA).

Another difference is that the auction does not end when there is no excess demand at round prices in any category, but rather when the optimal outcome given the bids received so far (using a combinatorial evaluation of bids analogous to that used after the supplementary bids round in a CCA) involves accepting a bid from each bidder – these become the winning bids and bidders pay the amount of their bid.

The closing rule differs from that in a clock auction in that the auction might continue even if there is no excess demand at round prices. However, this will only happen if any of the bidders who is still bidding at round prices would be outbid (by an alternative combination of bids that would involve some additional bids from other bidders).

Determining whether any lots require a price increase (and hence whether or not the auction ends) does not simply rely on assessing excess demand at current clock prices. Instead, the CMRA determines which lots need a price increment by checking which bidders would be at risk of losing, and then determining the lots for which demand at clock prices from these bidders clashes with the bids from other bidders.

One implication of the closing rule is that bidders always have an opportunity to bid back if they are not winning with one of the bids they have submitted. Therefore, bidders have less pressure to make

bids for all possible targets, and can instead introduce these progressively in response to changes in the clock prices.

At the same time, it is also possible that the auction might end when there is still excess demand at round prices, provided that it is possible to accept a bid from each bidder by considering their additional bids. This can help to resolve coordination problems where the headline bids from different bidders clash on the same lots, but where such bidders would be equally happy to acquire different lots instead in a way that would allow for accommodating demand from all bidders.

## Pricing

With the CMRA, bidders pay the amount of their winning bids (though these amounts are determined by competition with other bidders). This may be desirable as it provides bidders with certainty over what they will be required to pay if they win, and in particular may be helpful for internal governance and getting sign-off to submit particular bids.

On the other hand, the downside of the pay-as-you-bid rule is that bidders have a clear incentive to strategically reduce demand early to prevent competition from increasing prices and win some lots at a lower price. Nevertheless, the CMRA allows bidders to keep a range of additional bids potentially below clock prices, thus providing a mechanism by which bidders can compete for a larger package whilst at the same time keeping an option to win alternative packages at a lower price.

## Activity Rules

The CMRA adopts the relaxed activity rules developed for the CCA, which allow bidders to increase their demand (in terms of eligibility points) relative to the preceding round if doing so is consistent with the relative caps. This allows bidders to make bids that they would have been able to do in the supplementary bids round of a CCA.

As with the CCA implementation for this particular award, the activity rules would need to be applied separately for each of the time slices.

## Guarantees offered to bidders

The CMRA allows bidders to control their possible final outcomes, by allowing them to progressively increase the number of packages they bid for as they need to. The CMRA also provides certainty about the price to be paid and does not require (or allow) bidders to make

bids above round prices, ensuring that bidding is progressive and predictable.

The CMRA has a number of desirable features in common with the CCA:

- there are no aggregation risks in a CMRA, as bids are submitted for indivisible packages of lots;
- switching and coordination impediments are removed by allowing bidders to make a list of mutually exclusive bids each round, and by allowing bidders to increase their demand in response to price movements;
- the open stage combined with the ability to submit multiple additional package bids allows bidders to assess demand and form views over packages they are likely to win, which can help them to focus their bids on particular targets in scenarios where it is not possible/feasible to express demand for the full range of packages the bidder might be interested in – the CMRA will identify which, and increase the price of, lot categories where there is a clash in the demand from different bidders, based on all their bids rather than only clock bids, so that where bidders express substitutability between categories in their bids this can be taken into account;
- bidders can simply pursue a small number of preferred target packages, and only consider other packages if their preferred targets become too expensive, or when they run out of budget for these; and
- an efficient outcome is possible even if there are synergistic valuations, as prices are not bound to linear prices.

## Guarantees offered to the auctioneer

If bidders bid straightforwardly according to their valuations, then the outcome of the CMRA can be expected to be largely aligned with that of a CCA, and thus should perform well for multi-band auctions. An advantage of the CMRA is that it may facilitate the collection of relevant bids for an efficient outcome when some bidders have to bid to a tight budget constraint, as the multi-round process will expose them to the maximum price they may need to pay for a package.

## Gaming opportunities and incentives

The CMRA is subject to the problems associated with the pay-your-bid rule, in particular:

- bidders may try to shade their bids (i.e. bid below their true valuation) with a view to maximising their surplus (i.e. the difference between their valuation and the price paid);

- bidders may have an incentive to reduce demand early in order to win some lots at a lower price.

However, the incentives to strategically reduce demand in headline bids is (partly) mitigated through allowing bidders to make additional bids below round prices.

## Complications

The mechanics of the CMRA are clearly more complex than those of the SMRA or the simple clock auction (see below). As with the CCA, this can create discomfort for bidders and increase the scope for mistakes, especially if bidders try to second-guess competitors in order to bid strategically to distort the outcome in their favour.

The CMRA provides greater control to bidders than the CCA in relation to their likely outcomes, allowing them to focus on a smaller set of targets, and only move to alternative (or additional) targets as the auction progresses. However, whilst this should work well in settings where bidders are likely to focus on some targets first, it might not be practical if bidders want to keep a wide range of options throughout the process. Instead, if bidders wish to make bids for many alternative packages in each round, then the CMRA might be challenging in terms of determining all the relevant bids amounts and submitting them within the round time. These complications can be mitigated by allowing bidders to upload their bids and providing functionality to assist bidders in preparing bids, but submitting large sets of bids every round may remain challenging.

## Overall assessment

The CMRA offers a number of the same benefits as the CCA that are likely to be useful for this proposed award. In particular, it mitigates aggregation and substitution risk, and helps bidders to focus their bids on packages they might have a chance of winning.

In addition, the pay-your-bid pricing rule may be seen as desirable by bidders that do not like the uncertainty over final prices associated with the CCA – though this comes at the cost of providing some incentives for bidders to strategically reduce demand or shade bids, as in all first price auctions. In this auction this might be relevant due to the fact that the large supply of lots might allow bidders to share the spectrum lots available in a tacitly collusive outcome with a view to settling at low prices.

However, there is a possibility that some bidders may want to keep a large range of packages in play throughout the auction. This may be of particular relevance in this proposed award due to the existence of different time-slices, which can materially increase the number of

packages of interest to be considered. This might be difficult to do in a CMRA, as bidders would need to update a long list of bids in each round. In such cases, a CCA may be preferable in that it first discloses information to bidders to mitigate uncertainties, and then provides an opportunity for bidders to submit their final set of bids, so that bidders only need to prepare their full list of bids once.

| **Key advantages relative to the CCA** | **Key limitations relative to the CCA** |
|---|---|
| Pay-your-bid pricing rule can be simpler for bidders, reduce uncertainty over final prices, and help with internal governance. | Vulnerable to strategic demand reduction.<br>Susceptible to bid shading, which risks bidder error and an inefficient assignment.<br>Might be difficult for bidders to maintain a large set of bids throughout the auction, as they would need to update the list in each round. |

### 7.2.4 Recommended auction format

Both the CCA and the CMRA eliminate aggregation and substitution risks.

The CMRA offers many of the same benefits as the CCA, has a simpler pricing rule that may be easier for bidders to understand and gives more certainty over potential final prices when submitting bids – although the downside of any auction using a first-price rule is that it provides incentives for strategic demand reduction. However, a potentially more challenging issue for this proposed award is that bidders might be interested in a very large set of alternative spectrum portfolios, due to the fact that there are many lots available and that several licences are split into two time slices. As a result, bidders might need to consider a significant number of bids each round, which could be challenging; conversely, in a CCA bidders would only need to make a comprehensive assessment of all their bids in the supplementary bids round.

Given our assessment, we consider that the CCA, which has already been used by ComReg in previous awards including an award where spectrum was also available in different time slices, would on balance be preferable for this proposed award.

## 7.3 Format for the assignment of specific frequencies

Following the assignment of frequency-generic lots, the award will proceed to the assignment of specific frequencies to winners of frequency-generic lots.

We recommend restricting potential frequency assignments to those which maximise the extent to which contiguous frequencies can be assigned within each band, and where possible to assign bidders winning the same bandwidth in a particular band across the two time slices the same frequencies in both time slices.

Where there are multiple options for arranging winning bidders within a band, any conflicts would be resolved by means of a sealed-bid auction process (with an opportunity cost pricing rule) that would allow bidders to express any preferences for different locations (over the two time slices) within the band. For the avoidance of doubt, the approach we propose is analogous to that used in the 2012 MBSA in that bidders who have been assigned spectrum in a band across both time slices would be presented with options that specify a placement for both time slices, so that a bidder would not have to express preferences separately for each time slice. The reason for this is that preferences in one time slice are likely to depend on the bidder's placement in the other time slice, and presenting these as single options will allow the bidder to express this preference linkage. This approach also makes it possible to narrow down possible assignments in order to prevent, as far as it may be possible, a misalignment in the frequencies given to each bidder across both time slices.

## 7.4 Determination of potential frequency assignments

For the 700 MHz and 2.6 GHz paired bands, contiguous assignments can always be guaranteed, since the spectrum to be awarded in those bands is available as contiguous blocks (within the relevant band).

For the 2.3 GHz band there is a complication in that, with the proposed lot structure, the bottom 30 MHz and the top 10 MHz would be included as separate lot categories to the rest of the band and assigned as frequency-specific lots. If a bidder were to win one of the frequency-specific lots alongside some of the 2.3 GHz frequency generic lots, a contiguous assignment for that bidder could still be guaranteed by imposing a rule that the frequency-generic lots would automatically be located next to the relevant frequency-specific lot,

with other 2.3 GHz winners assigned frequencies within the remaining available frequencies. However, if a bidder were to win both frequency-specific lots as well as some (but not all) of the frequency-generic lots, it would not be possible to give that bidder a contiguous frequency assignment; bidders would need to take account of this when submitting their bids.

A similar situation arises with the 2.6 GHz unpaired band, where the current proposal is to make the top and bottom 5 MHz blocks available as two frequency-specific lots, with the middle 40 MHz offered as frequency-generic lots. If a bidder were to win just one of the frequency specific lots alongside some of the frequency-generic lots, then it would always be possible to give that bidder a contiguous assignment within the band. However, if a bidder were to win both frequency-specific lots plus some (but not all) of the frequency-generic lots, that bidder could not be given a contiguous assignment; as with the 2.3 GHz band, bidders would need to account for this when submitting their bids.

With the 2.1 GHz band, there is a potential complication due to the location of Meteor's existing spectrum rights over the period of time slice 1, which splits the rest of the band into two non-contiguous blocks of spectrum (one 2x15 MHz block and one 2x30 MHz block). As discussed above, this potentially limits the extent to which all winning bidders could be assigned contiguous rights of use in the paired 2.1 GHz band. Therefore, in a similar manner to the approach used in the 2012 MBSA and in the interests of facilitating an efficient assignment, our recommendation would be to require the existing licensee (Meteor) to relocate its current spectrum holdings by participating in the assignment stage of the award and competing for its preferred frequencies (with any additional 2.1 GHz lots it wins in time slice 1 forming a contiguous block with its current holdings). This would allow for all winners of 2.1 GHz licences to be guaranteed contiguous rights of use in the band in both time slices. If Meteor does not participate in the assignment stage, and retains its current location, then contiguity could only be guaranteed for time slice 2.

Another consideration for this proposed award is that there may be some benefit for a bidder that wins spectrum in a particular band across both time slices to be awarded the same frequencies in both time slices. This is because there is likely to be some cost and potential consumer disruption associated with having to retune equipment at the end of the first time slice to use different frequencies for the second. Our current understanding is that while these costs would be relatively small (on the basis that equipment would need to be retuned but not replaced) and actions can be taken to mitigate consumer distruption, there is still an argument for restricting the set of possible frequency assignment in a way that minimises the extent to which winning bidders will have to relocate from one time slice to the next. This issue was considered previously for the 2012 MBSA where licences were also allocated across two

time slices. For that award, if a winning bidder was assigned the same number of lots[61] across both time slices (for a given band), it would be guaranteed to be assigned the same frequencies in each of the two time slices. We believe that where possible the same approach would be appropriate for this proposed award.[62]

For bidders that win different amounts of spectrum in each time slice, there would inevitably need to be some relocation/retuning in any case, and our current understanding is that the cost of this would be approximately the same irrelevant of the extent to which the frequencies differ. In this case there would be little benefit in trying to align frequencies (to the extent possible) over the two time slices. However there may also be other factors to consider, such as minimising the complexity of any transition process between time slices, particularly if multiple operator transitions would be involved where the transition of one operator would be dependent upon the prior transition of another operator.

A final restriction that might be applied on the assignments allowed relates to the positioning of any unsold lots. Typically, it is recommended that, unless there is a good reason to take a different approach, any unsold lots are grouped into a contiguous block within the band. This supports long term effective management of the spectrum as it maximises the chances of the spectrum being assigned (and used) in the future. It may also be desirable to position the unsold lots in a particular part of the band, for example to minimise the risk of interference with users of adjacent spectrum, or to maximise future assignment options. However, if there is no good reason for this, then there may be benefits in not imposing such restrictions so as to maximise flexibility for winning bidders and minimise the complexity of any transition process. Such an approach was used in the 3.6 GHz band award to maximise the alignment of spectrum rights across mulltiple regions[63].

### 7.4.1 Proposed bidding process for assignment options

Once the possible assignment plans have been narrowed down, a one-shot bidding process can be used to determine which of these will become the final assignment plan. This can be done by inviting bidders to express their preferences, in the form of bids for

[61] Meteor's 2 x 15 MHz of spectrum rights in its existing 3G Licence would count as 3 lots in Time Slice 1.

[62] This would need to take into account the frequency-specific lots currently proposed for the 2.3 GHz and 2.6 GHz unpaired bands; a bidder might win the same amount of spectrum in one of those bands in both time slices, but if that includes a frequency-specific lot for one time slice but not the other, then it would not be possible to give that bidder the same frequencies in both time slices. This would need to be taken into account by bidders when submitting bids.

[63] See paragraph 3.167 of ComReg Document 16/71.

alternative assignments they could win. For a given band, each alternative assignment option for a bidder would specify the frequencies they would receive in each time slice. The winning outcome would maximise the total value of winning bids, subject to the assignments allocated to each winning being compatible. Prices associated with the winning bids can then be determined on an opportunity cost basis.

Bidding for assignment options is not subject to material risks and uncertainties that might impede bidders from expressing their demand. Therefore, a sealed-bid auction, which was the approach adopted for the 2012 MBSA and 3.6 GHz award, would work well. Bidders would be able to specify their value for each of their alternative options, and the auction mechanism would select the feasible assignment plan that yields the greatest value (in terms of total bid amount). Note that winners from the first stage are guaranteed the lots they won regardless of whether or not they submit any bids in the assignment stage; a bidder with no preference over particular frequency assignments could therefore choose to not submit any assignment bids, and its specific frequency assignment would simply be one that would fit with the preferences expressed by other winning bidders.

# Annex A Detailed assessment of auction formats not shortlisted

In this annex we present a detailed assessment of the auction formats not shortlisted in the main report. For each of them we also present a summary of their main advantages and disadvantages relative to the CCA, which is the format we recommend for this proposed award.

## A.1 SMRA with frequency-generic lots

The simultaneous multiple round ascending auction (SMRA) auction was the pioneer format for spectrum auctions. It is an efficient mechanism when bidders may require a single lot and must choose between (perfect or imperfect) substitutable lots in response to changes in prices. However, it has significant limitations when bidders seek multiple lots, as determining standing high bids on each lot independently of other lots exposes bidders to substitution and aggregation risks. In fact, the limitations of the SMRA in dealing with these risks has been the main motivation for developing and adopting combinatorial auctions for the award of spectrum licences when spectrum is offered in small lots that can be aggregated by bidders.

Aggregation risk is likely to be an important consideration for this proposed award where we could expect bidders to be seeking:

- a minimum amount of spectrum within any given band; and/or
- a combination of spectrum across multiple bands (e.g. a mix of high and low frequencies); and/or
- spectrum licences covering both time slices.

Addressing aggregation risk in a SMRA is not easy. There have been many attempts to introduce corrective measures, such as the use of 'withdrawals' and/or staged activity requirements, but none has been entirely satisfactory.

Another relevant consideration for this proposed award is that the SMRA can be unreasonably slow when there are many identical lots and little excess demand. Given the amount of spectrum available in this proposed award, this is likely to be the case, at least towards the end of the auction. The time required for the process to complete could potentially be reduced by using larger lots, but this removes flexibility for bidders to express their demand and for the mechanism to find an optimal distribution of the available frequencies across bidders.

In the early implementations of the SMRA, lots were typically frequency-specific, which exposed bidders to fragmentation risk. However, variants that support frequency-generic lots have since been developed. Our discussion below is based on the SMRA format with frequency-generic lots (grouped into lot categories, as proposed).

## Basic structure

In an SMRA, multiple, specific lots are offered simultaneously and bidders select the lots they wish to bid for. Bidding proceeds in rounds, and all lots stay in play until the auction finishes.

At the end of each round, the auctioneer evaluates the bids received for each lot in turn and selects a standing high bid for each. The standing high bids provide a provisional outcome. Where lots are over-subscribed, their price is increased for the following round. Bidders are then invited to submit further bids to change the provisional outcome.

Standing high bids remain valid and committing unless they are overbid in a subsequent round. This exposes standing high bidders (the bidders that submitted the standing high bids) seeking multiple lots to aggregation and substitution risks:

- as standing high bids for different lots are established independently, a bidder that bid for several lots may become the standing high bidder on some but not all of the lots for which it bid;
- standing high bidders may be outbid on only some lots, so there is no guarantee that they will be able to retain a particular combination of lots;
- bidders that hold standing high bids on some lots cannot easily switch to non-overlapping aggregations, as they may be 'stuck' with their standing high bids.

Some SMRA variants include provisions that allow bidders to *withdraw* standing high bids, typically subject to some restrictions (e.g. under specific circumstances or a limited number of times) and/or costs (e.g. penalties in the event that such lots remain unsold or eventually sell at a price below the withdrawn bid amount).

The auction ends following a round in which there was no bidding activity, so that the provisional outcome cannot be displaced. At the end of the auction, the standing high bid for each lot becomes the winning bid for the corresponding lot.

## Pricing

Bidders are required to pay the amount of their winning bids.

## Activity rules

The activity rules for the SMRA are based on the same concept of eligibility and activity as for the clock auction.

However, the activity rules in an SMRA can be extended to allow bidders to use *waivers* and *withdrawals* in order to help them manage aggregation and substitution risks:

- A bidder that uses a waiver in a given round will be exempt from losing activity in that round. This allows bidders to gather demand information or wait before making key decisions. Waivers can also help manage substitution risk by allowing bidders who wish to switch to a different combination of lots but are stuck with some standing high bids to wait to see if they are outbid on their standing high bids, so that they can switch to a new aggregation in one go. Typically, bidders are allowed to submit a limited number of waivers throughout the auction, but not in the first round.
- Allowing bidders to withdraw standing high bids is also aimed at mitigating risks faced by bidders. A bidder stuck with standing high bids it does not want can withdraw them in order to switch to a different aggregation of lots. However, there is a downside to allowing withdrawals in that they may also facilitate gaming by allowing bidders to withdraw strategic bids on lots they do not wish to acquire. Allowing withdrawals only under particular circumstances and/or making them subject to penalties can still help to avoid undesirable outcomes (as bidders may be willing to incur the cost of withdrawal to avoid such outcomes); however, restrictions and penalties should be sufficiently harsh to discourage bidders from strategically bidding on lots they do not wish to acquire.

As in the clock auction, the activity rules in the SMRA would prevent a bidder from increasing its activity as the auction progresses. However, the SMRA differs slightly in that a bidder's activity needs to take into account standing high bids, withdrawals and waivers. As in the other auction formats discussed above.

- total demand (activity) would be measured in eligibility points;
- bidders have an eligibility level for each round, which determines the bidder's maximum activity in the round (the activity of a bidder cannot exceed its eligibility level); and
- bidders' eligibility levels are adjusted downwards as the auction progresses if they reduce their activity – each bidder starts with an initial eligibility level, and after the first round the bidder's eligibility level would be set to its activity in the most recent round in which the bidder did not submit a waiver.

In the SMRA the activity of a bidder in a round is calculated as:

- the sum of the eligibility points of lots in that round for which the bidder holds the standing high bid at the start of the round

and for which the bidder does not withdraw or raise its bid during the round; plus
- the sum of the eligibility points of lots in that time slice for which the bidder submits a new bid in the round.

Another potential adaptation to the standard SMRA is to adopt a 'staged activity requirement'. The activity requirement establishes the threshold that triggers an eligibility adjustment, and the impact of any such adjustment. It is expressed as a percentage between 0% and 100% and is typically increased during the auction in a number of steps, ending at or close to 100%. An activity requirement of X% means that a bidder's eligibility will only be adjusted downwards if its activity falls below X% of its eligibility; in this case, the adjusted eligibility level will be set to the bidder's activity level divided by X%. The conditions for the auction to end would then typically require that the highest activity requirement level had been reached, so that all bidders had an opportunity to express their maximum demand. For this proposed award, a staged activity requirement would need to apply separately to each time slice.

The motivation for a variable activity requirement is to allow bidders to first explore demand conditions for some key lots that are likely to be highly competed for, before having to bid for other, complementary lots for which they might be less competition. This allows bidders to avoid becoming a standing high bidder on weakly contested lots before they are reasonably confident of winning more strongly competed key lots. However, a staged activity requirement could also provide opportunities for bidders to withhold their demand for key lots or bid strategically for non-target lots in the early stages of the auction. This may mean that bids are not especially meaningful until the activity requirement is increased (possibly until it reaches 100%), somewhat defeating the purpose of the staged activity requirement. In this case, the staged activity requirement will have limited benefits, and simply increase the risk that some bidders might game the auction.

## Guarantees offered to bidders

The SMRA exposes bidders seeking multiple lots to aggregation and substitution risks.

In an SMRA, bidders have full visibility of the price they will have to pay in the event that their bid is selected as a winning bid. This eliminates uncertainty about prices and the challenges faced by budget-constrained bidders and governance issues for bidders whose valuations might be materially above likely end prices. However, bidders seeking multiple lots and holding some standing high bids cannot be assured of the price they may have to pay for complementary lots. Therefore, bidders may need to make their bid decisions on the basis of expectations over final auction prices.

## Guarantees offered to the auctioneer

The SMRA offers the guarantee that provided any bids are received for a given lot, then the lot will sell unless the standing high bid on the lot is withdrawn (which may be subject to a financial penalty).

However, if there are complementarities across lots, the SMRA provides no guarantee that the lots will be assigned to bidders who value them, or at a price that is profitable for the bidder.

The SMRA also provides incentives for bidders to withhold their demand in order to bring the auction to an end at low prices, so the auctioneer has no guarantee that it will be able to assign the lots to those bidders who value them most, as it may not have the necessary information to assess this.

## Gaming opportunities

The SMRA is vulnerable to a range of gaming strategies, especially when bidding is for multiple lots across various lot categories. These include, for example, price-driving in non-target categories, hiding demand in the early stages of the auction, strategic demand reduction, predatory bidding or signalling to orchestrate a tacitly collusive outcome.

Since bids in the SMRA are not binding (unless they become a standing high bid), it is possible for bidders to bid for lots in categories they do not want simply to drive up the prices for competitors before switching into lot categories they do wish to acquire. This may, for example, be with the aim of reducing the competition they face in the auction for their target lots by limiting the budget available to competitors for bidding on those categories, or it could be a strategy designed to hurt competitors financially in order to hinder their ability to compete in the downstream market.

As with the clock auction, the SMRA also provide strong incentives for strategic demand reduction, a natural consequence of the property that prices can only increase as the auction progresses. Since winning bidders pay the amount of their winning bids, there may be a benefit from curtailing demand to acquire fewer lots than optimal (at the prevailing round prices) in exchange for ensuring lower overall prices. The lower the reserve prices, the stronger these incentives are as the gains from avoiding competition are greater.

For similar reasons, bidders can benefit from accommodating competitors or orchestrating a tacitly collusive outcome in which they share the lots available. The possibilities for bidders to indicate potential sharing outcomes and their intentions to competitors are greater in an SMRA than in a clock auction, as bidders may be able to send signals by bidding on specific combinations of lots, engaging in forms of predatory bidding ("*if you bid on my regions, I'll bid on*

*yours*"), or creating price differences between lots. These strategies are not simply a theoretical possibility, but have been seen in practice (for example, in some US SMRAs with regional structures).

Adopting a restricted information policy can somewhat mitigate the risks of signalling and strategic demand reduction. However, bidders will still have an incentive to unilaterally withhold their demand to dampen competition in the auction. Furthermore, bidders in an SMRA may still be able to make significant inferences about their competitors' bidding behaviour, especially if they have already made some (informed) assumptions about other bidders' likely demand. This introduces the risk that some bidders could base their strategies on the assumed behaviour of competitors, which might in fact prove wrong.

## Complications

As in the clock auction (but unlike in the CCA and CMRA), bidders who reduce their eligibility will be unable to submit any further bids that would involve an activity level greater than its current eligibility level. Therefore, attributing different eligibility points to different lots can create barriers to switching by making switching between certain packages irreversible. In the SMRA, this will be further complicated by standing high bids, which could further restrict bidders' ability to switch back and forth between substitutable packages as prices develop.

Another complication arises when there are many lots, in that the price for each lot will only increase when a new bid on the lot is received. When there is only little excess demand, this means that many rounds may be needed before the price of all identical lots increase to a new level. This makes the SMRA unreasonably slow when there are many lots available, as can be seen from recent awards that adopted the SMRA auction format.

## Overall assessment

The SMRA was the most prevalent auction format in early spectrum awards, and it is still used today. In fact, the SMRA can be suitable for simple awards in which a small number of substitutable lots are offered and in which bidders can acquire at most one lot (i.e. there are no aggregation risks or switching impediments). However, it has significant deficiencies and limitations for awards with many lots, especially if bidders have flexibility with respect to the number of lots they acquire and are subject to aggregation risks. In particular, the SMRA can expose bidders to excessive and unnecessary aggregation and substitution risks.

The SMRA is often proposed by some potential bidders, on the grounds that its simplicity encourages participation and reduces complexity. However, arguments in favour of the SMRA are highly dependent on market conditions. It is a general property that the SMRA reduces incentives to compete for additional lots when bidders can acquire multiple lots. This may lead to weaker competition and price reductions for bidders, but at the expense of increasing the risk of an inefficient outcome.

Concerns about tacit collusion in scenarios of limited competition can be mitigated by setting reserve prices as close as possible to the expected final auction prices and limiting transparency. Such reserve prices may also reduce the incentives to engage in gaming more generally. However, setting higher reserve prices entails a greater risk of regulatory failure due to choking off demand and creating inefficiently unsold lots. In practice, uncertainty about the likely competitive price limits the degree to which reserve prices can be used in this way.

For this proposed award, concerns about aggregation and substitution risks are of particular relevance. Offering the spectrum in small frequency blocks means that bidders will typically need to bid for several blocks (within a band) without guarantee that they will win the bandwidth they require to make efficient use of the spectrum. We expect that at least some bidders will also need to acquire spectrum covering a range of the available frequency bands and across both of the proposed time slices. Aggregation risk relating to bandwidth could be mitigated by offering the spectrum in larger blocks, but this would reduce the flexibility of the process in determining the number of users and their share of spectrum on the basis of demand. Aggregation risk due to requiring a combination of lots across multiple bands and time slices would be even harder to address, as bidders must be able to distinguish between which band(s) and which time slices they are bidding for. There would seem to be very little that could be done to reduce the risks, short of offering very specific pre-defined packages and allowing bidders to acquire just one of those packages. However, that approach would be entirely impractical as it would remove the majority of the benefits of using a market mechanism to determine the efficient outcome, and would require ComReg to form a view as to how best to define the packages to offer, which it would not have the relevant knowledge to do effectively.

Having a large number of substitutable lots (as would be the case in this auction, in particular with regards to the higher frequency bands) also has practical implications, in that increasing prices for all substitutable lots in an the SMRA when there is little excess demand can require many rounds, and it can take a very long time to reach market clearing prices. This contrasts with the other formats, in which round prices for all lots within a lot category are increased at once, so incrementing the price for substitutable lots happens much

faster. Therefore, a clock-based bid collection process in which the auctioneer announces a price for each lot category (rather than for individual lots) and bidders specify the number of lots they would wish to acquire in each category is more able to cope with large number of identical lots.

Table 10 provides a summary of key advantages and limitation of the SMRA auction, relative to the CCA, for this proposed award.

*Table 10: Advantages and disadvantages of the SMRA relative to the CCA*

| **Key advantages relative to the CCA** | **Key limitations relative to the CCA** |
|---|---|
| • There is a low risk of unsold lots, as a provisional winner can be assigned as soon as any bids are received on a lot (although such lots might not be efficiently assigned).<br>• The bidding mechanics are simple and the outcome is easy to verify. | • Bidders seeking multiple lots face aggregation risk.<br>• Bidders seeking multiple lots are subject to substitution risk – bidders may not be able to switch aggregations if they are 'stuck' with standing high bids on some lots (or doing so may involve costs if there are penalties for withdrawing bids).<br>• Strategic complexity is much greater if bidders have complementarities across lot categories.<br>• Differences between the eligibility points for different lot categories can further increase substitution risk, as bidders may not have sufficient eligibility to switch to relatively cheaper options once they have reduced their demand.<br>• There are significant incentives for strategic demand reduction and tacit collusion.<br>• May be very slow given that the are many lots available, leading to a very long and costly auction process. |

Given the likely strong complementarities between lots for at least some bidders, an SMRA seems inappropriate for the current award due to the extent to which it exposes bidders to aggregation and substitution risks. Using an SMRA might also require adopting strong measures to reduce the scope for gaming, such as a highly restricted information policy, limits to switching across categories, and high reserve prices. These measures require administrative decisions based on assumptions on the nature and structure of demand; as such, adopting an SMRA would entail a greater risk of regulatory failure in making these decisions.

Overall we do not consider the SMRA to be suitable for this proposed award.

## A.2 Simple clock auction

The clock auction represents way of simplifying the auction process relative to using a CCA by retaining the clock phase but dropping the supplementary bids round. The clock auction has an open stage, which mitigates uncertainty about final prices and the outcome as the auction progresses, and supports package bidding (as the auction will not close unless each bidder can be assigned the lots it bids for at prevailing round prices).

However, a clock auction does not provide bidders with an opportunity to bid for multiple alternative packages, and thus does not fully suppress substitution risk. In particular, switching between different categories of lots may be inhibited by the activity rules. The clock auction also has limitations arising from its pricing rule, which increases the risk of lots going inefficiently unsold, and is vulnerable to gaming, which might further compromise efficiency. It may be possible to somewhat mitigate these problems through restrictions on bidding behaviour. However, these may not be reasonable when we are uncertain about the potential requirements from different bidders. The risk of inefficiently unsold lots is avoided through the use of the combinatorial auctions that do not impose linear pricing.

### Basic structure

In a clock auction, multiple items are grouped in categories of identical lots. The mechanics are simple: the auctioneer specifies a price per lot for each lot category, and bidders state the number of lots in each category they want at the prevailing prices. If there is excess demand, the auctioneer will increase the price for categories with excess demand and invite bidders to submit further bids. The auction ends when there is no excess demand for any lot category,

and all bidders that submitted a bid in the final round are awarded the lots they bid in that round at the final clock prices.

## Pricing

Bidders pay the final clock round price for each lot they win.

## Activity rules

The activity rules for the clock auction prevent a bidder from increasing its demand as the auction progresses. However, relative to the CCA, the bidding restrictions arising from a reduction in total demand are stronger.

As for the CCA, the activity rules would be applied separately for each time slice. Each lot would have an associated number of eligibility points, set to reflect an allowed rate of switching between different lot categories, and a bidder's 'activity' in a round for a particular time slice would be defined as the sum of the eligibility points associated with the lots bid for in that time slice.

Then, for a given time slice:

- each bidder would have an 'eligibility level', which determines its maximum demand (activity) for lots in that time slice;
- in the first round, each bidder starts with an 'initial eligibility level', determined (for example, with reference to its demand on application or its deposit guarantee), and after the first round the bidder's eligibility level would be set to its activity in the previous round; and
- in any round, the total activity of a bidder cannot exceed its eligibility level.

## Guarantees offered to bidders

As with the CCA, the clock auction suppresses aggregation risk by supporting package bidding, in the sense that the auction does not end unless all bidders can be assigned all of the lots they bid for at prevailing prices. However, the clock auction will not fully suppress substitution risks, especially if there are material differences in the eligibility points assigned to different lot categories.

In the clock auction, winners pay the amounts of their winning bids; therefore pricing is much simpler than for the CCA or the sealed-bid combinatorial auction. This eliminates uncertainty about prices and the challenges faced by budget-constraint bidders. It also mitigates governance issues for bidders, in that they do not need to bid at a level that exceeds what they are likely to pay.

## Guarantees offered to the auctioneer

The clock auction offers few guarantees to the auctioneer in terms of achieving an efficient outcome. In particular, there is a significant risk that some lots would be inefficiently unsold, if the price increases applied by the auctioneer result in demand falling below supply. This is because there is a risk that demand might drop too abruptly from one round to another (e.g. if several bidders reduce demand in the same round, or if bidders reduce demand by several units in one step). Thus, in the course of one round we might go from a situation in which there is excess demand to a situation in which the auction ends with unsold lots. This risk of this can be reduced through the introduction of exit bids, however, these are likely to be unsuitable for multi-band awards where a large amount of spectrum is available for assignment.[64] Such large drops in demand may be the result of price increments being too large (referred to as 'price overshoot'), but can also arise regardless of how small the price increments are due to the structure of bidders' valuations. This can happen where a bidder's value per lot is increasing in the number of lots over some range. As a result of these increasing marginal valuations for lots, the demand of a bidder can drop by many lots at once – or the bidder might drop out altogether - as the price per lot increases slightly.

## Gaming opportunities and incentives

Clock auctions provide a clear incentive for bidders to strategically reduce demand to restrict competition in the auction and keep prices low. In particular, the use of uniform prices (i.e. all lots in a category have a common price per lot) means that competing for additional lots will drive the price that a bidder would pay even if it were ultimately to win a smaller number of lots in that category.

For instance, a bidder may be willing to pay a higher price per lot for a large package than for a small package, as a result of complementarities. However, if the large package becomes increasingly expensive the bidder would prefer to bid on the smaller package. The clock auction does not allow a bidder to submit alternative bids to express this trade-off, and the bidder will need to choose what package to bid for on the basis of expectations over likely prices. Indeed, the bidder may achieve a better outcome by reducing its demand early and acquiring the smaller package but at a lower price per lot. This can create a strong incentive for bidders to settle for a smaller number of lots at a lower price, rather than compete for a greater number of lots, possibly unsuccessfully.

[64] See footnote 11, Document 18/92a.

These incentives for strategic demand reduction are accentuated when bidders have information about aggregate demand, which allows them to assess whether they could bring the auction to a close with a unilateral reduction in demand. This further increases the risk of unsold lots, as several bidders might reduce their demand to this end at the same time.

Another vulnerability of the clock auction arises from the fact that a bidder will only need to honour its final round bid. Bids submitted in a round are discarded if a further round is required, which provides flexibility for bidders to switch between lot categories to manipulate prices when they are reasonably confident that the auction will not end. This is a serious concern in the context of a multi-band award, as a bidder can be reasonably sure that the auction will not close if there is high excess demand for any single one of the lot categories. This could allow a bidder to bid for certain lot categories simply to raise the cost for competitors, possibly motivated by a desire to reduce their residual budget for lots in categories for which the bidder does have an interest. Price-driving may also increase the risk of unsold lots and could be used to sterilise some of the available spectrum i.e. a bidder might be able to drive prices beyond a certain level in a given category, and then withdraw its demand so that lots remain unsold.

## Complications

An important limitation of the clock auction with multiple categories is that switching could be highly restricted by the eligibility points used for each lot category. In the clock auction, a bidder that reduces its eligibility will be unable to submit any further bids that would involve an activity level greater than its new eligibility level. This can lead to substitution risk when lots have different eligibility levels, and/or the number of lots required differs across lot categories. For instance, suppose a bidder is interested in acquiring either 50 MHz of TDD spectrum in band A, or 2x20 MHz of FDD spectrum in band B, and is indifferent between the two packages. Suppose also that lots in each band are assigned one eligibility point per 5 MHz block; so 50 MHz in band A has an activity level of 10, and 2x20 MHz in band B has an activity level of 8. If the bidder begins the auction by bidding for the band A spectrum, but the price of band A lots increases relative to the price if band B, the bidder could switch its demand to instead bid for 2x20 MHz in band B. However, this would represent a reduction in demand and the bidder's eligibility for future rounds. If the price of band B then increased relative to the price of band A, the bidder would not be able to switch its demand back to the band A spectrum, even if the change in prices means that it would wish to do so.

Note that this sort of switching impediment is not a problem with the CCA. In a CCA the eligibility points only determine when

constraints on further bids arise; however, bidders are still able to bid for packages that require greater eligibility than that available to the bidder when they become relatively cheaper than in the round in which the bidder reduced eligibility. Conversely, eligibility reductions in a clock auction will simply remove bid options to bidders, as bidders are unable to bid for packages requiring greater eligibility than the bidder's level, regardless of relative prices.

## Overall assessment

The clock auction is much simpler than the CCA in terms of bidding mechanics and the process for determining winners and prices. However, the clock auction involves a substantial risk of unsold lots, especially when there are complementarities across lots. There are extensions to the basic clock auction format that can be implemented to help mitigate this risk, such as the use of exit bids and/or a combinatorial closing rule.

Exit bids can be made when a bidder drops demand; they specify a price (required to be between the round price in the preceding round and the current round price) at which the bidder would be prepared to buy the lots it no longer demands at the current round price. If there are unsold lots at final round prices, these exit bids can be taken into account and may help to achieve a more efficient outcome. However, the extent to which bidders can fully express demand for packages of interest is limited, in particular if there is a large number of alternative packages to bid for and/or bidders have increasing marginal values for additional lots.

A combinatorial closing rule allows all bids (including exit bids) made in earlier rounds to be taken into account when determining winners to find the value maximising combination of bids, taking at most one from each bidder, subject to the number of allocated lots not exceeding supply. This can help to rectify inefficiencies that could otherwise result from one or more bidders having increasing marginal valuations (as it allows for bidders to win larger packages at a price below final clock prices if it fits with the demand from other bidders). However, the impact is likely to be small where there is a large number of alternative packages and bidders are limited in the extent to which they can express demand for the different options, and the CCA provides much better scope for establishing the efficient distribution of lots amongst bidders.

In addition, the clock auction creates strong incentives for strategic demand reduction. Setting prices close to expected clearing prices could reduce the potential benefits from engaging in such behaviour, but this may also increase the risk of choking off demand. Withholding information about aggregate demand might help to moderate the risk of strategic demand reduction by preventing bidders from assessing when they may be able to bring the auction

to an end unilaterally. However, this would significantly limit the benefits from having an open stage.

A clock auction also offers price driving opportunities when bidders can switch between lot categories, as it allows bidders to bid for lot categories it does not want simply to increase the price for competitors. The scope for price-driving can be limited by restricting the extent to which bidders are allowed to switch between lot categories. However, this may be an unreasonable restriction unless we can confidently rule out the possibility that bidders might genuinely consider lots in different bands substitutable (which we cannot do for this particular award).

Table 11 provides a summary of key advantages and limitations of the clock auction, relative to the CCA, for this proposed award.

*Table 11: Advantages and disadvantages of the clock auction relative to the CCA*

| **Key advantages relative to the CCA** | **Key limitations relative to the CCA** |
|---|---|
| • Bidding mechanics are simple and the outcome is easy to verify.<br>• No uncertainty about the final prices at the end of the clock stage.<br>• No governance issues relating to bidding above expected end prices. | • Bidders can be exposed to substitution risk.<br>• High risk of inefficiently unsold lots.<br>• Significant scope for driving prices in non-target lot categories.<br>• Strong incentives for strategic demand reduction. |

The clock auction is unlikely to be a good option for this proposed award, especially if there is scope for substitutability between licences in different bands, which we would expect. Limiting the opportunities for gaming the auction would require:

- setting reserve prices close to expected final prices;
- potentially restricting switching across lot categories; and
- adopting a highly restrictive information policy.

However, these measures would reduce the benefits from adopting an open auction format, as they limit the information available to bidders, the extent to which bidders can adjust their strategy in light of this information, and the extent to which final prices are determined by actual (rather than expected) demand.

Overall, we do not recommend the use of a simple clock auction for this proposed award.

# A.3 Sealed-bid combinatorial auction (SBCA)

The SBCA calculates the winning outcome on the basis of bids received in a single round. As in the CCA, each bidder can bid for multiple alternative, mutually exclusive packages. However, the SBCA omits the open stage, and thus does not feedback information to bidders to assist them in assessing the demand from competitors and likely end prices.

The SBCA maintains many of the desirable properties of the CCA – namely the elimination of bidder aggregation and substitution risks, and the fact that bidders who deviate from valuations face the risk of an undesirable outcome, which provides good incentives for straightforward bidding. However, it also retains some of its disadvantages, namely the perceived complexity of the mechanism used for determining winners and prices, the challenges faced by bidders operating under a budget constraint and governance issues for those bidders with valuations materially above likely prices.

Omitting the open stage relative to the CCA has the advantage that the process is greatly simplified, in terms of bidding mechanics, implementation and time required to complete the award process. In particular, a sealed-bid auction does not require activity rules, and thus avoids impediments to switching and the need to anticipate the consequence of bids in limiting subsequent bidding options. However, the absence of an open stage means that bidders must make their final set of bids without having an opportunity to mitigate their initial uncertainty about the final outcome and which bids might be compatible with the demand of others.

This is a particular problem in this proposed award as the large number of available lots means there are many possible packages and it would likely be necessary to limit the number of distinct packages that bidders can bid for to manage computational complexity. Without the benefit of an open stage it may be difficult for a bidder to know which packages are more likely to be compatible with the demand of others and which it therefore would stand a good chance of winning. In a SBCA, a bidder might fail to win anything simply because every one of its package bids conflicts with a winning bid of another bidder when it could have been awarded a package that it did not submit a bid for.

## Basic structure

In a SBCA, bidders are given one single opportunity to submit bids. Bidders specify the alternative packages they wish to bid for, and the bid amount for each of these packages. A bidder's bids are mutually exclusive, with at most one of these winning. As there is only one

round there is no need for activity rules or feeding back of round-by-round auction progress information to bidders.

The winning bids are selected so that the total value of bids accepted is the greatest possible given the supply of lots. This optimisation process is the same as that used for the CCA.

## Pricing

The SBCA can be used with a first-price rule (bidders pay the full amount of their bid) or opportunity cost pricing (identical to that used in the CCA).

A first-price may have some advantages when bidders are highly asymmetric and competition in the auction is limited, in that it may encourage participation from weaker bidders if information about bidders is not disclosed. However, the first-price rule increases strategic complexity in that a bidder's bid determines its own price and expected surplus, and thus bidders have an incentive to reduce their bids to the minimum they expect to be needed to stand a good chance of winning. As a consequence, the winning outcome depends on bidders' expectations about the strength of competition, which might turn out to be wrong and so lead to an inefficient assignment.

Conversely, under opportunity-cost pricing, bidders' decisions should be fairly simple provided that they have sufficient budget to bid in a way that reflects their actual demand profile. In particular, it is not necessary to second-guess what competition might be faced from other bidders, unlike with a first-price auction. In such situations, an opportunity-cost pricing is likely to promote efficiency.

## Activity rules

The SBCA does not feature an open stage, and thus does not require activity rules.

## Guarantees offered to bidders

The SBCA retains some of the key guarantees to bidders provided by the CCA, namely:

- it suppresses aggregation risks by supporting package bidding;
- it suppresses substitution risks by allowing bidders to bid for alternative, mutually exclusive packages with a guarantee that the winner determination mechanism will select that which would provide the greatest surplus to the bidder; and
- bidding above valuation does not increase the chances of winning at a price below valuation.

However, the SBCA does not offer any indication of the maximum price that a bidder may need to pay for a given price (which is provided in the CCA after the final clock round).

## Guarantees offered to the auctioneer

As in the CCA, the SBCA guarantees an efficient assignment of lots provided that each bidder submits a set of bids that reflects its full demand profile. However, as discussed above it is possible that where there are restrictions on the number of packages that may be submitted (to manage computational complexity) bidders may fail to bid on packages that can mesh with other bidders' packages and so fail to win; this might result in inefficient outcomes in complex auctions with many packages.

## Gaming opportunities and incentives

Gaming opportunities in a SBCA are limited. Lack of information about competitors' behaviours is a strong destabilising factor against collusion. Furthermore, as there is just one round, there is no possibility of dynamic strategies for signalling or adapting to competitors' behaviour. As a result, the SBCA is robust against strategies such as strategic demand reduction, predatory bidding played out over rounds or tacit collusion.

As in the CCA, it is possible that some bidders may try to submit bids that are not reflective of their demand and are simply aimed at increasing competitors' prices. However, these strategies are highly risky when there is limited information about other bidders and their willingness to pay, as they may lead to the bidder winning a less preferred package, possibly at a price above valuation.

## Complications

The SBCA can be subject to similar complications as the CCA, in terms of challenges faced by budget-constrained bidders, governance issues and potential misunderstandings of the rules. Relative to the CCA, the problems faced by budget-constrained bidders and governance issues are significantly worse. This is because bidders are not given any information about the demand from competitors, and therefore must make final decisions on their bids purely on the basis of their prior expectations.

A SBCA may be particularly complicated for bidders in the context of this proposed award where there is a relatively large number of lots available, especially if it is necessary to restrict the total number of packages that each bidder can bid for. This is because if bidders

cannot submit bids for all the packages they may possibly be interested in, then they will need to select a subset of those packages to bid for. Unlike in a CCA, bidders would need to make this selection without the additional information provided by an open stage about the potential conflicts with demand from competitors. The CCA allows bidders to assess conflicts (within a particular band, for example) during the clock rounds, which may prompt bidders to offer flexibility to contract demand in contended lot categories or switch demand to another category in their supplementary bids. Conversely, bidders in a SBCA will not benefit from this information, and might omit some key packages that could fit around the demand of their competitors. This leads to an increased risk of an inefficient assignment in the event that bidders fail to identify relevant packages.

## Overall assessment

A clear advantage of using a sealed-bid process over the CCA is that it is easier and faster to implement and run, and the award can therefore be concluded to a firm timetable. Using a single-round also simplifies the auction rules and mechanics greatly, and with this the work potentially required by bidders in preparing for the auction. Multi-round open auction formats aim to reveal information about relative demand and prices for different lot categories; however, this requires bidders to assess their preferred option at round prices and consider the implications that switching or reducing demand might have on their possibilities for bidding in subsequent rounds. This typically requires greater preparation from bidders (often involving practical training programmes based on simulations of the bidding process), who may will need to be able to consider their bids in a relatively tight round timeframe to avoid ending up in a situation in which they cannot submit the bids they would want. Conversely, bidding in sealed-bid process only requires bidders to carefully set out their bids once, without bidding constraints that would apply to bid submission in a round of an open auction. In this sense, the SBCA entails a relatively lower risk of errors arising from a misunderstanding of the auction rules, as bidders will not need to worry about the implications of clock bids on their ability to submit their final set of bids.

The benefits from simplifying the bid submission would appear to increase with the number of lots and lot categories. Once bidders who wish to acquire licences in several lot categories have identified all their alternative target packages, filling in the bids for a sealed-bid process should be relatively easy. However, such a simplification will not be achieved if bidders need to be restricted in relation to the total number of packages they can bid for, which is likely to be necessary when using many lots/lot categories in order to control computational complexity in determining winners and prices. In this

case, bidders could face a high degree of uncertainty when selecting the packages they bid for.

Obtaining information from demand in different lot categories may be key when there are multiple substitutable bands available in the award, especially if there were need to constrain the total number of packages that each bidder can bid for. In this context, an open stage can assist bidders in identifying the packages for which to bid. This is important if the number of packages a bidder can bid for is materially smaller than the total number of theoretically possible packages. Therefore, a sealed bid auction may not be appropriate if there is a large number of available packages, as will be the case for this proposed award.

Another drawback of sealed-bid processes is that some bidders may feel uncomfortable about not being able to revise their bids in the event of an unfavourable outcome, and might have regrets 'after the event'. This could especially affect bidders who have a tight budget and cannot bid up to their valuation, who may need to choose between alternative targets or may wish to revise their budget if they face stronger competition than anticipated. More generally, this can affect all bidders if they are subject to common value uncertainty. Nevertheless, we should not overstate these problems, as even in an open auction, the degree to which common value uncertainty is mitigated may be limited when there is a mix of bidders using different technologies and business plans that makes it difficult to draw inferences from others' bidding behaviour for one's own valuations.

**Table 6** provides a summary of key advantages and limitation of the sealed-bid, combinatorial auction, relative to the CCA, for this proposed award.

*Table 12: Advantages and disadvantages of the SBCA relative to the CCA*

| **Key advantages relative to the CCA** | **Key limitations relative to the CCA** |
|---|---|
| • Much simpler rules, as no activity rules are required<br>• Faster process<br>• Less preparation required<br>• Not possible for bidders to attempt dynamic strategies aimed at gaming the process regardless of whether such strategies could have an impact or not.<br>• Incentives to submit price-driving bids further reduced by lack of | • Common value uncertainty is not addressed<br>• No guidance about which packages might be more relevant to bid for because they might be potentially winning<br>• Strategically complex for bidders facing tight budget constraints, as the process does not provide indication of likely prices and what packages bidders may win |

| | |
|---|---|
| information about competitors' demand | before bidders need to make their final bids<br>• Governance issues for bidders with valuations materially above expected prices accentuated, as the process does not provide information for bidders to calculate the maximum price they may need to pay |

On the basis of the above, and the discussion in Section 7, we believe that the SBCA is unlikely to be suitable for this proposed award due to the likely benefits of using an auction format that has an open stage.

# Annex B Time slices – [✂REDACTED]