



An Coimisiún um
Rialáil Cumarsáide
Commission for
Communications Regulation

Proposed Multi Band Spectrum Award – Draft Information Memorandum and Draft Regulations

The 700 MHz Duplex, 2.1 GHz, 2.3 GHz and
2.6 GHz Bands

Draft Information Memorandum and Draft Regulations

Reference: ComReg 20/32

Date: 13/05/2020

An Coimisiún um Rialáil Cumarsáide

Commission for Communications Regulation

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Chapter 1

1 Introduction

- 1.1 In Document 19/124, the Commission for Communications Regulation (“ComReg”) set out its response to consultation and draft Decision on its proposed award process (“Award Process”) in respect of spectrum rights of use in the 700 MHz Duplex, 2.1 GHz, 2.3 GHz 2.6 GHz FDD and 2.6 GHz TDD bands (“Award Spectrum”)¹.
- 1.2 In Chapter 10 of Document 19/124, ComReg noted its intention to publish a draft Information Memorandum (“draft IM”) for the Award Process.
- 1.3 The purpose of this draft IM is to detail and consult on the rules and procedures ComReg intends to employ in the implementation of its substantive proposals *as currently set out in its draft Decision (Chapter 9 of Document 19/124)*. It also sets out ComReg’s proposals regarding the information policy on “Exposure Pricing” (see Section 1.3 and Section 4.2.2)².
- 1.4 This draft IM and associated materials have been prepared in light of the proposals and draft Decision noted above. ComReg welcomes and acknowledges the responses received to Document 19/124 and notes that the matters raised in respect of same will be addressed in ComReg’s forthcoming response to consultation and final Decision on the Award Process which ComReg aims to publish in Q4 2020. In that regard, and by the end of June, ComReg intends to publish non-confidential versions of submissions received to Document 19/124. At the same time, in light of certain proposals put forward in submissions to Document 19/124, ComReg intends to invite comments on same, with a view to informing, in due course, ComReg’s updated regulatory impact assessments (“RIA”s).
- 1.5 In addition, whilst this draft IM reads as if it is a finalised document, it is subject to consultation and further consideration and no final decisions have yet been made as to the content and effect of any final IM. Further, ComReg may make such minor or editorial amendments to the text of any final IM as it considers necessary and without further consultation, where such amendments do not affect the substance of the final IM.
- 1.6 ComReg has sought to provide as much clarity as possible in this draft IM regarding the envisaged rules and procedures, taking into account the

¹ ComReg Document 19/124 – *Proposed Multi Band Spectrum Award - Response to Consultation and Draft Decision on the 700 MHz Duplex, 2.1 GHz, 2.3 GHz and 2.6 GHz Bands* – published 20 December 2019.

² As indicated in paragraph 6.76 of Document 19/124.

possibility that some Interested Parties may not have participated in any previous or similar spectrum award process. Following publication of the final IM, ComReg will also facilitate the submission of questions regarding the Award Process (and Award Rules) and will respond publicly to these questions on an anonymous basis.

- 1.7 Although this draft IM is similar in layout to information memoranda employed by ComReg in previous spectrum awards, ComReg would stress that this draft IM has been prepared by reference to the specifics of the current Award Process. All prospective Applicants should therefore familiarise themselves with this draft IM in its entirety and, in particular, should not rely upon knowledge of earlier information memoranda.

1.1 Legal Framework and Agreement

- 1.8 In preparing this draft IM, ComReg has been guided by its statutory functions, objectives and duties relevant to its management of the radio frequency spectrum (see Annex 2 of Document 19/124) and its most recent Radio Spectrum Management Strategy Statement (Document 18/118³).
- 1.9 Any new rights of use for radio frequencies in the Award Spectrum will be assigned through licences granted by ComReg under Section 5 of the Wireless Telegraphy Act 1926, as amended (“the 1926 Act”). In order to grant such licences, ComReg is required to make regulations under Section 6 of the 1926 Act which would prescribe, among other things, the form and duration of the licences, the terms on which they are granted, the circumstances and manner in which they may be suspended or revoked, the fees to be paid on the granting of the licences, and the terms and conditions to be observed by holders of such licences. The making of such regulations is subject to the consent of the Minister for Communications, Climate Action and Environment⁴.
- 1.10 In that regard, Annex 2 of this draft IM contains the following two draft statutory instruments:
- the Wireless Telegraphy (Liberalised Use and Related Licences in the 700 MHz Duplex, 2.1 GHz, 2.3 GHz and 2.6 GHz Bands) Regulations 2020 (“MBSA2 Licence Regulations”). These regulations would apply to the grant of new rights of use for the Award Spectrum; and
 - the Wireless Telegraphy (Third Generation and GSM Licence) (Amendment) and Interim Licensing) Regulations 2020. These regulations would give effect to ComReg’s proposals for the liberalisation

³ ComReg Document 18/118 – *Radio Spectrum Management Strategy 2019 to 2021* – published 20 December 2018.

⁴ Section 37 of the Communications Regulation Act 2002 as amended.

of existing 2.1 GHz rights of use (see Chapter 4 of Document 19/124) and licence period alignment by way of the grant of interim 2.1 GHz rights of use to Three Ireland (Hutchison) Limited (see Annex 7 of Document 19/124).

- 1.11 In addition, Interested Parties should note the requirement to be authorised to provide an electronic communications network or service in Ireland⁵. Interested Parties can consult ComReg's website for further details⁶ and, in particular, the General Authorisation contained in Document 03/81R6⁷ which sets out the general conditions of authorisation.
- 1.12 Chapters 3, 4 and 5 of this draft IM set out important provisions relating to the Award Process to which Interested Parties must agree if they wish to participate in the Award Process and which are binding. Chapter 2 and Annex 2 (Draft Regulations) sets out information on the Award Spectrum and the terms and conditions to be attached to licences for new rights of use in respect of the Award Spectrum.
- 1.13 For the avoidance of doubt, references throughout this draft IM to ComReg exercising its discretion mean ComReg acting reasonably and in accordance with its statutory functions, objectives and duties.
- 1.14 Capitalised terms in this draft IM, unless otherwise defined, have the meanings assigned to them in Annex 1.

1.2 COVID 19: Temporary ECS licences

- 1.15 Since the publication of Document 19/124, and in response to the extraordinary situation presented by the novel coronavirus (COVID-19), ComReg has consulted upon⁸ and put in place a licensing framework⁹ (with the consent of the Minister) for the temporary assignment for an overall period of up to 6 months of:

⁵ Under Regulation 4(1) of the Authorisation Regulations, any undertaking intending to provide an electronic communications network or service shall, before doing so, notify ComReg of its intention to provide such a network or service, following which that undertaking will be deemed to be authorised under Regulation 4(4). Under Regulation 4(6) of the Authorisation Regulations, any undertaking which fails to comply with Regulation 4(1) or Regulation 4(5) (notification of any changes to the information supplied) commits an offence.

⁶ See http://www.comreg.ie/licensing_and_services/general_authorisation.551.html for further details.

⁷ See <https://www.comreg.ie/publication-download/general-authorisation-for-the-provision-of-electronic-communications-networks-and-services>

⁸ See ComReg Documents 20/21, 20/23 and 20/27 available at <https://www.comreg.ie/industry/radio-spectrum/spectrum-awards/covid-19-temporary-spectrum-management-measures>.

⁹ See the Wireless Telegraphy (Temporary Electronic Communications Services Licences) Regulations 2020 ([S.I. No. 122 of 2020](#)).

- additional spectrum rights of use in the 700 MHz Duplex and 2.6 GHz Band; and
- liberalised spectrum rights of use in the 2.1 GHz Band, as this band is otherwise currently licensed for 3G-use only.

1.16 Following applications from three MNOs, three Temporary ECS Licences were issued as detailed below.

Table 1: Temporary ECS Licences issued due to COVID-19

Licensee	Commencement Date	Expiry Date ¹⁰	Spectrum Bands
Meteor Mobile Communications Limited (“Meteor”)	9 April 2020	8 July 2020	700 MHz and 2.1 GHz bands
Three Ireland (Hutchison) Limited (“Three”)	9 April 2020	8 July 2020	700 MHz and 2.1 GHz bands
Vodafone Ireland Limited (“Vodafone”)	22 April 2020	21 July 2020	700 MHz and 2.1 GHz bands

1.17 When consulting upon this temporary spectrum licensing framework, ComReg clarified that it was intended solely to address the exceptional and extraordinary situation presented by COVID-19 and is entirely without prejudice to this Award Process.

1.3 Information Policy and Exposure Pricing

1.18 In Chapter 6 of Document 19/124, ComReg set out its preliminary view that the Combinatorial Clock Auction (“CCA”) is the auction format best suited to deliver on its objectives and address the particular considerations arising in the proposed Award Process.

¹⁰ Under the 2020 Temporary ECS Licence Regulations, Licences were granted for an initial period of 3 months, with the potential for a renewal of up to a further 3 months, with the renewed rights of use expiring no later than 6 months from the date of the Regulations (i.e. on 7 October 2020 or earlier)

- 1.19 Concerns had been expressed by some Interested Parties that the CCA lacks transparency and creates a governance challenge¹¹ for some bidders. However, in light of its experience and the successful use of CCAs in recent awards, ComReg considered such concerns to be relatively minor and manageable. ComReg noted that this is especially the case under the more recent activity rules¹².
- 1.20 Notwithstanding, ComReg acknowledged that it was exploring whether additional information could be provided to Bidders in terms of the maximum price a Bidder would have to pay if a Primary Bid went on eventually to win. In particular, ComReg noted that:
- *“it is currently working on whether additional information can be provided over the course of clock rounds to assist bidders in assessing the financial exposure resulting from their bids. If ComReg decides to provide such further information, this will be set out as part of ComReg’s information policy during the award (i.e. Information Memorandum)”¹³; and*
 - *“[f]or the avoidance of doubt, however, ComReg does not make any promise or guarantee that changes to the information policy will be made as a result”¹⁴.*
- 1.21 ComReg commissioned DotEcon to consider and advise on whether additional information could be provided to Bidders in the course of a CCA in terms of the final price a Bidder would have to actually pay arising from Bids made in the clock rounds (“Exposure Pricing”).
- 1.22 DotEcon’s findings are set out in a report provided in Annex 12 of this document. In summary, in relation to Exposure Pricing, DotEcon:
- i. proposes that an Exposure Pricing mechanism should take the form of Bidders being presented with a Discount that is specific to each Bidder which would be applied to the clock prices of any package;

¹¹ The decision process where bid teams within bidding firms need to seek approval from management and shareholders for their budget and bid strategy and the firm may have to seek funds on financial markets, for either auction expenditures or further activity, may generate inefficiencies and practical difficulties.

¹² In particular, the use of “relaxed primary bids” and the “final price cap” in more recent awards (e.g. 2012 MBSA, 3.6 GHz award) addressed such concerns by allowing certain bids to be made in the clock stage that would previously need to have been made in the supplementary stage. Consequently, clock prices in those awards were better predictors of what the successful bidders would have to pay as the outcome of the clock rounds were more aligned with the award outcome.

¹³ Document 19/124, p127.

¹⁴ Ibid, p,137.

- ii. concludes from the simulations (using both real bid data and 5,000 random auction scenarios) that Exposure Pricing is feasible and would provide additional information to Bidders about the maximum they might pay if the clock Rounds stopped and the auction moved to the Supplementary Bids Round (on the assumption that no Lots were unallocated in the final clock round); and
- iii. concludes that Exposure Pricing would not risk distorting the outcome of the Award Process. In particular, if Bidder-specific Discounts are provided as additional information, it is very unlikely that this could be used to facilitate gaming, as information is highly aggregated and does not allow Bidders' Bid histories to be inferred.

1.23 DotEcon proposes that this information would be provided as part of the information policy for this Award Process on the basis that each Bidder would only be informed of its own Bidder-specific Discounts and would not be provided with information about the Discounts applicable to any other Bidder. This is purely additional information being provided to the Bidder about what it would pay at most for a particular package if the clock rounds stopped now with no excess demand and it won that package. Further, if a Bidder makes a Bid for a package in a clock round where there is a positive Discount, no guarantee is being made that the Bidder will enjoy this Discount in full (i.e. pay at most the current clock price less the Discount), as the clock rounds could continue (and the Discount change) or the clock rounds could end with excess supply.

1.24 In light of the detailed literature review and the proof of concept provided by the auction simulations, ComReg is of the preliminary view that an Exposure Pricing mechanism in the above form would provide additional helpful information to Bidders and reduce the internal governance challenges without the risk of distorting the outcome of the Award Process. ComReg therefore proposes to provide this additional information to Bidders during the Main Stage of the Award Process.

1.25 ComReg also proposes that, in order to ensure Bidders have full confidence in the implementation of Exposure Pricing:

- a programme of tests independent from the auctioneer and ComReg's advisors, DotEcon, would be conducted as part of the Award Process in order to ensure that Exposure Pricing operated in line with the methodology provided in this draft IM; and
- ComReg's detailed Bidder training programme, including the use of mock

auctions¹⁵ and the Bidder playgrounds¹⁶ would allow Bidders to simulate auction scenarios using the Exposure Pricing functionality in order to ensure such Bidders are fully comfortable and familiar with Exposure Pricing.

- 1.26 For the avoidance of doubt, this is not a replacement for any feature previously provided, and Aggregate Demand information would continue to be provided to all Bidders. Bidders will also receive the same information about Aggregate Demand in the final Primary Bid Round as in any other Primary Bid Round. As a result, Bidders will be able to assess whether there are unassigned Lots that could potentially affect the final outcome of the auction, depending on what Supplementary Bids are made. This information should assist Bidders in formulating their Supplementary Bids.
- 1.27 As explained in Annex 7, in some cases it may be possible for a Bidder to secure its Final Primary Package by increasing its final Primary Bid by an amount equal to the total price of unallocated Lots in the final clock round, less the total price of those Lots at Reserve Prices, plus an increment. In some circumstances, this may allow a Bidder to secure its Final Primary Package without having to Bid the full amount of its valuation for that package. The EAS will assist Bidders in performing these calculations by also reporting the value of any unsold Lots in the final Primary Bid Round at final Primary Bid Round prices and at Reserve Prices. Interested Parties should refer to Annex 7 for further information on such bids and the cautionary remarks on same.
- 1.28 Finally, Interested Parties are reminded that ComReg considers the concerns raised in relation to transparency to be relatively minor and manageable. The inclusion or otherwise of an Exposure Pricing mechanism relates to the proposed information policy of this draft IM rather than the proposed award format. Therefore, and for the avoidance of doubt, ComReg's preliminary views on the proposed award format would remain the same absent any inclusion of Exposure Pricing functionality.
- 1.29 Interested Parties are invited to comment on the DotEcon Report (contained in Annex 12) and Section 4.2.2 of this Document. ComReg will make a final determination on whether to include an Exposure Pricing mechanism following an assessment of all information provided by respondents and any other advice it may receive.

¹⁵ ComReg provides a mock auction scenario for each Bidder, where the various features and Auction Rules are illustrated.

¹⁶ This allows Bidders access to the Electronic Auction System where it can create its own auction simulations including the number of Bidders and associated Bids in advance of the commencement of the auction.

1.4 Structure of Information Memorandum

1.30 The remainder of this draft IM is structured as follows:

- **Chapter 2** details the Award Spectrum, the Lots included in the Award Process, and the terms and conditions of the various Licences that may be awarded as a result of the Award Process;
- **Chapter 3** details the various stages of the Award Process and the timelines for the Award Process;
- **Chapter 4** details the Auction Rules;
- **Chapter 5** provides additional details on the legal terms and conditions that are applicable to this Award Process;
- Annexes:
 - Annex 1:** Glossary;
 - Annex 2:** Draft Statutory Instruments;
 - Annex 3:** Application Form for participation in the Award Process;
 - Annex 4:** Rollout and Coverage – Specific Locations;
 - Annex 5:** Worked Example of Activity Rules for the Primary Bid Rounds and Caps on Supplementary Bids;
 - Annex 6:** Example of Winner and Price Determination;
 - Annex 7:** Implications of the Final Price Cap;
 - Annex 8:** Relationships, resolution of Bidder connections, exemptions and changes;
 - Annex 9:** Methodology for generating Assignment Options;
 - Annex 10:** Determination of Winning Bids and Base Prices in the Main Stage;
 - Annex 11:** Relative Caps in the Primary Bid Rounds;
 - Annex 12:** A DotEcon Report on Exposure Pricing;
 - Annex 13:** Worked examples of Exposure Pricing; and

Annex 14: Relocation rebate

- 1.31 In the event of receiving correspondence on matters relating to this document, including Exposure Pricing, and to the Award Process in general, ComReg hereby gives notice that it will publish all material correspondence received in this regard subject to the provisions of its guidelines on the treatment of confidential information¹⁷.

1.5 Next Steps and Submissions

- 1.32 A six week period is being provided to Interested Parties for the submission of comments on this draft IM, with a deadline of **12:00 hours on Wednesday 24 June 2020**. Considering the complexity of material contained in this document, and the current Government's measures regarding COVID-19 which may make the mobilisation of resources challenging at this time, ComReg has given an additional two weeks over the normal four weeks identified in ComReg's Consultation Procedures¹⁸. Responses must be submitted in written form and sent to the below email address for the attention of Mr. Joseph Coughlan and clearly marked – **Submissions to ComReg Document 20/32**:

Email: marketframeworkconsult@comreg.ie

- 1.33 ComReg requests that electronic submissions be submitted in an unprotected format so that they can be redacted (if required) and included in a ComReg submissions document for electronic publication.
- 1.34 In order to promote openness and transparency, ComReg will publish all respondents' submissions to this consultation, as well as all substantive correspondence on matters relating to this document and consultation process. However, ComReg appreciates that respondents may wish to provide confidential information if their comments are to be meaningful, so publication of such documents will be subject to the provisions of ComReg's guidelines on the treatment of confidential information (Document 05/24¹⁹).
- 1.35 Respondents should submit views in accordance with the instructions set out below. When submitting a response to this consultation that it considers contains confidential information, a respondent must choose one of the following options:

¹⁷ See ComReg Document 05/24 – *Guidelines on the treatment of confidential information* – published 23 March 2005.

¹⁸ ComReg Document 11/34 - *Information Notice on ComReg Consultation Procedures* – published 6 May 2011.

¹⁹ ComReg Document 05/24 – *Guidelines on the treatment of confidential information* – published 23 March 2005.

- A. Submit both a non-confidential version and a confidential version of the response. The confidential version must have all confidential information clearly marked and highlighted in accordance with the instruction set out below. The separate non-confidential version must have actually redacted all items that were marked and highlighted in the confidential version.

OR

- B. submit only a confidential version and ComReg will perform the required redaction to create a non-confidential version for publication. With this option, respondents must ensure that confidential information has been marked and highlighted in accordance with the instructions set out below.
- 1.36 For ComReg to perform the redactions under Option B above, respondents must mark and highlight all confidential information in their submission as follows:
- (a) Confidential information contained within a paragraph must be highlighted with a chosen particular colour;
 - (b) Square brackets must be included around the confidential text – one at the start and one at the end of the relevant highlighted confidential information; and
 - (c) A scissors symbol (Symbol code: Wingdings 2:38) must be included after the first square bracket. For example, “Redtelecom has a market share of [✂ < 25%].”
- 1.37 Where confidential information has not been marked in accordance with the instructions above, then ComReg will not create the non-confidential redacted version and the respondent will be required to provide the redacted non-confidential versions in accordance with Option A above.

Chapter 2

2 Licences and Award Spectrum

2.1 Introduction

2.1 By means of this Award Process, ComReg intends to:

- grant new rights of use for 470 MHz of radio frequency spectrum in respect of the Award Spectrum;
- facilitate the granting of interim rights of use to Three Ireland (Hutchison) Limited in the 2.1 GHz Band; and
- facilitate the early liberalisation of existing rights of use in the 2.1 GHz Band.

2.1.1 New rights of use in the Award Spectrum

2.2 ComReg will assign new rights of use in respect of the Award Spectrum through Licences granted to Winning Bidders under Section 5 of the 1926 Act. The Licences will be governed by the MBSA2 Licence Regulations to be made by ComReg under Section 6 of the 1926 Act (subject to the consent of the Minister for Communications, Climate Action and Environment). A draft of the MBSA2 Licence Regulations is included in Annex 2 of this document. The main type of Licence to be granted under the MBSA2 Licence Regulations will be MBSA2 Liberalised Use Licences, which will:

- permit a Licensee to keep, possess, install, maintain, work and use apparatus for wireless telegraphy (“Apparatus”) for the terrestrial provision of electronic communications services (“ECS”); and
- grant a “liberalised” right of use for radio frequencies in specific frequency assignments in the Award Spectrum in the national territory of the State (being those identified in Section 2.2 below).

2.3 The terms and conditions attached to MBSA2 Liberalised Use Licences are described in Section 2.3 below and are set out in the draft MBSA2 Licence Regulations and in the indicative MBSA2 Liberalised Use Licence attached to those Regulations²⁰. Among other things, MBSA2 Liberalised Use Licences are

²⁰ For the avoidance of doubt, in the event of any inconsistency between this IM and the final MBSA2 Licence Regulations, the MBSA2 Licence Regulations prevail.

being made available with a commencement date of [1 December 2020]²¹ (or such other date as may be specified by ComReg) and shall expire on [30 November 2040]²².

2.4 Winning Bidders will also be entitled to apply for a MBSA2 Preparatory Licence which will allow the holders of such licences to install networks and associated equipment in advance of the commencement date of their MBSA2 Liberalised Use Licence, but will not allow any wireless telegraphy transmissions²³. The terms and conditions attached to a MBSA2 Preparatory Licence are described in Section 2.4 below and are set out in the draft MBSA2 Licence Regulations and in the indicative MBSA2 Preparatory Licence attached to those Regulations.

2.5 Under certain pre-conditions, Eircom Limited (“Eir”) will also be entitled to apply for a MBSA2 2.3 GHz Band Transition Licence. The purpose of a MBSA2 2.3 GHz Band Transition Licence is to:

- safeguard the interests of users in remote rural areas who are currently receiving a Rurtel Service from Eir under its Universal Service Obligation (USO) because they do not presently have access to an alternative fixed telephony service;
- facilitate the timely and orderly transition of the remaining Eir customers receiving a Rurtel Service to a comparable or improved alternative service in accordance with Eir’s obligations under the USO as appropriate;
- facilitate the determination and specification of a clear end-date for all Transition Activities²⁴ to be completed, enabling Winning Bidders to introduce new services in the 2.3 GHz Band in affected areas as soon as possible and not unnecessarily delaying the delivery of future liberalised services; and
- ensure the efficient use of spectrum during the Transition period.

2.6 The terms and conditions attached to a MBSA2 2.3 GHz Band Transition

²¹ The commencement date of MBSA2 Liberalised Use Licences, and its consequent effect on the expiry date given a 20 year licence duration, will be considered further in ComReg’s response to consultation and final Decision.

²² Any delay to the commencement of MBSA2 Liberalised Use Licences due to the Transition Activities provided for in Section 3.8 of this Information Memorandum, or otherwise, shall not affect this expiry date.

²³ If a Licensee wishes to test equipment, it must apply separately to ComReg for a test licence (see <https://testandtrial.ie/>).

²⁴ Transition Activities refer to the activities required by the Existing Licensee to make adjustments to their existing networks in order to comply with the outcome of the Award Process and align their use of spectrum with the rights of use that they obtain, if any, in the Award Process (see Section 3.8 below for further information).

Licence are described in Section 2.5 below and are set out in the draft MBSA2 Licence Regulations and in the indicative MBSA2 2.3 GHz Band Transition Licence attached to those Regulations.

- 2.7 The MBSA2 Licence Regulations provide for the granting of MBSA Spectrum Lease Licences, the purpose of which is to facilitate the leasing of spectrum rights in the Award Spectrum in accordance with such procedures as may be specified by ComReg under Regulation 19 of the Framework Regulations. The terms and conditions attached to a MBSA2 Spectrum Lease Licence are described in Section 2.6 below and are set out in the draft MBSA2 Licence Regulations and in the indicative MBSA2 Spectrum Lease Licence attached to those Regulations.

2.1.2 2.1 GHz Band Interim Licences and Early Liberalisation

- 2.8 ComReg will assign interim rights of use in the 2.1 GHz Band through Licences granted under Section 5 of the 1926 Act. These 2.1 GHz Band Interim Licences will be governed by the 2.1 GHz Band Interim Licence and Early Liberalisation Regulations to be made by ComReg under Section 6 of the 1926 Act (subject to the consent of the Minister for Communications, Climate Action and Environment). These Regulations will also provide for the early liberalisation of existing rights of use in the 2.1 GHz Band through an amendment of the principal regulations governing these Existing 2.1 GHz Band rights of use²⁵. A draft of the 2.1 GHz Band Interim Licence and Early Liberalisation Regulations is included in Annex 2 of this document.
- 2.9 The terms and conditions of such interim and liberalised existing licences in the 2.1 GHz Band are set out in the draft 2.1 GHz Band Interim Licence and Early Liberalisation Regulations and the indicative licences attached to those Regulations.

2.2 The spectrum in the Award Process, Lots and Lot Categories

- 2.10 Through this Award Process, ComReg is making available new rights of use for 470 MHz of spectrum (i.e. the Award Spectrum) on a national basis.
- 2.11 Within the Award Spectrum there are 9 different types of Spectrum Blocks, as

²⁵ i.e. the Wireless Telegraphy (Third Generation and GSM Licence) Regulations, 2002 (S.I. No. 345 of 2002) as amended by the Wireless Telegraphy (Third Generation and GSM Licence) (Amendment) Regulations, 2003 (S.I. No. 340 of 2003).

follows:

- 700 MHz Duplex Blocks;
- 2.1 GHz Band Blocks;
- 2.3 GHz Band Fixed Frequency Block (Lower);
- 2.3 GHz Band Generic Frequency Blocks;
- 2.3 GHz Band Fixed Frequency Block (Upper);
- 2.6 GHz Band FDD Blocks;
- 2.6 GHz Band TDD Fixed Frequency Block (Lower);
- 2.6 GHz Band TDD Generic Frequency Blocks; and,
- 2.6 GHz Band TDD Fixed Frequency Block (Upper).

2.12 These Spectrum Blocks, with the exception of the 700 MHz Duplex Blocks, are being made available as Lots in two Time Slices (see Table 5 below for further detail).

2.13 This results in 17 Lot Categories as listed below, where **A-Lots** refer to the fixed frequency Lots (of which there are 8), and **B-Lots** refer to the frequency-generic Lots (of which there are 95):

- 700 MHz Duplex Lots (“B700”);
- 2.1 GHz Lots Time Slice 1 (“B2.1/1”);
- 2.1 GHz Lots Time Slice 2 (“B2.1/2”);
- 2.3 GHz Fixed Frequency Lot (Lower) Time Slice 1 (“A2.3L/1”);
- 2.3 GHz Fixed Frequency Lot (Lower) Time Slice 2 (“A2.3L/2”);
- 2.3 GHz Generic Frequency Lots Time Slice 1 (“B2.3/1”);
- 2.3 GHz Generic Frequency Lots Time Slice 2 (“B2.3/2”);
- 2.3 GHz Fixed Frequency Lot (Upper) Time Slice 1 (“A2.3U/1”);
- 2.3 GHz Fixed Frequency Lot (Upper) Time Slice 2 (“A2.3U/2”);

- 2.6 GHz FDD Lots Time Slice 1 (“B2.6F/1”);
- 2.6 GHz FDD Lots Time Slice 2 (“B2.6F/2”);
- 2.6 GHz TDD Fixed Frequency Lot (Lower) Time Slice 1 (“A2.6TL/1”);
- 2.6 GHz TDD Fixed Frequency Lot (Lower) Time Slice 2 (“A2.6TL/2”);
- 2.6 GHz TDD Generic Frequency Lots Time Slice 1 (“B2.6T/1”);
- 2.6 GHz TDD Generic Frequency Lots Time Slice 2 (“B2.6T/2”);
- 2.6 GHz TDD Fixed Frequency Lot (Upper) Time Slice 1 (“A2.6TU/1”);
and
- 2.6 GHz TDD Fixed Frequency Lot (Upper) Time Slice 2 (“A2.6TU/2”).

2.14 As a result, there are 103 Lots in the Award Process, across the Award Spectrum.

2.15 Table 2 identifies the Spectrum Blocks and the number of Lots available in Time Slice 1 and Time Slice 2.

2.16 Table 3 and Table 4 below provide details on the fixed frequency Lots (A-Lots) and the frequency-generic Lots (B-Lots) respectively.

Table 2: Spectrum Blocks and the number of available Lots in each Time Slice

Spectrum Blocks	Duplex arrangement and Frequency range	Lot Type	Time Slice 1		Time Slice 2	
			Number of Lots Available	Lot Size	Number of Lots Available	Lot Size
700 MHz Duplex Blocks	FDD: 703-733 MHz paired with 758-788 MHz	B	6 Lots of 2 x 5 MHz ²⁶			
2.1 GHz Blocks	FDD: 1920 – 1980 MHz paired with 2110 – 2170 MHz ²⁷	B	9	2 x 5 MHz	12	2 x 5 MHz
2.3 GHz Fixed Frequency Block (Lower)	TDD: 2300 – 2330 MHz	A	1	1 x 30 MHz	1	1 x 30 MHz
2.3 GHz Generic Frequency Blocks	TDD: 2330 – 2390 MHz	B	12	1 x 5 MHz	12	1 x 5 MHz
2.3 GHz Fixed Frequency Block (Upper)	TDD: 2390 – 2400 MHz	A	1	1 x 10 MHz	1	1 x 10 MHz
2.6 GHz FDD Generic Frequency Blocks	FDD: 2500 – 2570 MHz paired with 2620 – 2690 MHz	B	14	2 x 5 MHz	14	2 x 5 MHz
2.6 GHz TDD Fixed Frequency Block (Lower)	TDD: 2570 – 2575 MHz	A	1	1 x 5 MHz	1	1 x 5 MHz
2.6 GHz TDD Generic Frequency Blocks	TDD: 2575 – 2615 MHz	B	8	1 x 5 MHz	8	1 x 5 MHz
2.6 GHz TDD Fixed Frequency Block (Upper)	TDD: 2615 – 2620 MHz	A	1	1 x 5 MHz	1	1 x 5 MHz

²⁶ 700 MHz Duplex Blocks are being made available in one temporal period and are therefore not subject to Time Slices.

²⁷ This includes the three Spectrum Blocks currently assigned to Eir in Time Slice 1: 1935-1940 / 2125-2130 MHz; 1940-1945 / 2130 – 2135 MHz; and 1945-1950 / 2135-2140 MHz.

Table 3: Fixed Frequency A-Lots

Lot Category	Frequency range	Time Slice	Lots available	Lot size
A2.3L/1	2300 – 2330 MHz	1	1	30 MHz
A2.3L/2	2300 – 2330 MHz	2	1	30 MHz
A2.3U/1	2390 – 2400 MHz	1	1	10 MHz
A2.3U/2	2390 – 2400 MHz	2	1	10 MHz
A2.6TL/1	2570 – 2575MHz unpaired	1	1	5 MHz
A2.6TL/2	2570 – 2575MHz unpaired	2	1	5 MHz
A2.6TU/1	2615 – 2620 MHz unpaired	1	1	5 MHz
A2.6TU/2	2615 – 2620 MHz unpaired	2	1	5 MHz

Table 4: Frequency generic B-Lots

Lot Category	Frequency range	Time Slice	Number of Lots	Lot size
B700	703 – 733 MHz- paired with 758 – 788 MHz	1 & 2	6	2 x 5 MHz
B2.1/1	1920 – 1980 MHz paired with 2110 – 2170 MHz ²⁸	1	9	2 x 5 MHz
B2.1/2	1920 – 1980 MHz paired with 2110 – 2170 MHz	2	12	2 x 5 MHz
B2.3/1	2330 – 2390 MHz	1	12	5 MHz
B2.3/2	2330 – 2390 MHz	2	12	5 MHz
B2.6F/1	2500 – 2570 MHz paired with 2 620 – 2 690 MHz	1	14	2 x 5 MHz
B2.6F/2	2500 – 2570 MHz paired with 2620 – 2690 MHz	2	14	2 x 5 MHz
B2.6T/1	2575 – 2615 MHz	1	8	5 MHz
B2.6T/2	2575 – 2615 MHz	2	8	5 MHz

2.17 Figure 1, Figure 2, Figure 3 and Figure 4 below illustrate the band plans for the Award Spectrum in this Award Process.

²⁸ This does not include the three Spectrum Blocks currently assigned to Eir in Time Slice 1: 1935 – 1940 / 2125 – 2130 MHz; 1940 – 1945 / 2130 – 2135 MHz; and 1945 – 1950 / 2135 – 2140 MHz.

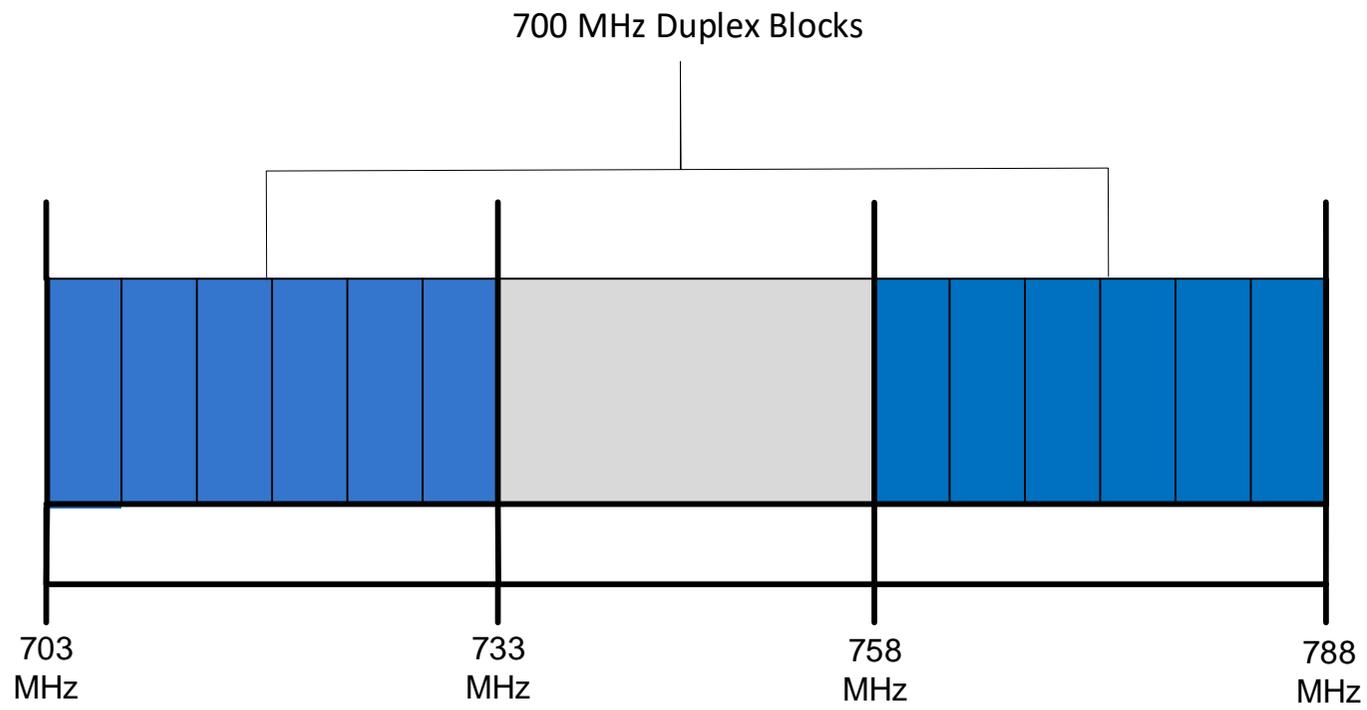


Figure 1: 700 MHz Duplex Blocks

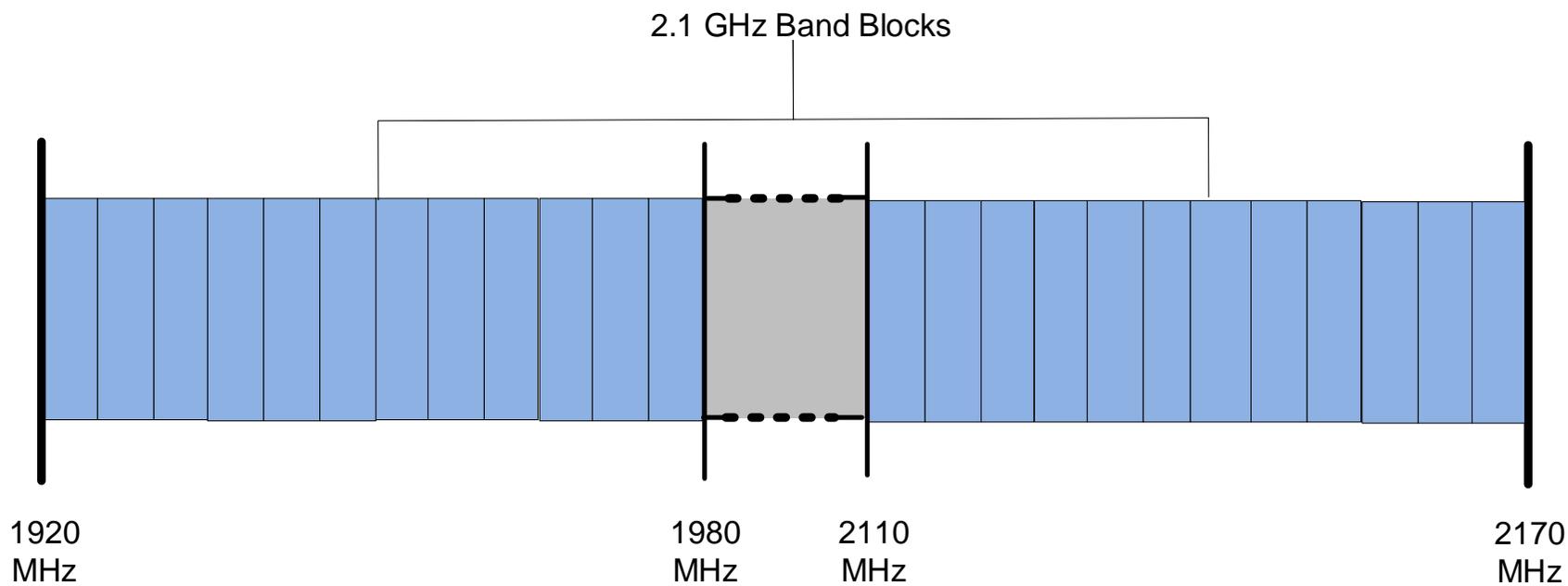


Figure 2: 2.1 GHz Band Blocks

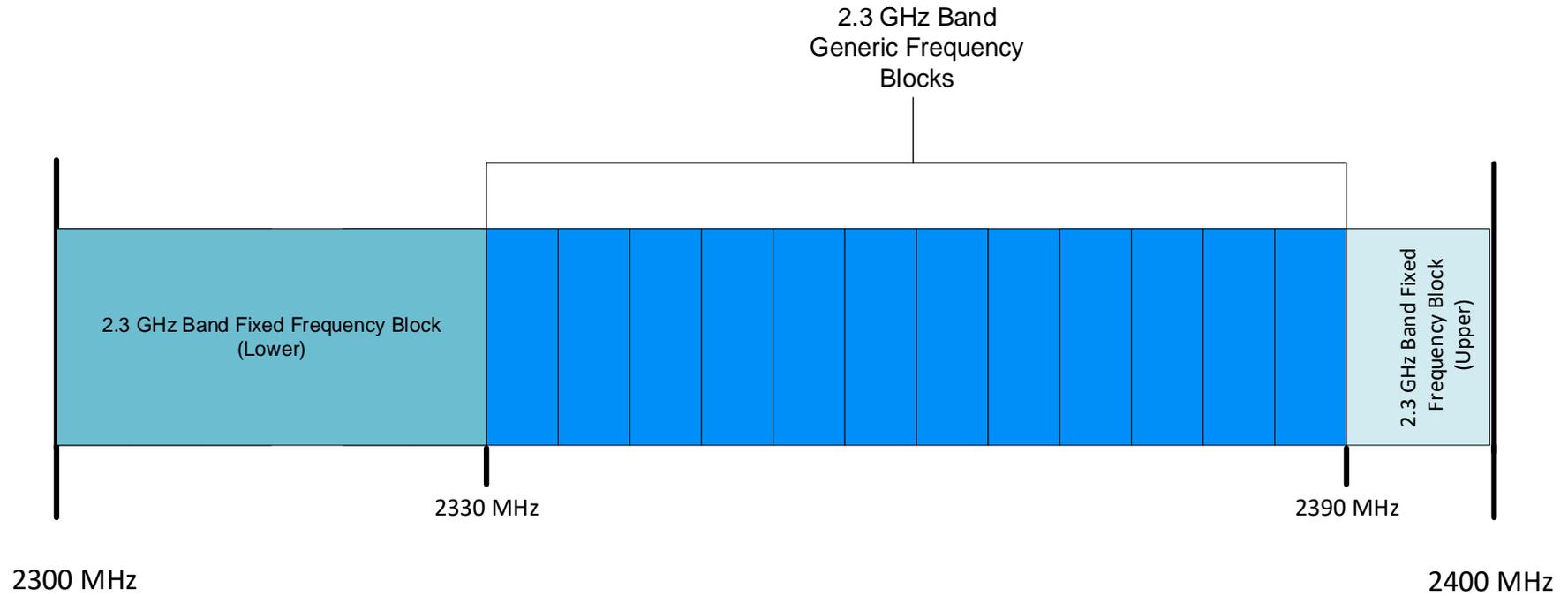


Figure 3: 2.3 GHz Band Fixed Frequency Block (Lower), 2.3 GHz Band Fixed Frequency Block (Upper) and 2.3 GHz Band Generic Frequency Blocks

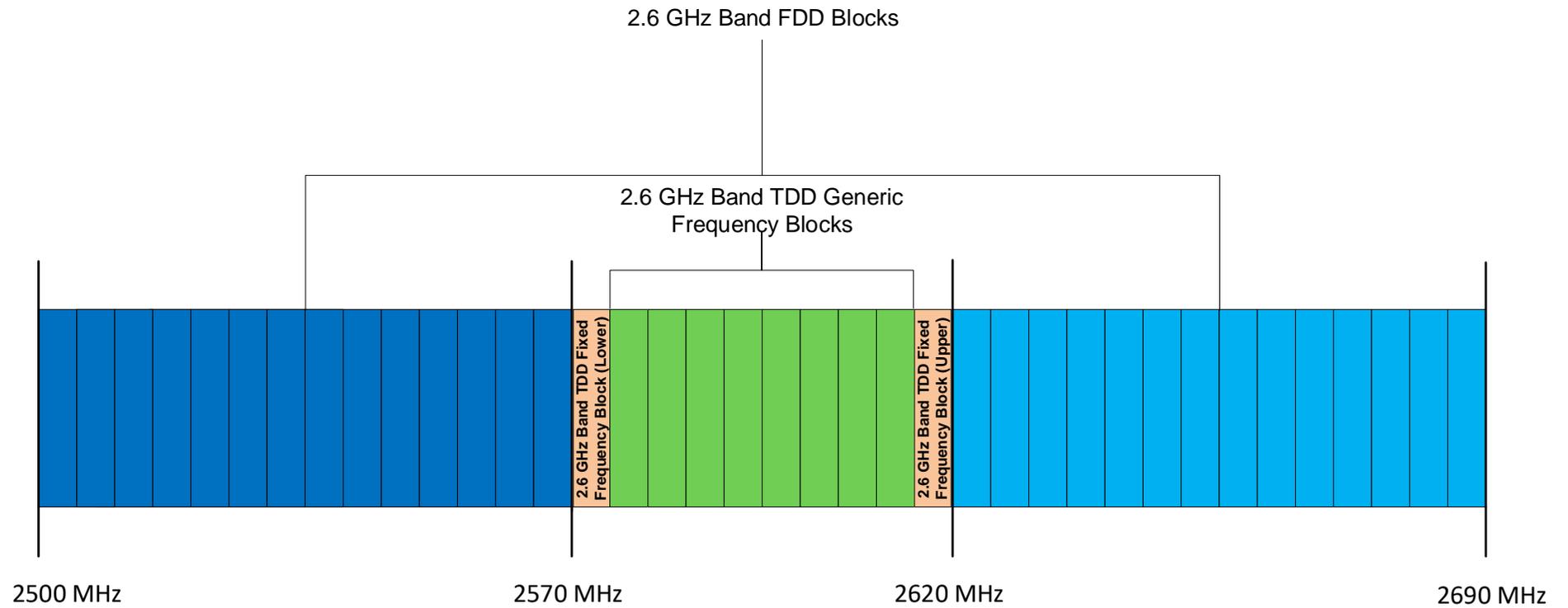


Figure 4: 2.6 GHz Band FDD Blocks, 2.6 GHz Band TDD Fixed Frequency Blocks (Lower), 2.6 GHz Band TDD Generic Frequency Blocks and 2.6 GHz Band Fixed Frequency Blocks (Upper)

2.3 The MBSA2 Liberalised Use Licence – Terms and Conditions

2.18 The following describes the principal terms and conditions associated with a MBSA2 Liberalised Use Licence. These terms and conditions are set out in the draft MBSA2 Licence Regulations and the indicative MBSA2 Liberalised Use Licence attached to those regulations (see Annex 2 of this document).²⁹

2.3.1 Entitlement to apply for a MBSA2 Liberalised Use Licence

2.19 In accordance with the rules for the Notification and Grant Stage (see Section 3.7 of this IM), each Winning Bidder will be entitled to apply for a MBSA2 Liberalised Use Licence.

2.3.2 Scope of a MBSA2 Liberalised Use Licence

2.20 A MBSA2 Liberalised Use Licence will permit a Licensee to keep, possess, install, maintain, work and use Apparatus in the portion of the Award Spectrum assigned thereunder for terrestrial systems capable of providing ECS.

2.21 It is a “Non-exclusive” Licence for the national territory of the State where, as set out in the draft MBSA2 Licence Regulations:

- a “Non-exclusive” licence means that ComReg is not precluded from authorising the keeping and having possession by persons other than the Licensee, on a Non-Interference and Non-Protected Basis, of Apparatus for the radio frequency spectrum specified in the Licence³⁰; and
- “on a Non-Interference and Non-Protected Basis” means that the use of Apparatus is subject to no Harmful Interference being caused to any Radiocommunication Service, and that no claim may be made for

²⁹ For the avoidance of doubt, in the event of any inconsistency between this Information Memorandum and the MBSA2 Licence Regulations, the latter shall prevail.

³⁰ For the 700 MHz Duplex, 2.1 GHz Band and 2.6 GHz Band, the relevant EC decisions oblige member states to designate and make available the band on a non-exclusive basis.

For the 2.3 GHz Band, as discussed in Section 7.3 of Document 19/124, ComReg considers it appropriate also to make this band available on a non-exclusive basis as this would, among other things:

- provide for consistency across the spectrum bands in the Award Spectrum;
- accord with standard practice for licensing spectrum bands; and
- likely align with the provisions in any future EC decision on this band, given the approach taken by the European Commission in relation to other bands in the Award Spectrum.

the protection of Apparatus used on this basis against Harmful Interference originating from Radiocommunication Services.

2.22 In addition, all Apparatus licensed under a MBSA2 Liberalised Use Licence is required to comply with, among other things, the conditions of the Licence and the relevant European Commission (“EC”) or Electronic Communications Committee (“ECC”) decisions, including:

- EC Decision 2016/687 in respect of 700 MHz Duplex Blocks;
- EC Decision 2012/688 in respect of 2.1 GHz Band Blocks;
- ECC Decision 14(02) in respect of 2.3 GHz Band Blocks; and
- EC Decision 2008/477 in respect of 2.6 GHz Band Blocks.

2.3.3 MBSA2 Liberalised Use Licence Duration

2.23 Spectrum rights of use in the 700 MHz Duplex are being made available in one temporal period from 1 December 2020 (or such other date as may be specified by ComReg) to 30 November 2040³¹.

2.24 Spectrum rights of use in the 2.1 GHz Band, 2.3 GHz Band and 2.6 GHz Band are being made available in two Time Slices. The commencement date and the expiry date for each Time Slice are set out in Table 5 below:

Table 5: Commencement and expiry dates³² for the 2.1 GHz Band, 2.3 GHz Band and 2.6 GHz Bands in Time Slice 1 and Time Slice 2

Time Slice	Frequency Band	Commencement date	Expiry date
Time Slice 1	2.1 GHz Band	16 October 2022	11 March 2027
	2.3 GHz Band	1 December 2020	
	2.6 GHz Band		
Time Slice 2	2.1 GHz Band	12 March 2027	30 November 2040
	2.3 GHz Band		
	2.6 GHz Band		

2.25 There is no implied or express right of renewal, extension or any other form of prolongation of a MBSA2 Liberalised Use Licence (and the spectrum rights of

³¹ The commencement date of MBSA2 Liberalised Use Licences, and its consequent effect on the expiry date given a 20 year licence duration, will be considered further in ComReg’s response to consultation and final Decision.

³² Or other such date or dates as may be specified by ComReg.

use granted by same) beyond the expiry date of 30 November 2040³³.

- 2.26 Prior to the expiry of MBSA2 Liberalised Use Licences, ComReg intends to consider the future use of the Award Spectrum, including identifying the appropriate process for dealing with the spectrum which becomes available due to the expiration of MBSA2 Liberalised Use Licences.

Potential for Delayed Commencement of MBSA2 Liberalised Use Licences

- 2.27 It should be noted that circumstances outside ComReg's reasonable control could lead to ComReg being unable to make any or all Lots in the Award Spectrum available for inclusion in a MBSA2 Liberalised Use Licence of a Winning Bidder by the commencement dates identified above³⁴.
- 2.28 Interested Parties are hereby expressly put on notice of the potential for delayed access to any and all Lots in the Award Spectrum and, in submitting an Application, Applicants acknowledge and accept same.
- 2.29 Section 2.3.7 below details the refunds of Licence fees payable to a Winning Bidder or the adjustment of Licence fees payable by a Winning Bidder, as the case may be, in the event of delayed access to Lots beyond the commencement dates detailed in Table 5.
- 2.30 To the extent permitted by law, ComReg's aggregate liability for all loss or damage of any nature arising from delayed access to Lots beyond the commencement dates as set out in Table 5 is expressly limited to the refunds or adjustments of Licence fees as set out in Section 2.3.7 of this Information Memorandum and, by submitting an Application, Interested Parties agree to same.

2.3.4 Licence Conditions Applicable to MBSA2 Liberalised Use Licences

- 2.31 This section describes the conditions which are applicable to MBSA2 Liberalised Use Licences.

³³ Or other expiry date as may be specified by ComReg in advance of the Award Process.

³⁴ The circumstances for delayed access to certain Lot(s) could be caused by a number of things including, for example, implications arising from the Covid-19 outbreak; the Award Process continuing on such that it is not possible to issue licences by the commencement dates identified above; and/or, the Transition Activities of Existing Licensees.

Coverage, Roll-out, Associated Compliance Reporting, Measuring and Monitoring Conditions

Outdoor Coverage

2.32 It is a condition of a MBSA2 Liberalised Use Licence that applies to rights of use in the 700 MHz Duplex that the Licensee shall achieve and maintain a minimum outdoor coverage obligation. The particulars of this obligation are outlined below and depend on whether or not the Licensee is an Existing MNO, and also on the quantum of 700 MHz Duplex spectrum rights held by the Licensee.

Outdoor Coverage – Existing MNOs

2.33 A Licensee that is an Existing MNO and wins at least 2 × 10 MHz in the 700 MHz Duplex shall achieve and maintain:

- the minimum outdoor coverage levels as set out in Table 6 below; and
- the minimum outdoor coverage levels at specific locations as set out in Table 8 below.

2.34 A Licensee that is an Existing MNO and wins only 2 × 5 MHz in the 700 MHz Duplex shall also achieve and maintain the minimum outdoor coverage levels as set out in Table 7 and Table 8, save that the minimum Single User Throughput Cell Edge level applicable will be 20 Mbit/s for those cases where a Single User Throughput Cell Edge level of 30 Mbit/s is specified.

Table 6: Outdoor Coverage Obligations on an Existing MNO winning at least 2 x 10 MHz in the 700 MHz Duplex

Outdoor Coverage Service (Single User Throughput Cell Edge)	Coverage dimension	Coverage level to be met in ³⁵ :		
		3 Years	5 Years	7 Years
30 Mbit/s	Population	85%	92%	95%
30 Mbit/s	Motorways	75%	85%	90%
30 Mbit/s	Primary Roads	60%	75%	80%
3 Mbit/s	Population	99%	99%	99%
3 Mbit/s	Geographic Area	90%	91%	92%

Table 7: Outdoor Coverage Obligations on an Existing MNO winning 2 x 5 MHz in the 700 MHz Duplex

Outdoor Coverage Service (Single User Throughput Cell Edge)	Coverage dimension	Coverage level to be met in ³⁶ :		
		3 Years	5 Years	7 Years
20 Mbit/s	Population	85%	92%	95%
20 Mbit/s	Motorways	75%	85%	90%
20 Mbit/s	Primary Roads	60%	75%	80%
3 Mbit/s	Population	99%	99%	99%
3 Mbit/s	Geographic Area	90%	91%	92%

³⁵ From the earliest commencement date of the 700 MHz Duplex Blocks in the MBSA2 Liberalised Use Licence.

³⁶ From the earliest commencement date of the 700 MHz Duplex Blocks in the MBSA2 Liberalised Use Licence.

Table 8: Outdoor coverage obligations at specific locations for an Existing MNO winning at least 2 × 10 MHz in the 700 MHz Duplex³⁷

Coverage	Location	Obligation ³⁸
Outdoors: 30 Mbit/s (Single User Throughput Cell Edge)	<p>Specific locations as set out in Annex 4 which include</p> <ul style="list-style-type: none"> • Business and technology Parks: Located at the Industrial Development Authorities (IDA) 31 business and technology Parks and 9 Strategic Sites; • Hospitals: the Health Service Executive (HSE) identifies a list of the 48 public and 17 private hospitals; • Higher Education Campuses: The Higher Education Authority (HEA) identifies a list of 8 Universities, 11 Institutes of Technology and 5 other colleges; • Air and Sea Ports: the Department of Transport Tourism and Sport (DTTAS) identifies a list of the 7 main airports and the Irish Maritime Development Office (IMDO) identify a list of the 7 passenger sea ports; • Train and bus stations: the National Transport Authority (NTA) identifies the busiest 144 train stations and Bus Éireann identifies a list of the main 16 bus stations; and • Top visitor attraction information points: Fáilte Ireland identifies a list of the top 21 fee charging and 21 free entry visitor attractions. 	<p>For each category</p> <p>70 % in 3 years</p> <p>90 % in 5 years</p> <p>100 % in 7 years</p>

Outdoor Coverage – New Entrants

2.35 A Licensee that is a New Entrant and wins at least 2 × 10 MHz in the 700 MHz Duplex and 2 × 20 MHz across the remaining Award Spectrum shall achieve and maintain the minimum outdoor coverage levels as set out in Table 9 below.

³⁷ Where an Existing MNO wins only 2 × 5 MHz in the 700 MHz Duplex the minimum Single User Throughput Cell Edge level applicable will be 20 Mbit/s.

³⁸ From the earliest commencement date of the 700 MHz Duplex Blocks in the MBSA2 Liberalised Use Licence.

Table 9: Obligations on New Entrants that win 2 × 10 MHz in the 700 MHz Duplex and 2 × 20 MHz of spectrum within any of or across the 2.1 GHz, 2.3 GHz or 2.6 GHz Bands³⁹

Outdoor Coverage Service (Single User Throughput Cell Edge)	Coverage dimension	Coverage level to be met in ⁴⁰ :		
		4 Years	6 Years	10 Years
30 Mbit/s	Population	75%	80%	90%

2.36 A Licensee that is a New Entrant and only wins 2 × 10 MHz or 2 × 5 MHz in the 700 MHz Duplex shall also achieve and maintain the minimum outdoor coverage levels as set out in Table 9 above, save that the minimum Single User Throughput Cell Edge level applicable will be 20 Mbit/s and 10 Mbit/s respectively.

Native Wi-Fi

2.37 It is a condition of a MBSA2 Liberalised Use Licence that, if the Licensee provides a mobile voice and/or text service using rights of use in the Award Spectrum, then the Licensee shall:

- use (i.e. deploy and maintain) Native Wi-Fi technology on its network in respect of rights of use in the Award Spectrum within 2 years of the Licence commencement date; and
- shall make available Native Wi-Fi voice and/or text services (as appropriate to the type of mobile service/s provided by the Licensee) to all end users on its network (including the end users of third-party customers⁴¹), where those end users:
 - have established for themselves a suitable Wi-Fi connection; and
 - have a Native Wi-Fi / Wi-Fi calling-enabled mobile device.

³⁹ Or equivalent: i.e. 1 × 40 MHz of TDD spectrum.

⁴⁰ From the earliest commencement date of the 700 MHz Duplex Blocks in the MBSA2 Liberalised Use Licence.

⁴¹ e.g. MVNOs.

Measuring and Monitoring Coverage Compliance

2.38 For the purpose of determining compliance with the above outdoor coverage obligations, ComReg will measure and monitor the coverage obligation based on the following principles:

- the ComReg network planning tools, supported by field measurements which may include field tests where appropriate, will be the key component in assessing compliance with the coverage obligations;
- all spectrum rights of use available to the Licensee can be used to contribute to meeting the coverage obligations;
- while acknowledging that newer technologies will be rolled out over time, LTE technology is expected to continue to be used by operators in delivering data to consumers for some time and in this regard ComReg will use the RSRP as the metric for determining coverage levels;
- the obligations are set to incentivise Licensees to rollout new sites as appropriate, upgrade sites with additional spectrum and make use of improvements in technology. Such as new standards including carrier aggregation and carrier sharing or extension techniques;
- depending on how the above techniques are deployed on a network, this will yield varying benefits in terms of increasing the range of a cell for a given throughput;
- where carrier aggregation is deployed using carriers with similar propagation characteristics the additional bandwidth and resultant throughput gains will be available, to a large extent, for the whole of the cell range;
- where frequency bands with different propagation characteristics are carrier aggregated (e.g. the 700 MHz Duplex and the 2.1 GHz Band), the throughput enhancements will be considered over the range of the highest of the frequency bands (e.g. the 2.1 GHz Band);
- a RSRP base level of -95 dBm will be used as a proxy for a 30 Mbit/s SUTP⁴² level for a 10 MHz downlink carrier. Where capacity increasing techniques are used (such as carrier aggregation and or deploying

⁴² ComReg notes that for the purpose of assessing compliance with the obligation where an Existing MNO was to obtain 2 x 5 MHz in the 700 MHz Duplex (i.e. where the obligation is to provide 20Mbit/s SUTP), ComReg will deploy the same methodology for the 30 Mbit/s case, (i.e. assume a 2 x 10 MHz carrier is deployed).

additional bandwidth), a lower RSRP value can be used;

- where two or three band carrier aggregation is deployed across bands with similar propagation characteristics (e.g. 700 MHz Duplex, 800 MHz Band and 900 MHz Band carriers) an RSRP level of -100 dBm and -105 dBm will apply respectively;
- a RSRP base level of -110 dBm will be used as a proxy for a 3 Mbit/s SUTP level for a 10 MHz downlink carrier. Where capacity increasing techniques are used such as carrier aggregation and or deploying additional bandwidth, a lower RSRP value can be used;
 - where two or three band carrier aggregation is deployed across bands with similar propagation characteristics (e.g. 700 MHz Duplex, 800 MHz Band and 900 MHz Band carriers) an RSRP level of -112 dBm and -114 dBm will apply respectively;
- noting that there may be many different potential combinations of spectrum and deployment techniques that could be used by a New Entrant, ComReg will apply the same principles as identified above in determining the appropriate approach to measuring and monitoring the coverage obligations; and
- as new technologies or coverage enhancing techniques are rolled out, ComReg will consider proposals from Licensees as to how this could influence meeting the coverage obligations.

2.39 It is a condition of a MBSA2 Liberalised Use Licence that the holder of rights of use in the 700 MHz Duplex conducts a self-assessment each year as to whether it has met and maintained its coverage obligations and submits an annual report to ComReg regarding same (“Coverage Compliance Report”). Details of this compliance reporting condition are set out in Section 4 of Part 4 of Schedule 1 of the draft MBSA2 Licence Regulations and includes that:

- the Licensee shall identify in the Coverage Compliance Report whether it has either (a) met the relevant outdoor coverage obligations and Native W-Fi coverage obligations specified in its Licence, or (b) failed to meet any of said obligations. The Licensee shall identify the outdoor coverage levels obtained at the time of the report. Where the Licensee has failed to meet any of the relevant coverage obligation, the Licensee shall provide adequate reasons and supporting information for same; and

- the Licensee shall submit its Coverage Compliance Report each calendar year within the 31 calendar days following the anniversary of the commencement date of its MBSA2 Liberalised Use Licence.

2.40 ComReg reserves the right to publish details of these reports, subject to the assessment of confidential information in line with ComReg Document 05/24.

Rollout Obligations for the 2.1 GHz, 2.3 GHz and 2.6 GHz Bands

2.41 It is a condition of a MBSA2 Liberalised Use Licence that, if the Licensee has obtained rights of use to spectrum in any of the 2.1 GHz, 2.3 GHz and 2.6 GHz Bands (“Performance Bands”), the Licensee shall:

- where the Licensee is an Existing MNO or an Existing Operator (other than an Existing MNO), at a minimum deploy and maintain the appropriate number of base stations as set out in Table 10 in each of the Performance Bands where rights of use are obtained, within 4 years of the of the earliest commencement date of Spectrum Blocks in each of the Performance Bands; or
- where the Licensee is a New Entrant (Mobile) or a New Entrant (Other), at a minimum deploy and maintain the number of base stations as set out in Table 11 in each of the Performance Bands where rights of use are obtained within 5 years of the Licence commencement date.

2.42 For the purposes of the above condition:

- “base station” means a network-controlled Apparatus with a minimum spectrum efficiency capability of 4 bits/Hz; and
- “network-controlled Apparatus” means Apparatus which has backhaul capability over a network connection under the control of the Licensee. For the avoidance of doubt, “plug-and-play” type Apparatus (such as femto cells, terminal stations and repeaters) are not network-controlled Apparatus.

Table 10: Existing MNO and Existing Operator base station rollout obligation for the Performance Bands⁴³

	Rollout Obligation			
Band	2.1 GHz	2.3 GHz	2.6 GHz TDD	2.6 GHz FDD
Time	4 Years			
Existing MNO	1,200	525	525	525
Existing Operator (other than an Existing MNO)	290	290	290	290

Table 11: New Entrant base station rollout obligation for the Performance Bands

	Rollout Obligation			
Band	2.1 GHz	2.3 GHz	2.6 GHz TDD	2.6 GHz FDD
Time	5 Years			
New Entrant (Mobile)	290	290	290	290
New Entrant (Other)	80	80	80	80

- 2.43 Base stations worked and used pursuant to a spectrum leasing arrangement count towards the base station rollout obligation of the Lessor's Licence.
- 2.44 Where a Licensee shares a base station with another Licensee, such base stations can count towards the base station rollout obligation of each Licensee, provided that at least one licensed Spectrum Block of each Licensee is worked and used by the rollout base station.

⁴³ ComReg set out its proposal for a base station rollout obligation for the Performance Bands in Table 11 of Document 19/124, which included a proposed requirement for Existing Operators winning rights of use to spectrum in the 2.3 GHz Band and / or the 2.6 GHz Band to roll out 550 base stations within 4 years in each of these bands. However, in Annex 11 of document 19/124, "Draft Rollout RIA – Performance Bands", ComReg proposed to set the obligation at 525 base stations for such cases. Therefore, the base station rollout obligation for the Performance Bands has been updated in Table 10 to reflect the outcome of the Draft Rollout RIA – Performance Bands.

Monitoring Rollout Compliance

2.45 It is a condition of a MBSA2 Liberalised Use Licence that the Licensee submits an annual report to ComReg regarding compliance with its rollout obligation (“Rollout Compliance Report”). Details of this compliance reporting condition are set out in Section 5 of Part 4 of Schedule 1 of the draft MBSA2 Licence Regulations and include that:

- the Licensee shall identify in the Rollout Compliance Report whether it has either (a) met the relevant rollout obligation specified in its Licence, or (b) failed to meet the said obligation and reasons for same. ComReg may seek to verify that the rollout obligation has been met. For example, by means of infrastructure surveys or other alternative means as it deems appropriate;
- the information required for the Rollout Compliance Report shall be agreed with ComReg in advance, and the Rollout Compliance Report shall have sufficient detail and granularity to allow ComReg to verify the results of the Licensee’s Rollout Compliance Report; and
- the Licensee shall submit its Rollout Compliance Report each calendar year within 31 calendar days following the anniversary of the commencement date of its MBSA2 Liberalised Use Licence.

2.46 ComReg reserves the right to publish details of these reports, subject to the assessment of confidential information in line with ComReg Document 05/24.

Quality of Service and associated compliance reporting conditions

2.47 It is a condition of a MBSA2 Liberalised Use Licence that the Licensee meets the minimum Quality of Service (“QoS”) obligations⁴⁴ as set out in Section 6 of Part 4 of Schedule 1 of the draft MBSA2 Licence Regulations. These QoS obligations consist of the following:

- minimum “availability of the network” standard;
- minimum “voice call” standard⁴⁵; and

⁴⁴ The QoS obligations attached to a MBSA2 Liberalised Use Licence apply to all relevant services provided using the spectrum blocks listed in Part 1 of a Licensee’s Licence. For the avoidance of doubt, this will include all relevant services of the Licensee and those services provided by any third parties (e.g. MVNOs) via contractual or other arrangements with the Licensee that use those spectrum blocks.

⁴⁵ The minimum “voice call” standard obligation also applies to all relevant ‘managed’ voice call services, provided to customers and third-party customers by the Licensee. ‘Managed’ voice call

- a “VoLTE availability” obligation⁴⁶.

2.48 It is a further condition of a MBSA2 Liberalised Use Licence that a Licensee shall, every twelve months, measure and submit an annual report to ComReg regarding its compliance with (a) the availability of the network standard, (b) the voice call QoS standard and (c) the VoLTE availability obligation (“QoS Compliance Report”). Details of this compliance reporting condition are set out in Section 6 of Part 4 of Schedule 1 of the draft MBSA2 Licence Regulations and include that:

- the Licensee shall identify in the QoS Compliance Report whether it has either (a) met the relevant QoS obligations specified in its Licence, or (b) failed to meet any of the said obligations and, if so, reasons for same;
- the information required for the QoS Compliance Report shall be agreed with ComReg in advance and the QoS Compliance Report shall have sufficient detail and granularity to allow ComReg to verify the results of the Licensee’s QoS Compliance Report;
- upon request by ComReg, the Licensee shall carry out drive test measurements and submit these results to ComReg⁴⁷. These drive test measurements are to be carried out at the Licensee’s own expense and to a standard as agreed with ComReg; and
- the Licensee shall submit its QoS Compliance Report each calendar year within the 31 calendar days following the anniversary of the commencement date of its MBSA2 Liberalised Use Licence.

2.49 ComReg reserves the right to publish details of these reports, subject to the assessment of confidential information in line with ComReg Document 05/24.

Cessation of use of a terrestrial system

2.50 It is a condition of a MBSA2 Liberalised Use Licence that, in Part 2 of its

services include traditional voice call services carried over circuit-switched connections and the ‘managed’ packet-switched voice call services (e.g. using VoIP or similar protocols) which can be provided over different technologies (e.g. VoLTE, Native Wi-Fi, etc.).

⁴⁶ The VoLTE obligation applies to any Licensee that has (a) deployed LTE in any of the bands in which it holds rights of use under a MBSA2 Liberalised Use Licence and (b) also offers a mobile voice service to consumers using those bands.

⁴⁷ ComReg does not envisage drive test measurements being required on a frequent basis, but notes that such measurements may be appropriate in circumstances where:

- a Licensee is submitting a QoS Compliance Report for the first time; or
- ComReg’s own verification checks, or other information suggests that there may be discrepancies in the compliance report on QoS or the Licensee may not be meeting its QoS obligations.

Licence, the Licensee specifies the terrestrial system applicable to each Apparatus specified in its Licence.

- 2.51 It is a further condition of a MBSA2 Liberalised Use Licence that, where a Licensee intends to cease the use of a terrestrial system that is used to provide services under its MBSA2 Liberalised Use Licence⁴⁸, the Licensee shall:
- notify ComReg of this intention at least 6 months⁴⁹ in advance of the proposed termination date; and
 - use all reasonable endeavours to ensure that any adverse effects on users caused by the cessation of use of a terrestrial system are minimised.

Compliance with rules to prevent spectrum hoarding

- 2.52 It is a condition of a MBSA2 Liberalised Use Licence that the Licensee complies with any rules to prevent spectrum hoarding as laid down by ComReg under Regulation 17(10) of the Framework Regulations. While no such rules have yet been laid down by ComReg, ComReg reserves the right to specify such rules in the future and such rules may apply to rights of use for radio frequencies associated with MBSA2 Liberalised Use Licences.

Assignment of rights and obligations of a MBSA2 Liberalised Use Licence

- 2.53 The assignment (i.e. Transfer or Lease) of rights and obligations of a MBSA2 Liberalised Use Licence will be permitted.
- 2.54 In relation to any such assignment of rights and obligations, among other things, it is a condition of the MBSA2 Liberalised Use Licence that the Licensee shall:
- notify ComReg of its intention to transfer some or all of its rights of use of radio frequencies attached to its MBSA2 Liberalised Use Licence;

⁴⁸ For the avoidance of doubt, the entitlement of a Licensee to cease the use of a terrestrial system is without prejudice to the contractual rights of parties who have entered into contracts with the Licensee.

⁴⁹ Should a Licensee notify ComReg that it could cease using one technology in favour of another within a time period shorter than 6 months, such a proposal would be assessed by ComReg at the relevant time in light of its statutory functions, objectives and duties, considering, among other things, how consumer disruption would be minimised.

- only transfer the rights of use for radio frequencies attached to its MBSA2 Liberalised Use Licence in accordance with the Transfer Regulations⁵⁰;
- notify ComReg of its intention to lease any rights of use for radio frequencies attached to its MBSA2 Liberalised Use Licence;
- only lease the rights of use for radio frequencies attached to its MBSA2 Liberalised Use Licence in accordance with such procedures as may be specified by ComReg under Regulation 19 of the Framework Regulations;
- not, without the prior consent of ComReg (which shall not be unreasonably withheld), lease any rights of use for radio frequencies attached to its MBSA2 Liberalised Use Licence; and
- ensure that, if the address of the Licensee or its Transferee or Lessee changes, the Licensee, Transferee or Lessee shall, as soon as possible, but in any event within 28 calendar days, notify ComReg in writing of the change.

2.55 It should be noted that the Transfer Regulations do not apply to spectrum transfers forming part of a merger or acquisition which is required to be notified to the Competition and Consumer Protection Commission in accordance with Part 3 of the Competition Acts 2002 (as amended) or to the European Commission in accordance with Council Regulation (EC) No 139/2004.

Provision of updated information for Part 2 and Part 3 of the Licence

2.56 Part 2 and Part 3 of the MBSA2 Liberalised Use Licence details the Apparatus to which the Licence relates and the location of each Apparatus.

2.57 It is a condition of the MBSA2 Liberalised Use Licence that the Licensee submit up to date information to ComReg in respect of Parts 2 and 3 of its MBSA2 Liberalised Use Licence in advance of its Licence commencement date and on or before the anniversary of that date each year that the Licence is in force.

2.58 It is ComReg's intention to publish details of MBSA2 Liberalised Use Licences, including information contained in Part 2 and Part 3, on its website subject to the assessment of confidential information in line with ComReg Document

⁵⁰ S.I. No. 34 of 2014. These regulations provide for the transfer of spectrum rights of use in the RSPP bands, which include the 2.1 GHz and 2.6 GHz Bands, but do not presently include the 700 MHz Duplex or 2.3 GHz Band. However, ComReg intends to amend these regulations to include the 700 MHz Duplex and 2.3 GHz Band. See also ComReg Document 14/11r.

05/24.

Payment of fees

2.59 It is a condition of a MBSA2 Liberalised Use Licence that the Licensee shall make payment of all applicable fees as detailed in the draft MBSA2 Licence Regulations.

2.3.5 MBSA2 Liberalised Use Licence Technical Conditions

2.60 This section outlines the technical conditions which apply to a MBSA2 Liberalised Use Licence, including:

- those applicable to the Award Spectrum;
- that only terrestrial systems compatible with the relevant EC Decisions and ECC Decision are worked and used in the Award Spectrum;
- compliance with the European Union (Radio Equipment) Regulations 2017⁵¹ and the European Communities (Electromagnetic Compatibility) Regulations 2017⁵²; and
- compliance with planning arrangements agreed in all memoranda of understanding (“MoU”) between ComReg and its neighbouring administrations, particularly with Ofcom (or its successor) in the UK, in relation to the Award Spectrum⁵³.

700 MHz Duplex

2.61 The technical conditions for a MBSA2 Liberalised Use Licence for 700 MHz Duplex Blocks are detailed in Section 2(1) of Part 4 of Schedule 1 of the draft MBSA2 Licence Regulations.

2.62 The conditions are in accordance with the parameters set out in the Annex to EC Decision 2016/687/EU and, among other things, require a Licensee in the 700 MHz Duplex to:

⁵¹ S.I. No. 248/2017 - European Union (Radio Equipment) Regulations 2017.

⁵² S.I. No. 69/2017 - European Communities (Electromagnetic Compatibility) Regulations 2017.

⁵³ MoU's are available on the ComReg website under [International Spectrum Coordination](#), available at www.comreg.ie

- ensure that the in-block radiated power from a base station transmitter in the downlink direction does not exceed 64 dBm / 5 MHz EIRP;
- comply with the out-of-block Block Edge Mask (BEM) as specified in EC Decision 2016/687/EU; and
- where a Licensee wins more than 2×10 MHz in the 700 MHz Duplex and if this assignment is deployed starting at 703 MHz, provide protection to the frequency range 470 – 694 MHz.

2.1 GHz Band

2.63 The technical conditions for a MBSA2 Liberalised Use Licence for 2.1 GHz Band Blocks are detailed in Section 2(2) of Part 4 of Schedule 1 of the draft MBSA2 Licence Regulations.

2.64 The conditions are in accordance with the parameters set out in EC Decision 2012/688/EU and, among other things, require a Licensee in the 2.1 GHz Band to:

- ensure that the in-block radiated power from a base station transmitter in the downlink direction does not exceed 64 dBm / 5 MHz EIRP; and
- comply with the out-of-block Block Edge Mask (BEM) as specified in EC Decision 2012/688/EU.

2.3 GHz Band

2.65 The technical conditions for a MBSA2 Liberalised Use Licence for 2.3 GHz Band Blocks are detailed in Section 2(3) of Part 4 of Schedule 1 of the draft MBSA2 Licence Regulations.

2.66 As there is no relevant EC decision for this band, the technical conditions for the 2.3 GHz Band are in accordance with the parameters set out in the Annex to ECC Decision (14)02 and, among other things, require a Licensee in the 2.3 GHz Band to:

- comply with the TDD Inter-Licensee Synchronisation Procedure as set out in Section 3 of Schedule 1 of the draft MBSA2 Licence Regulations;
- ensure that the in-block radiated power from a base station transmitter in the downlink direction for the 2.3 GHz Band Fixed Frequency Block (Lower) and the 2.3 GHz Band Generic Frequency Blocks does not exceed 68 dBm / 5 MHz EIRP;

- ensure that the in-block radiated power from a base station transmitter in the downlink direction for the 2.3 GHz Band Fixed Frequency Block (Upper) does not exceed 45 dBm / 5MHz EIRP, to ensure coexistence with systems above 2.4 GHz; and
- comply with the out-of-block BEM as specified in the draft MBSA2 Licence Regulations.

2.67 A Licensee which obtains the 2.3 GHz Band Fixed Frequency Block (Lower) is required to coordinate with any MBSA2 2.3 GHz Band Transition Licensee before the deployment of base stations within the coordination zone identified in Document 19/124c (as may be updated by ComReg). This coordination will be required until the MBSA2 2.3 GHz Band Transition Licensee completes its Transition Activities (which will be specified in a Transition Plan).

2.6 GHz Band FDD Blocks

2.68 The technical conditions for a MBSA2 Liberalised Use Licence for 2.6 GHz Band FDD Blocks are detailed in Section 2(4) of Part 4 of Schedule 1 of the draft MBSA2 Licence Regulations.

2.69 The conditions are in accordance with the parameters set out in the Annex to EC Decision 2008/477/EU and, among other things, require a Licensee with such blocks to:

- ensure that the in-block radiated power from a base station transmitter in the downlink direction in the 2.6 GHz Band FDD Blocks does not exceed 61 dBm / 5 MHz EIRP;
- comply with the out-of-block BEM as specified in the Annex to EC Decision 2008/477/EU; and
- comply with mitigation measures detailed in the draft MBSA2 Licence Regulations to ensure compatibility and coexistence between MFCN in the 2.6 GHz Band and aeronautical radars operating in the 2700 – 2900 MHz frequency range. These mitigation measures include in-band and out-of-band power flux density (pfd) limits⁵⁴.

⁵⁴ Specific pfd limits were indicated in Document 19/124. As these pfd limits may vary depending on the number of Licensees in the 2.6 GHz Band and the quantum of spectrum assigned to each Licensee in the downlink part of the 2.6 GHz Band (2570-2690 MHz), the pfd limit per Licensee is derived by the formulae set out in the draft MBSA2 Licence Regulations.

2.6 GHz Band TDD Fixed Frequency Block (Lower), 2.6 GHz Band TDD Generic Frequency Blocks and 2.6 GHz Band TDD Fixed Frequency Block (Upper)

- 2.70 The technical conditions for a MBSA2 Liberalised Use Licence for 2.6 GHz Band TDD Fixed Frequency Block (Lower), 2.6 GHz Band TDD Generic Frequency Blocks and 2.6 GHz Band TDD Fixed Frequency Block (Upper) are detailed in Section 2(4) of Part 4 of Schedule 1 of the draft MBSA2 Licence Regulations.
- 2.71 The conditions are in accordance with the parameters set out in the Annex to EC Decision 2008/477/EU and, among other things, require a Licensee holding the 2.6 GHz Band TDD Fixed Frequency Block (Lower), 2.6 GHz Band TDD Generic Frequency Blocks and/or the 2.6 GHz Band TDD Fixed Frequency Block (Upper) to:
- ensure that the in-block radiated power from a base station transmitter in the downlink direction in the 2.6 GHz Band TDD Generic Frequency Blocks does not exceed 61 dBm / 5 MHz EIRP;
 - ensure that the in-block radiated power from a base station transmitter in the downlink direction in the 2.6 GHz Band TDD Fixed Frequency Block (Lower) and the 2.6 GHz Band TDD Fixed Frequency Block (Upper) does not exceed 25 dBm / 5 MHz;
 - comply with the relevant out-of-block BEM as specified in the Annex to EC Decision 2008/477/EU, as amended;
 - comply with the inter-Licensee synchronisation procedure as set out in Section 3 of Part 4 of Schedule 1 of the draft MBSA2 Licence Regulations; and
 - comply with mitigation measures detailed in the draft MBSA2 Licence Regulations to ensure compatibility and coexistence between MFCN in the 2.6 GHz Band and aeronautical radars operating in the 2700 – 2900 MHz frequency range. These mitigation measures include in-band and out-of-band pfd limits.

Radio Equipment Regulations

- 2.72 All radio equipment placed on the Irish market or put into service must comply with the European Union (Radio Equipment) Regulations 2017⁵⁵. It is a function of ComReg to ensure compliance with these regulations, which

⁵⁵ S.I. No. 248/2017, giving effect to Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 and to Regulation (EC) No 765/2008 of 9 July 2008.

includes defining the regulated interface requirements for radio services in Ireland (currently set out in Document 06/47R⁵⁶).

2.73 It is a condition of a MBSA2 Liberalised Use Licence that the Licensee ensures that:

- Apparatus complies with relevant radio interface specifications set out in Document 06/47R (as may be amended from time to time); and
- Apparatus, or any part thereof, complies with the European Union (Radio Equipment) Regulations 2017, including ensuring that:
 - any electromagnetic disturbance generated by any Apparatus does not exceed the level above which it may cause interference with any other lawful radio and telecommunications equipment or apparatus for wireless telegraphy; and
 - any radio and telecommunications equipment or other apparatus for wireless telegraphy supplied by a Licensee, or any installations constructed by a Licensee, shall be appropriately immune to electromagnetic interference.

Award Spectrum Duplex Arrangements

2.74 A MBSA2 Liberalised Use Licence will permit a Licensee to keep, possess, install, maintain, work and use Apparatus using FDD⁵⁷ only in:

- the 700 MHz Duplex Blocks;
- the 2.1 GHz Band Blocks; and
- the 2.6 GHz Band FDD Blocks.

2.75 For avoidance of doubt, a Licensee is not permitted to keep, possess, install, maintain, work or use Apparatus using TDD⁵⁸ in the above Spectrum Blocks.

2.76 A MBSA2 Liberalised Use Licence will permit a Licensee to keep, possess, install, maintain, work and use Apparatus using TDD only in the:

⁵⁶ Interface Requirements for Radio Services in Ireland – ComReg Document 06/47R. <https://www.comreg.ie/publication-download/interface-requirements-for-radio-services-in-ireland>

⁵⁷ “FDD” describes a full-duplex communications link that uses two different radio frequencies for transmitter and receiver operation. The transmit direction and receive direction frequencies are separated by a defined frequency offset.

⁵⁸ “TDD” is a method for emulating full-duplex communication over a half-duplex communication link. The transmitter and receiver both use the same frequency but transmit and receive traffic is switched in time.

- 2.3 GHz Band Fixed Frequency Block (Lower);
- 2.3 GHz Band Generic Frequency Blocks;
- 2.3 GHz Band Fixed Frequency Block (Upper);
- 2.6 GHz Band TDD Fixed Frequency Block (Lower);
- 2.6 GHz Band TDD Generic Frequency Blocks; and
- 2.6 GHz Band TDD Fixed Frequency Block (Upper).

2.77 For the avoidance of doubt, a Licensee is not permitted to keep, possess, install, maintain, work or use Apparatus using FDD in the above Spectrum Blocks.

Guard bands

2.78 There are no Licence conditions that create or mandate guard bands between adjacent users of spectrum. Bidders should therefore identify any guard band requirements that their choice of technology may require and should bid accordingly.

2.3.6 Fees for a MBSA2 Liberalised Use Licence

2.79 The fee for a MBSA2 Liberalised Use Licence consists of:

- (i). a once-off, upfront **Spectrum Access Fee (“SAF”)**, which is paid by a Winning Bidder at the conclusion of the Award Process and prior to the grant of the Licence; and
- (ii). an annual **Spectrum Usage Fee (“SUF”)** which is an index-linked fee that is paid at defined intervals over the duration of the Licence⁵⁹.

2.80 Licences granted on foot of this Award Process are not subject to Value Added Tax (“VAT”). However, if the VAT rules should change over the duration of the Licences, so as to require the application of VAT to such fees, then VAT would be applied as appropriate and, in submitting an Application, Applicants acknowledge and accept same.

Spectrum Access Fee

2.81 The SAF payable by a Winning Bidder for a MBSA2 Liberalised Use Licence in the Notification and Grant Stage is an upfront fee that comprises:

⁵⁹ For the avoidance of doubt, because the commencement date of each particular Licence may be different, the date on which future SUFs fall due, may be different for different Licensees.

- the Base Price associated with the Winning Bid for that Winning Bidder, payable for winning Lots in the Main Stage of the Award Process; and
- the Additional Price for that Winning Bidder, if any, payable for the assignment of B-Lots as a result of the Assignment Stage of the Award Process.

2.82 The **Base Price** for a Winning Bidder is determined as follows:

- where the Main Stage of the Award Process is not required, the Base Price is the sum of the Reserve Prices for all Lots to be included in the Licence. Table 12 and Table 13 below set out the Reserve Prices per Lot for each Lot Category;
- where the Main Stage of the Award Process is required, the Base Price is determined by the Main Stage of the Auction as detailed in Chapter 4 of this document. The Base Price will be no less than the sum of the Reserve Prices for all Lots to be included in the Licence.

Table 12: Reserve Price per 700 MHz Duplex Lot

Lot Category	Reserve Price (€)
B700	8,755,000

Table 13: Reserve Prices per Lot per Time Slice

Lot Category	Reserve Price (€) for Time Slice 1 (“/1”)	Reserve Price (€) for Time Slice 2 (“/2”)
B2.1	1,416,000	2,447,000
A2.3L	963,000	1,090,000
B2.3	216,000	245,000
A2.3U	432,000	489,000
B2.6F	432,000	489,000
A2.6TL	216,000	245,000
B2.6T	216,000	245,000
A2.6TU	216,000	245,000

2.83 The **Additional Price** for a Winning Bidder, if any, is the price associated with the assignment of specific Lots to this Winning Bidder as determined in the Assignment Stage of this Award Process. This price will be determined using the methodology as detailed in Chapter 4.

Spectrum Usage Fees

- 2.84 For a MBSA2 Liberalised Use Licence, the total annual SUF is the sum of the SUFs associated with each Lot included in the Licence.
- 2.85 The annual SUF before CPI Adjustment per Lot type is set out in Table 14 and Table 15 below.

Table 14: Annual SUF before CPI adjustment per Lot of 700 MHz Duplex

Lot Category	Annual SUF before CPI Adjustment (€)
B700	1,168,778

Table 15: Annual SUF before CPI adjustment per Lot

Lot Category	Annual SUF before CPI Adjustment (€) for Time Slice 1 (“/1”)	Annual SUF before CPI Adjustment (€) for Time Slice 2 (“/2”)
B2.1	615,147	615,147
A2.3L	274,082	274,082
A2.3U	123,029	123,029
B2.3	61,515	61,515
B2.6F	123,029	123,029
A2.6TL	61,515	61,515
A2.6TU	61,515	61,515
B2.6T	61,515	61,515

- 2.86 SUFs are index-linked to the overall Consumer Price Index⁶⁰ (“CPI”) as published by the Central Statistics Office⁶¹ of Ireland (or its successor). As the CPI may vary over time, the SUF per Lot may increase or decrease over the

⁶⁰ If the CPI data ceases to be published or if the method of its calculation changes fundamentally, ComReg reserves the right to select another appropriate index and to amend the method of calculating indexing accordingly.

⁶¹ See <http://www.cso.ie>.

duration of the Licence (“CPI Adjustment”).

- 2.87 The CPI Adjustment for a SUF is calculated using 1 December 2020 [or such other date as may be specified by ComReg] as the base date for the CPI (i.e. CPI = 100). ComReg will use the most current CPI data available to it at that time. For example, for 1 December, ComReg envisages that the most up to date CPI data available is likely to be from October of that year.
- 2.88 The first SUF is to be paid by a Winning Bidder in advance of licence commencement and for the spectrum rights of use that commence within 1 year of that licence commencement date. Thereafter annual SUFs are to be paid on or before each anniversary of the commencement date of the Licence for the duration of the Licence for the spectrum rights of use licensed in that year (i.e. next 365 days).
- 2.89 Where rights of use for radio frequencies are granted for a period that includes part of a whole year (i.e. less than 365 days between the previous anniversary and the expiry of those rights of use), the SUF for that part of the year shall be calculated using the above methodology and adjusted on a pro-rata daily basis.

Arrangements for Paying Fees

- 2.90 The Licence fees for a MBSA2 Liberalised Use Licence are to be paid into ComReg’s Nominated Bank Account, the details of which are set out in the Application Form in Annex 3⁶².
- 2.91 Where the due date for payment of a fee is not a Working Day, payment shall be made on or before the Working Day immediately preceding that due date.
- 2.92 As set out in Section 3.7 of this document, a Winning Bidder which fails to pay the SAF and/or applicable first SUF by the applicable due date/s may forfeit its Deposit and its entitlement to be granted the Licence concerned. Any such forfeiture of a Deposit or non-granting of a Licence will not prejudice ComReg’s entitlement to recover the full amount of the SAF and/or first SUF as a simple contract debt.
- 2.93 Where a Licensee has already been granted a MBSA2 Liberalised Use Licence, failure by a Licensee to make a Licence fee payment on or before the date it falls due constitutes non-compliance by the Licensee with its Licence conditions and ComReg may take steps to recover the sum due. This is without

⁶² ComReg may amend the details of the account to which the Licence fees shall be paid and this will be notified to the Licensee as required.

prejudice to its right to take compliance actions in accordance with its statutory powers, including those set out in the Authorisation Regulations (see also under Section 2.3.8 below).

- 2.94 A Licensee shall pay interest on any fee or part thereof that has not been paid by its due date and is outstanding⁶³. The applicable interest rate shall be that which applies to late payments in commercial transactions under the European Communities (Late Payment in Commercial Transactions) Regulations 2012 (S.I. No. 580/2012), as amended. The applicable time period for any interest payment shall run from the date on which the full / partial fee fell due to the date on which the full / partial fee is paid.
- 2.95 An amount payable by a person in respect of an outstanding Licence fee may be recovered by ComReg from the person as a simple contract debt in any court of competent jurisdiction.

2.3.7 Refunds or Adjustments of Licence Fees

- 2.96 As noted in Section 2.3.3 of this document, in limited circumstances ComReg may refund or adjust Licence fees payable by Winning Bidders due to the delayed commencement of Lots.
- 2.97 The refund or adjustment of fees payable to a Winning Bidder for each Lot so delayed shall be calculated as follows:
- a pro-rata portion of the SAF already paid by the Winning Bidder on a daily basis for each whole day following the commencement dates as set out in paragraph 2.23 and Table 5 (or other commencement date as indicated by ComReg in relation to the Award Process) that ComReg does not make the Lot available for use⁶⁴; and
 - a pro-rata portion of SUFs⁶⁵ already paid by the Winning Bidder on a daily basis for each whole day following the commencement dates as set out in paragraph 2.23 and Table 5 (or other commencement date as indicated by ComReg in relation to the Award Process) that ComReg does not make the Lot available for use.

⁶³ For the avoidance of doubt, any fees paid in respect of late payment are not subject to refunds or adjustments as discussed in Section 2.3.7.

⁶⁴ To calculate the SAF associated with a Lot in a MBSA2 Liberalised Use Licence, ComReg will use the Round Prices in the final Primary Bid Round and other relevant information.

⁶⁵ ComReg does not envisage a requirement to refund SUF payments for delayed Lot(s), as no SUF payments will be requested by ComReg for delayed Lot(s) until such time as ComReg notifies the Winning Bidder of the commencement date of these Lots.

- 2.98 For each Winning Bidder, ComReg currently intends to purchase NTMA⁶⁶ Exchequer Notes in respect of the pro-rata portion of the SAF already paid for delayed Lot(s)⁶⁷. Interest, if earned⁶⁸, less any financial fees and related taxation, if applicable, will be paid by ComReg to the Winning Bidder on these funds.
- 2.99 For each month following the commencement dates as set out in paragraph 2.23 and Table 5 (or other commencement dates as indicated by ComReg in relation to the Award Process), refunds to the Winning Bidder will be paid by ComReg within 5 Working Days of the end of the month or, if desired by the Winning Bidder, these refunds can be offset against the following year's SUF (or multiple years' SUF). For the avoidance of doubt:
- no refund of the SAF and/or SUFs, including interest, if earned, shall be payable by ComReg to any Winning Bidder for any delay to the availability of any Lot caused, or contributed to, by acts or omissions of that Winning Bidder, its servants or agents, or any failure on behalf of its suppliers;
 - in submitting an Application, an Applicant agrees that if it becomes a Winning Bidder, a failure to obtain consents, approvals, Apparatus or funding necessary to deploy a network or complete its Transition Activities as provided for under Section 3.8 of this document shall be deemed to be an omission on behalf of that Winning Bidder; and
 - to the extent permitted by law, ComReg's liability for damage or loss of any nature arising from delayed access to Lots is expressly limited to the refunds or adjustments identified above and, in submitting an Application, an Applicant agrees to same.

Other Refunds of Licence Fees

- 2.100 Where a Licensee requests an amendment to its Licence which is accepted by ComReg and which results in a reduction in the:

⁶⁶ National Treasury Management Agency.

⁶⁷ However, ComReg reserves the right to manage all monies held in accordance with good treasury management.

⁶⁸ The current rate of interest on NTMA Exchequer Notes is zero per cent. However, the rate of interest associated with the NTMA Exchequer Notes could be a negative rate. For the avoidance of doubt, ComReg reserves the rights to calculate the refund paid to the Winning Bidder to be less the amount of negative interest accrued over the period a Deposit has been held by ComReg. See also Section 3.3.4 below.

- quantum of rights of use for radio frequencies held under the Licence⁶⁹; or
- duration of one or more Lots held under the Licence,

the Licensee shall not be entitled to any refund of the applicable SAF but shall be entitled to a refund in respect of the excess of any SUF already paid.

2.101 A Licensee who surrenders any Lots held under its Licence will not be liable for any SUFs in respect of such surrendered Lots, beyond the date upon which the Licensee ceases to have use of those Lots under its amended Licence.

2.102 Where a Licence is amended, surrendered, or withdrawn following an enforcement action by ComReg, ComReg will not refund any fees (SAF or SUFs) already paid by the Licensee concerned in respect of such Licence.

Relocation Rebate

2.103 Where Eir in relation to its Existing 2.1 GHz Band Licence incurs Relocation costs as a result of the Assignment Stage that it otherwise would not have incurred, these costs qualify for a rebate under the relocation costs rules and methodology as set out in Annex 14 of this document.

2.3.8 Enforcement Actions – Compliance with Licence Conditions, Licence Suspension and Licence Withdrawal

2.104 ComReg will enforce conditions attached to Licences in accordance with its statutory powers, including those set out in the Authorisation Regulations.

2.105 A Licence may be suspended or withdrawn in accordance with the Authorisation Regulations.

2.106 If enforcement action by ComReg results in the suspension, withdrawal, or foreshortening of a Licence or part thereof, ComReg will not refund any fees (SAF or SUFs) already paid by the Licensee concerned in respect of such Licence.

2.3.9 Amending a MBSA Liberalised Use Licence

2.107 ComReg may amend any of the rights, obligations, conditions, and procedures relating to a Licence from time to time and in accordance with the Authorisation Regulations.

⁶⁹ That is, a reduction in the Licensee's assigned quantum of rights of use in the Award Spectrum.

2.3.10 Other Considerations

Potential Collaboration Agreements between Wireless Operators

2.108 ComReg's most recent consideration of the issues associated with potential collaboration agreements between wireless operators (such as spectrum pooling, spectrum sharing and network sharing) is set out in Section 7.4.2 of its Radio Spectrum Management Strategy – 2016 to 2018 (Document 16/50).

2.4 The MBSA2 Preparatory Licences – Terms and Conditions

2.109 Winning Bidders will be entitled to apply for a MBSA2 Preparatory Licence, which will allow the holders of such licences to install networks and associated equipment in advance of the commencement date of their MBSA2 Liberalised Use Licence, but will not allow any wireless telegraphy transmissions⁷⁰.

2.110 The following outlines the principal terms and conditions associated with a MBSA2 Preparatory Licence. These terms and conditions are set out in the draft MBSA2 Licence Regulations.

2.4.1 Entitlement to Apply for a MBSA2 Preparatory Licence

2.111 In accordance with the rules for the Notification and Grant Stage as discussed in Section 3.7 of this Information Memorandum, Winning Bidders will be entitled to apply for a MBSA2 Preparatory Licence.

2.4.2 Scope of a MBSA2 Preparatory Licence

2.112 A MBSA2 Preparatory Licence allows the Licensee to keep and have possession of, install and maintain Apparatus for terrestrial systems capable of providing electronic communications services in the Award Spectrum. It is a condition of a MBSA2 Preparatory Licence that the Licensee shall not work or use said Apparatus⁷¹.

2.113 It is a "Non-exclusive" Licence for the national territory of the State and all Apparatus licensed under the MBSA2 Preparatory Licence is required to

⁷⁰ If a licensee wishes to test equipment then they must apply for a separate test licence as applicable.

⁷¹ If a Licensee wishes to test equipment, they must apply separately to ComReg for a test licence (see <https://testandtrial.ie/> in that regard).

comply with, among other things, the relevant EC or ECC decisions, including:

- EC Decision 2016/687 in respect of the 700 MHz Duplex;
- EC Decision 2012/688 in respect of the 2.1 GHz Band;
- ECC Decision 14(02) in respect of the 2.3 GHz Band; and
- EC Decision 2008/477 in respect of the 2.6 GHz Band.

2.4.3 MBSA2 Preparatory Licence – Duration and Renewal

2.114 The duration of a MBSA2 Preparatory Licence is set by reference to its commencement and expiry dates.

2.115 Before a MBSA2 Preparatory Licence will be granted to a Winning Bidder, it must pay the SAF associated with its MBSA2 Liberalised Use Licence (see also Section 2.4.5 below in respect of the administrative fee). Consequently, the commencement date of a MBSA2 Preparatory Licence will be defined by reference to the timing of the Award Process and the Notification and Grant Stage as discussed in Section 3.7 of this document.

2.116 The expiry date of a MBSA2 Preparatory Licence will be set by reference to the latest commencement date of a Lot in the Licensee's MBSA2 Liberalised Use Licence.

2.4.4 Licence Conditions Applicable to all MBSA2 Preparatory Licences

2.117 The conditions associated with a MBSA2 Preparatory Licence are set out in Schedule 3 of the draft MBSA2 Licence Regulations.

2.4.5 Fees for a MBSA2 Preparatory Licence

2.118 An administrative fee of €100.00 will be payable to ComReg prior to the issue of a MBSA2 Preparatory Licence.

2.119 In addition, before a MBSA2 Preparatory Licence will be issued, Winning Bidders must pay the SAF associated with its MBSA2 Liberalised Use Licence.

2.4.6 Enforcement Actions – Compliance with Licence Conditions, Licence Suspension and Licence Withdrawal

2.120 ComReg will enforce conditions attached to a MBSA2 Preparatory Licence in accordance with its statutory powers, including those set out in the Authorisation Regulations.

2.121 A MBSA2 Preparatory Licence may be suspended or withdrawn in accordance with the Authorisation Regulations.

2.4.7 Amendment of a MBSA2 Preparatory Licence

2.122 ComReg may amend the rights, obligations and procedures relating to a MBSA2 Preparatory Licence from time to time in accordance with the Authorisation Regulations.

2.4.8 The MBSA2 Licence Regulations and Indicative MBSA2 Preparatory Licence

2.123 The MBSA2 Licence Regulations provide for the issuing of a MBSA2 Preparatory Licence on foot of this Award Process. Among other things, the MBSA2 Licence Regulations specify the:

- duration of a MBSA2 Preparatory Licence;
- conditions of a MBSA2 Preparatory Licence; and
- MBSA2 Preparatory Licence fees.

2.124 An indicative MBSA2 Preparatory Licence is set out in Schedule 3 of the MBSA2 Licence Regulations.

- Part 1 of Schedule 3 sets out further licence conditions associated with the MBSA2 Preparatory Licence; and
- Part 2 of Schedule 3 sets out the Statement of Authorised Apparatus associated with the MBSA2 Preparatory Licence.

2.5 MBSA2 2.3 GHz Band Transition Licence – Terms and Conditions

2.125 Following the Award Process, an Existing 2.3 GHz Band Licensee⁷² may be required to make adjustments to their existing networks (referred to as “Transition Activities”) in order to comply with the outcome of the Award Process if they wish to continue to provide services in the 2.3 GHz Band.

2.126 Subject to certain conditions, an Existing 2.3 GHz Band Licensee will be able to apply for a MBSA2 2.3 GHz Band Transition Licence in order to facilitate the timely and orderly completion of its Transition Activities in line with the MBSA2

⁷² Eir is currently the only Existing 2.3 GHz Band Licensee.

2.3 GHz Band Transition Plan as provided for in Section 3.8 of this document.

2.127 The following describes the principal terms and conditions associated with the MBSA2 2.3 GHz Band Transition Licence. These terms and conditions are set out in the draft MBSA2 Licence Regulations.

2.5.1 Entitlement to apply for a MBSA2 2.3 GHz Band Transition Licence

2.128 To be entitled to apply for a MBSA2 2.3 GHz Transition Licence, the following preconditions apply, namely that the undertaking:

- is an Existing 2.3 GHz Band Licensee; and
- agrees to take appropriate measures that will ensure migration of its RurTel customers to an alternative platform/s in a timely, efficient and orderly manner.

2.129 An undertaking will only be able to apply for a MBSA2 2.3 GHz Band Transition Licence for point-to-multipoint radio links as specified in Parts 1 and 2 of Schedule 4 of the draft MBSA2 Licence Regulations. MBSA2 2.3 GHz Band Transition Licences shall only be granted for the corresponding duplex frequencies, and for equipment with the same functionality, as currently licensed under the undertaking's Existing 2.3 GHz Band Licence(s).

2.5.2 Scope of a MBSA2 2.3 GHz Band Transition Licence

2.130 A MBSA2 2.3 GHz Band Transition Licence allows the Licensee to keep and have possession of, install, maintain, work and use Apparatus for point to multi-point radio links for the provision of RurTel Services in the 2.3 GHz Band.

2.131 A MBSA2 2.3 GHz Band Transition Licence is also a "Non-exclusive" Licence for point to multi-point radio links as specified in Parts 1 and 2 of Schedule 4 of its MBSA2 Liberalised Use Licence and all Apparatus licensed under the MBSA2 2.3 GHz Band Transition Licence is required to comply with, among other things, the conditions in the Licence and the draft MBSA2 Licence Regulations.

2.5.3 MBSA2 2.3 GHz Band Transition Licence – Duration and Renewal

2.132 The duration of the MBSA2 2.3 GHz Transition Licence is set by reference to its commencement and expiry dates.

- 2.133 The commencement date of a MBSA2 2.3 GHz Transition Licence will be 1 December 2020, or such other date as determined by ComReg.
- 2.134 The expiry date of a MBSA2 2.3 GHz Transition Licence will be determined by ComReg by reference to the completion of the Licensee's Transition Activities.
- 2.135 Once issued, the duration of a MBSA2 2.3 GHz Transition Licence may be amended by ComReg in accordance with the provisions of the Authorisation Regulations.

2.5.4 Licence Conditions Applicable to all MBSA2 2.3 GHz Transition Licences

- 2.136 The terms and conditions of a MBSA2 2.3 GHz Band Transition Licence will be similar to those for the Existing 2.3 GHz Band Licence, except that:
- the duration and the frequency assignment will be determined and amended by ComReg, as appropriate, in order to facilitate the completion of any Transition Plan in the 2.3 GHz Band; and
 - the Licensee will be subject to any co-channel inter-operator coordination procedure determined by ComReg.
- 2.137 The conditions associated with a MBSA2 2.3 GHz Band Transition Licence are set out in Schedule 4 of the draft MBSA2 Licence Regulations. Among other things, Schedule 4 of the MBSA2 Licence Regulations sets out conditions in relation to ensuring that the Apparatus, or any part thereof, complies with the provisions of the European Union (Radio Equipment) Regulations 2017.
- 2.138 It is also a condition of a MBSA2 2.3 GHz Transition Licence that the Licensee submit up to date information to ComReg in respect of Parts 1 and Part 2 of its MBSA2 2.3 GHz Transition Licence in advance of its Licence commencement date and on or before the anniversary of that date each year that the Licence is in force.
- 2.139 It is ComReg's intention to publish details of MBSA2 2.3 GHz Transition Licences, including information contained in Part 1 and Part 2, on its website subject to the assessment of confidential information in line with ComReg Document 05/24.

2.5.5 Fees for a MBSA2 2.3 GHz Band Transition Licence⁷³

2.140 The annual fee for a MBSA2 2.3 GHz Band Transition Licence is the higher of either:

- the existing fees set out in the Wireless Telegraphy (Radio Link Licence) Regulations (S.I. No. 370 of 2009) but updated to present day prices using the overall CPI (“**MBSA2 2.3 GHz Band Transition Licence Price A**”); or
- a reasonable approximation of the opportunity cost of RurTel Services remaining in the 2.3 GHz Band beyond the commencement date of new rights of use in the 2.3 GHz Band (“**MBSA2 2.3 GHz Band Transition Licence Price B**”).

2.141 **MBSA2 2.3 GHz Band Transition Licence Price A** would be based on an Annual Fee (€) of €1,060 per point to point link and €4,240 for a point to multi-point radio link (i.e. four (4) times the annual fees (€) for a point to point radio link)⁷⁴.

2.142 **MBSA2 2.3 GHz Band Transition Licence Price B** would be calculated as follows:

- sum the SAF paid by each Winning Bidder to obtain the total SAF for the winning outcome in Award Process.
- allocate the total SAF for the Award to each Lot Category in proportion to Round Prices in the Final Primary Bid Round – this gives an estimate for the value associated with each Lot Category.
- for each of the 2.3 GHz Band Lot Categories, in each of the two Time Slices, divide the allocated SAF (i.e. estimate for the value associated with each Lot Category) by the number of Lots in the Lot Category sold to give an estimate of the average value per Lot for that Lot Category. This provides an estimate for the value of the following Lot Categories:
 - A2.3L/1
 - A2.3L/2

⁷³ By way of background, readers are referred to Section 9.3.2 of Document 19/59R (and as also summarised in paragraphs 8.26 – 8.27 of Document 19/124)

⁷⁴ This is based on Table 1 of S.I. No. 370 of 2009 where the fee associated with a frequency (1 GHz < F < 17 GHz) and a bandwidth ≤3.5 MHz was indexed to CPI for the period September 2009 to January 2020.

- B2.3/1
- B2.3/2
- add the estimated value for B2.3/1 and B2.3/2 to give an “*average estimated value for a 2.3 GHz Generic Frequency Lot*” for the full duration over both Time Slices.
- add the estimated value for A2.3L/1 and A2.3L/2 to give an “*average estimated value for the 2.3 GHz Fixed Frequency Lot (Lower)*” for the full duration over both Time Slices.
- add the discounted sum of SUFs for B2.3/1 and B2.3/2 to the *average estimated value for a 2.3 GHz Generic Frequency Lot* to give a total estimated value for a 2.3 GHz Generic Frequency Lot in the Award. This represents an estimate of the *Current market value of a 2.3 GHz Generic Frequency Lot*.
- add the discounted sum of SUFs for A2.3L/1 and A2.3L/2 to the *average estimated value for the 2.3 GHz Fixed Frequency Lot (Lower)* to give a total estimated value for the 2.3 GHz Fixed Frequency Lot (Lower) in the award. This represents the *Current estimated value of the 2.3 GHz Fixed Frequency Lot (Lower) Lot* in the 2.3 GHz Band.
- using a 20 year Licence duration, amortise the *Current estimated value of a 2.3 GHz Generic Frequency Lot* to give an *annual estimated value of the 2.3 GHz Generic Frequency Lot*.
- using a 20 year Licence duration, amortise the *Current estimated value of the 2.3 GHz Fixed Frequency Lot (Lower) Lot* to give an *annual estimated value of the 2.3 GHz Fixed Frequency Lot (Lower)*.
- calculate the difference between the *annual estimated value of the 2.3 GHz Generic Frequency Lot* multiplied by six and the *annual estimated value of the 2.3 GHz Fixed Frequency Lot (Lower)*. This is the value for **MBSA2 2.3 GHz Band Transition Licence Price B**⁷⁵.

2.143 Where spectrum rights for a MBSA2 2.3 GHz Band Transition Licence are granted for a portion of a year, the fee to be paid by the Licensee for that year will be based on the relevant fee (i.e. either Price A or Price B) and shall be calculated as $A \times (B/12) = C$, where:

⁷⁵ This value would be adjusted annually in line with the population of State which remains affected by the MBSA2 2.3 GHz Band Transition Licence.

- A is the relevant annual fee set out in paragraphs 2.141 and 2.142 above;
- B is the number of whole months for which the spectrum rights for a MBSA2 2.3 GHz Transition Licence are granted (if granted for a period of less than one month then, for the purpose of these calculations only, they shall be considered as a being granted for a period of one month); and
- C is the appropriate fee to be paid.

2.144 Additionally, before a MBSA2 2.3 GHz Band Transition Licence will be issued, a Winning Bidder must pay the SAF associated with its MBSA2 Liberalised Use Licence (if applicable).

2.145 ComReg may refund or adjust Licence fees payable by a MBSA2 2.3 GHz Band Transition Licensee where it has fully transitioned out of the 2.3 GHz Band to the satisfaction of ComReg prior to the expiry of a MBSA2 2.3 GHz Band Transition Licence. The refund of fees payable to a MBSA2 2.3 GHz Band Transition Licensee shall be calculated as a pro-rata portion of the annual fee already paid on a daily basis for each whole day following the transition from the 2.3 GHz Band.

2.5.6 Enforcement Actions – Compliance with Licence Conditions, Licence Suspension and Licence Withdrawal

2.146 ComReg will enforce conditions attached to a 2.3 GHz Band Transition Licence in accordance with its statutory powers, including those set out in the Authorisation Regulations.

2.147 A MBSA2 2.3 GHz Band Transition Licence may be suspended or withdrawn in accordance with the Authorisation Regulations.

2.148 In the event that enforcement action by ComReg results in the suspension, withdrawal (or foreshortening) of a MBSA2 2.3 GHz Band Transition Licence, no Licence fees paid in connection with that MBSA2 2.3 GHz Band Transition Licence will be refundable.

2.5.7 Amendment of a MBSA2 2.3 GHz Band Transition Licence

2.149 ComReg may amend the rights, obligations and procedures relating to a MBSA2 2.3 GHz Transition Licence from time to time in accordance with the Authorisation Regulations.

2.5.8 The draft MBSA2 Licence Regulations and Indicative MBSA2 2.3 GHz Transition Licence

2.150 The MBSA2 Licence Regulations provide for the issuing of a MBSA2 2.3 GHz Transition Licence on foot of this Award Process. Among other things, the MBSA2 Licence Regulations specify the:

- duration of a MBSA2 2.3 GHz Transition Licence;
- conditions of a MBSA2 2.3 GHz Transition Licence; and
- MBSA2 2.3 GHz Transition Licence Fees.

2.151 An indicative MBSA2 2.3 GHz Transition Licence is set out in Schedule 4 of the MBSA2 Licence Regulations.

2.6 The MBSA2 Spectrum Lease Licence

2.152 The purpose of the MBSA2 Spectrum Lease Licence is to facilitate the leasing of spectrum rights in accordance with such procedures as may be specified by ComReg under Regulation 19 of the Framework Regulations.

2.153 The following describes the principal terms and conditions associated with the MBSA2 Spectrum Lease Licence. These terms and conditions are set out in Schedule 2 of the draft MBSA2 Licence Regulations.

2.6.1 Entitlement to apply for a MBSA2 Spectrum Lease Licence

2.154 A MBSA2 Spectrum Lease Licence may be applied for in accordance with such procedures as may be specified by ComReg under Regulation 19 of the Framework Regulations.

2.6.2 Scope of the MBSA2 Spectrum Lease Licence

2.155 A MBSA2 Spectrum Lease Licence allows the Licensee to keep and have possession of, install, maintain, work and use Apparatus for terrestrial systems capable of providing ECS in the Award Spectrum.

2.156 A MBSA2 Spectrum Lease Licence is a “Non-exclusive” Licence for one or more specific areas of the State and as set out in the schedule to same, and all Apparatus licensed under the MBSA2 Spectrum Lease Licence are required to comply with, among other things, the relevant EC and ECC decisions, including:

- EC Decision 2016/687 in respect of Lots available in the 700 MHz Duplex;
- EC Decision 2012/688 in respect of Lots available in the 2.1 GHz Band;
- ECC Decision 14(02) in respect of Lots available in the 2.3 GHz Band; and
- EC Decision 2008/477 in respect of Lots available in the 2.6 GHz Band.

2.6.3 MBSA2 Spectrum Lease Licence Duration and Renewal

2.157 The duration of a MBSA2 Spectrum Lease Licence is set by reference to its commencement and expiry dates as detailed in the Licence. These dates will be determined in accordance with such procedures as may be specified by ComReg under Regulation 19 of the Framework Regulations.

2.6.4 Licence Conditions Applicable to all MBSA2 Spectrum Lease Licences

2.158 The conditions associated with a MBSA2 Spectrum Lease Licence are set out in Schedule 2 of the draft MBSA2 Licence Regulations. Among other things, Schedule 2 of the draft MBSA2 Licence Regulations sets out conditions in relation to ensuring that the Apparatus or any part thereof, complies with the European Union (Radio Equipment) Regulations 2017.

2.159 It is also a condition of a MBSA2 Band Spectrum Lease Licence that the Licensee submit up to date information to ComReg in respect of Parts 2 and 3 of its MBSA2 Spectrum Lease Licence in advance of its licence commencement date and on or before the anniversary of that date each year that the Licence is in force. Part 2 and Part 3 of the MBSA2 Spectrum Lease Licence details the Apparatus to which the Licence relates and the location of each Apparatus.

2.160 It is ComReg's intention to publish details of MBSA2 Spectrum Lease Licences, including information contained in Part 2 and Part 3, on its website subject to the assessment of confidential information in line with ComReg Document 05/24.

2.6.5 Fees for a MBSA2 Spectrum Lease Licence

2.161 The fee for a MBSA2 Spectrum Lease Licence will be determined in accordance with such procedures as may be specified by ComReg under

Regulation 19 of the Framework Regulations.

2.162 Additionally, before a MBSA2 Spectrum Lease Licence will be issued, Winning Bidders must pay the SAF associated with its MBSA2 Liberalised Use Licence.

2.6.6 Enforcement Actions – Compliance with Licence Conditions, Licence Suspension and Licence Withdrawal

2.163 ComReg will enforce conditions attached to a MBSA2 Spectrum Lease Licence in accordance with its statutory powers, including those set out in the Authorisation Regulations.

2.164 A MBSA2 Spectrum Lease Licence may be suspended or withdrawn in accordance with the Authorisation Regulations.

2.165 In the event that enforcement action by ComReg results in the suspension, withdrawal (or foreshortening) of a MBSA2 Spectrum Lease Licence, no Licence fees paid in connection with the MBSA2 Spectrum Lease Licence will be refundable.

2.6.7 Amendment of a MBSA2 Spectrum Lease Licence

2.166 ComReg may amend the rights, obligations and procedures relating to a MBSA2 Band Spectrum Lease Licence from time to time in accordance with the Authorisation Regulations.

Chapter 3

3 The Award Process

- 3.1 This chapter provides an overview of the various stages of the Award Process and sets down rules around the structure of Bidding Groups and Bidder behaviour during the Award Process. The detailed rules that apply to the Auction stages of the Award Process are described in Chapter 4.
- 3.2 For the purpose of this document, and for the Award Process, the term:
- “Award Rules” shall refer to the rules and procedures relating to the Award Process, as presented in Chapters 3 and Chapter 4 of this Information Memorandum, and to any other material to which the rules in Chapters 3 and 4 directly refer; whereas
 - “Auction Rules” shall refer to the rules and procedures relating specifically to the Auction itself, as presented in Chapter 4 only, and to any other material to which the rules in Chapter 4 directly refer.
- 3.3 While Chapter 3 provides a description of some Auction Rules, in particular in Sections 3.5 and 3.6 below, to the extent that there is any inconsistency between the description of the rules set out in this chapter and the Auction Rules set out in Chapter 4, the description set out in Chapter 4 prevails.
- 3.4 For the avoidance of doubt, references throughout this Information Memorandum to ComReg using its discretion shall mean ComReg exercising such discretion acting reasonably and in accordance with its statutory functions, objectives and duties.

3.1 Lots Available

- 3.5 The available spectrum rights of use will be awarded on a national basis, using the band plans set out in Section 2.2 of this document.
- 3.6 A total of 103 Lots across the Award Spectrum will be available.
- 3.7 There are two Lot Types:
- **A-Lots** – comprising 8 fixed frequency Lots; and
 - **B-Lots** – comprising 95 frequency-generic Lots.
- 3.8 B-Lots will first be Bid for on a frequency-generic basis. That is, demand for B-

Lots expressed⁷⁶ by Bidders will be for blocks of spectrum within the frequency ranges outlined below but which do not have specific frequencies associated with them. The specific frequency assignments for the B-Lots will subsequently be determined in a separate Assignment Stage.

- 3.9 All A-Lots have a fixed frequency range associated with them and therefore will not be included in the Assignment Stage.
- 3.10 The 700 MHz Duplex Lots are being made available in one temporal period from 1 December 2020 (or some later date as may be specified by ComReg in accordance with the provisions set out in Chapter 2) to 30 November 2040.
- 3.11 The 2.1 GHz Band Lots are being made available in two distinct time periods (called “Time Slices”) as follows:
- **Time Slice 1:** 16 October 2022 to 11 March 2027; and
 - **Time Slice 2:** 12 March 2027 to 30 November 2040⁷⁷.
- 3.12 All remaining Lots are also being made available in two distinct Time Slices as follows:
- **Time Slice 1:** 1 December 2020 (or some later date as may be specified by ComReg in accordance with the provisions set out in Chapter 2) to 11 March 2027; and
 - **Time Slice 2:** 12 March 2027 to 30 November 2040⁷⁸.
- 3.13 Therefore, for the Main Stage of the Award Process, Lots will be divided into 17 **Lot Categories** where the suffix “/1” or “/2” indicates the relevant Time Slice.
- 3.14 Table 16 and Table 17 below provide an overview of the Lot Categories within each of the A-Lots and B-Lots respectively, identifying for each Lot Category:
- the frequency range for the Lot(s) in that Lot Category;

⁷⁶ This includes Initial Bids as expressed in the Application Form. A Bidder’s Initial Bid is the Package defined by the Lots specified by the Bidder on its Initial Bid Form and the corresponding Bid Amount calculated as the sum of the Reserve Prices for the Lots specified on the Bidder’s Initial Bid Form.

⁷⁷ Or such other date(s) as may be specified by ComReg in accordance with the provisions set out in Chapter 2.

⁷⁸ Or such other date(s) as may be specified by ComReg in accordance with the provisions set out in Chapter 2.

- the Licence duration associated with Lots in that Lot Category;
- the Time Slice pertaining to the Lot Category;
- the number of Lots available in that Lot Category;
- the size of each Lot (in MHz) in that Lot Category;
- the Reserve Price⁷⁹ per Lot for Lots in that Lot Category and the associated annual Spectrum Usage Fees (SUFs) before Indexation; and;
- the number of Eligibility Points associated with a Lot in that Lot Category for the purpose of applying the Activity Rules in the Main Stage of the Auction⁸⁰.

⁷⁹ Licences are awarded subject to payment of the SAF determined by the Award Process and the first applicable SUF payment. The Reserve Price indicates the minimum SAF for each Lot included in the Licence and does not include the first or any subsequent payment of SUFs.

⁸⁰ The Eligibility Points are used to rank different combinations of Lots (or Packages) in order to assess demand and implement the Activity Rules. The Eligibility of a Package is equal to the sum of Eligibility Points of all the Lots included in the Package. The Activity Rules constrain the amount that Bidders can offer when bidding for Packages with greater Eligibility than their earlier Bids. However, Bidders can still bid for such Packages subject to these constraints being met. Further details are provided in Section 3.5 and Section 4.2.

Table 16: Fixed Frequency A-Lots available in the Award Process

Lot Category	Frequency range	Licence duration ⁸¹	Time Slice	Lots available	Lot size	Reserve Price per Lot (€)	Annual SUF per Lot (€)	Eligibility Points/Lot
A2.3L/1	2300 – 2330 MHz	01/12/2020 to 11/03/2027	1	1	30 MHz	963,000	274,082	6
A2.3L/2	2300 – 2330 MHz	12/03/2027 to 30/11/2040	2	1	30 MHz	1,090,000	274,082	6
A2.3U/1	2390 – 2400 MHz	01/12/2020 to 11/03/2027	1	1	10 MHz	432,000	123,029	2
A2.3U/2	2390 – 2400 MHz	12/03/2027 to 30/11/2040	2	1	10 MHz	489,000	123,029	2
A2.6TL/1	2570 – 2575MHz unpaired	01/12/2020 to 11/03/2027	1	1	5 MHz	216,000	61,515	1
A2.6TL/2	2570 – 2575MHz unpaired	12/03/2027 to 30/11/2040	2	1	5 MHz	245,000	61,515	1
A2.6TU/1	2615 – 2620 MHz unpaired	01/12/2020 to 11/03/2027	1	1	5 MHz	216,000	61,515	1
A2.6TU/2	2615 – 2620 MHz unpaired	12/03/2027 to 30/11/2040	2	1	5 MHz	245,000	61,515	1

⁸¹ Note that, as discussed in subsection 2.3.3, the commencement and expiry dates of Lots in Time Slice 1 may be adjusted by ComReg.

Table 17: Frequency generic B-Lots available in the Award Process

Lot Category	Frequency range	Licence duration ⁸²	Time Slice	Number of Lots	Lot size	Reserve Price per Lot (€)	Annual SUF per Lot (€)	Eligibility Points/Lot
B700	703 – 733 MHz paired with 758 – 788 MHz	01/12/2020 to 30/11/2040	1 & 2	6	2 x 5 MHz	8,755,000	1,168,778	4
B2.1/1	1920 – 1980 MHz paired with 2110 – 2170 MHz ⁸³	16/10/2022 to 11/03/2027	1	9	2 x 5 MHz	1,416,000	615,147	2
B2.1/2	1920 – 1980 MHz paired with 2110 – 2170 MHz	12/03/2027 to 30/11/2040	2	12	2 x 5 MHz	2,447,000	615,147	2
B2.3/1	2330 – 2390 MHz	01/12/2020 to 11/03/2027	1	12	5 MHz	216,000	61,515	1
B2.3/2	2330 – 2390 MHz	12/03/2027 to 30/11/2040	2	12	5 MHz	245,000	61,515	1
B2.6F/1	2500 – 2570 MHz paired with 2620 – 2690 MHz	01/12/2020 to 11/03/2027	1	14	2 x 5 MHz	432,000	123,029	2

⁸² Note that, as discussed in subsection 2.3.3, the commencement and expiry dates of Lots in Time Slice 1 may be adjusted by ComReg.

⁸³ This does not include the three lots currently assigned to Eir.

B2.6F/2	2500 – 2570 MHz paired with 2620 – 2690 MHz	12/03/2027 to 30/11/2035	2	14	2 x 5 MHz	489,000	123,029	2
B2.6T/1	2575 – 2615 MHz	01/12/2020 to 11/03/2027	1	8	5 MHz	216,000	61,515	1
B2.6T/2	2575 – 2615 MHz	12/03/2027 to 30/11/2035	2	8	5 MHz	245,000	61,515	1

3.2 Process Overview and Timeline

3.15 The Award Process will comprise of the following stages:

- i. **Application Stage** (see Section 3.3 below) – Applicants must submit Applications to ComReg to participate in the Award Process. Such Applications must be made in accordance with the procedures described in Section 3.3 of this document. The Application must include an **Initial Bid** nominating a selection of Lots at Reserve Prices;
- ii. **Qualification Stage** (see Section 3.4 below) – ComReg will assess all Applications received in order to determine which Applicants are qualified to participate in the Award Process as Bidders. ComReg will also establish whether an Auction is necessary on the basis of the demand expressed by Bidders in their Initial Bids.
- iii. if required, an **Auction**, consisting of a Main Stage and/or an Assignment Stage, where:
 - o **the Main Stage** (see Section 3.5 below) determines the number of Lots to be awarded to each Bidder in each Lot Category, and the Base Prices that Winning Bidders will have to pay for their Lots. The Main Stage consists of:
 - one or more Primary Bid Rounds, during which Bidders express their demand for Lots at given Round Prices set by the Auctioneer each round;
 - a Supplementary Bids Round, in which Bidders can submit multiple, mutually-exclusive Bids for alternative Packages of Lots, with discretionary Bid Amounts (subject to the constraints described in Section 3.5.3 of this document); and
 - an announcement to all Bidders of the Winning Bidders and the number of Lots won by each Winning Bidder in each Lot Category and, for each Winning Bidder, its own Base Price⁸⁴.
 - o **Assignment Stage** (see Section 3.6 below) – if required for any band⁸⁵, which determines the specific frequencies to be assigned

⁸⁴ The Base Price is the price to be paid by a Winning Bidder for the Package of Lots assigned to it in the Main Stage of the Auction (determined using an Opportunity Cost rule).

⁸⁵ Where a Winning Bidder is assigned all B-Lots in a band, an Assignment Stage would not be required for that band. If for all bands there is either just a single Winning Bidder that has won all B-Lots or there is no Winning Bidder, then no Assignment Stage will be required.

to each Winning Bidder of frequency-generic B-Lots (i.e. Assignment Bidders) and the Additional Prices to be paid by each Assignment Bidder. The Assignment Stage consists of:

- if required⁸⁶, an Assignment Round, in which Assignment Bidders may bid for their preferred frequency assignments for the frequency-generic B-Lots won in the Main Stage. This provisionally⁸⁷ determines the specific frequencies to be assigned to each Assignment Bidder, which will be notified to all Assignment Bidders, along with each Assignment Bidder's own Additional Price that it must pay for its frequency assignment; and
 - a Negotiation Phase, in which Assignment Bidders can negotiate a re-organisation of the frequency assignments resulting from the Assignment Round (subject to restrictions and approval from ComReg).
- iv. **Notification and Grant Stage** (see Section 3.7 below) – ComReg will notify the Winning Bidders of their entitlement to apply for and be granted a Licence in accordance with the outcome of the Award Process, subject to certain conditions being met including the payment of fees.

3.16 This above process is illustrated in Figure 5 below.

3.17 If an Auction is necessary, an Electronic Auction System (EAS) will be used. This will provide Bidders an interface through which they must check and submit their Bids.

⁸⁶ If there is more than one feasible frequency assignment (Assignment Option) for at least one Assignment Bidder, the Assignment Stage will include an Assignment Round to determine the specific frequencies to be provisionally assigned to each Assignment Bidder.

⁸⁷ This is provisional in the sense that the subsequent Negotiation Phase could result in alternative frequency assignments.

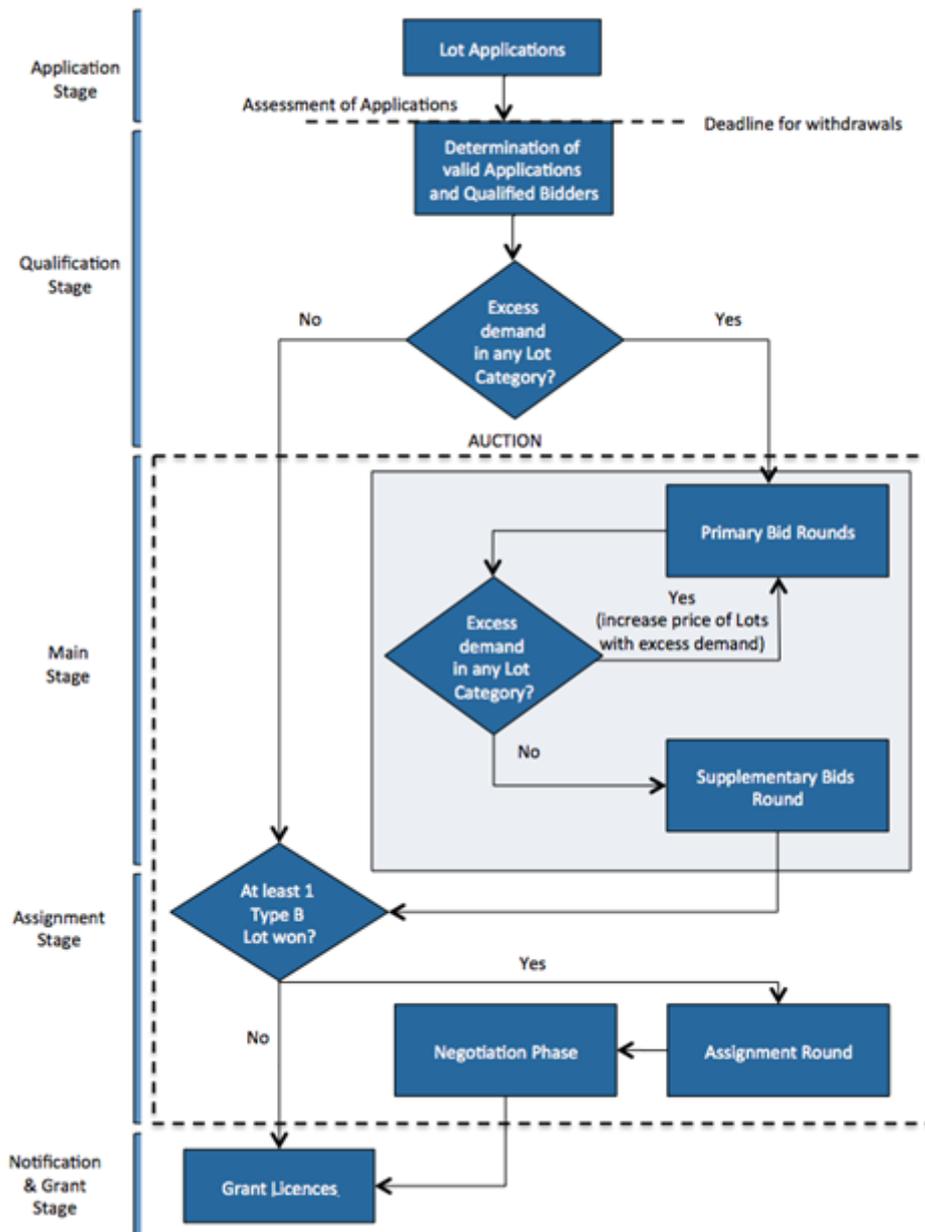


Figure 5: Overview of the Award Process⁸⁸

3.18 The indicative timeline for the first two stages of the Award Process (i.e. the Application Stage and the Qualification Stage) is set out in Table 18 below.

3.19 ComReg reserves the right to vary these indicative timelines as may be necessary, in order to take into account any changed or unforeseen circumstances. ComReg, in doing so, would give appropriate notice to Interested Parties (e.g. by issuing a public notice on its website or giving notice

⁸⁸ In relation to the “At least 1 B-Lot won?” test, some B-Lot Lot Categories may not be included in the Assignment Stage where a Winning Bidder is assigned all B-Lots in that Lot Category.

to selected parties, such as Applicants or Bidders, depending on the stage of the Award Process).

Table 18: Indicative timeline for the Award Process

Stage	Milestone	Indicative Timeline ⁸⁹
Application Stage	Publication of final IM on the ComReg website	X
	Presentation to Interested Parties on the Award Process and the Auction Rules	X + 3 weeks
	Deadline for submission of questions regarding the Award Process	X + 4 weeks
	Final date for ComReg to publish its responses to questions regarding the Award Process on its website	X + 6 weeks
	ComReg will accept calls for confirmation of the receipt of Deposits	X + 7 weeks
	Deadline for submission of completed Application Form	X + 8 weeks
	Deadline for receipt of Deposits	X + 8 weeks
	Restrictions on Award Process related communication come into effect	On submission of first Application to ComReg
	Qualification Stage	Deadline for withdrawal of Application
Each Applicant to be informed by ComReg about whether or not it has been successful in qualifying as a Bidder.		X + 14 weeks ⁹⁰

⁸⁹ Subject to change on publication of the final IM.

⁹⁰ ComReg reserves the right to bring this date forward.

	<p>Confirmation that:</p> <ul style="list-style-type: none"> • a Main Stage of the Auction is required and notification to Bidders of scheduled start date of the mock auctions; or • a Main Stage is not required but an Assignment Stage is required and notification to Winning Bidders of Winning Bids and scheduled start date of the mock auctions; or • neither a Main Stage or an Assignment Stage is required and notification to Winning Bidders of Winning Bids and progression to Notification and Grant Stage 	
	<p>Return of Deposits to Applicants who have not been successful in qualifying as a Bidder or who withdrew their Application.</p>	<p>X + 15 weeks</p>
	<p>Circulation of Bidder Materials for accessing and using the EAS and proceed to the start of mock auction for Bidders</p>	<p>X + 15 weeks</p>
<p>Main Stage (if required)</p>	<p>Auction to determine the Winning Bidder(s) for Lots and the Base Price to be paid</p>	<p>TBD</p>

Assignment Stage (if required)	Determination of the specific frequencies to be assigned to each Winning Bidder of frequency-generic B-Lots and the Additional Prices to be paid by each Assignment Bidder	TBD
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- 3.20 All references to a specific time of day in this IM are to Irish time.
- 3.21 ComReg is currently not in a position to announce with certainty the timing of the later stages of the Award Process as these will depend on the outcome of earlier stages in the Award Process⁹¹ and/or circumstances outside ComReg's control.
- 3.22 ComReg will provide further information on the timing of these later stages to the appropriate parties (e.g. Bidders, Winning Bidders) during the course of the Award Process. However, ComReg can confirm that, subject to developments outside its control, the timelines for these later stages will be in accordance with the provisions of this IM which, among other things, provides that:
- the start date of the Auction will be notified to Bidders with at least ten clear Working Days prior notice (see Section 3.4.1 of this document);
 - there will be at least three clear Working Days between the last Primary Bid Round and the start of the Supplementary Bids Round (see Section 4.2.3 of this document);
 - following the outcome of the Assignment Round (if required), a period of ten clear Working Days will be provided to Assignment Bidders to negotiate a re-organisation of the specific frequencies awarded in the Assignment Round, subject to a number of restrictions and approval from ComReg (see Section 4.3.10); and
 - upon completion of the Assignment Stage, ComReg will issue a communication to Winning Bidders and Existing Licensees of the specific frequency assignments determined by the Assignment Stage to inform the formulation of a Transition Plan (as further detailed in Section 3.8 of this document).

⁹¹ For example: the outcome of the Qualification Stage will determine whether there is a need for a Main Stage, the end of the Main Stage informs the start date of the Assignment Stage etc. (except where a Main Stage is not required but an Assignment Stage is).

3.3 Application Stage

- 3.23 The Award Process begins on the date of publication of this IM.
- 3.24 The deadline for all Interested Parties to submit their Applications to participate in the Award Process, together with the required monetary Deposit (the “**Application Date**”)⁹² is *[a time and date will be specified in the final Information Memorandum but will allow approximately 8 weeks to submit a complete and valid Application⁹³]*.
- 3.25 For an Application, in order to be deemed valid and complete, ComReg must have received the following:
- a completed Application Form⁹⁴;
 - receipt of a Deposit, in cleared funds, in ComReg’s Nominated Bank Account; and
 - any other documentation required to be annexed to the Application Form.
- 3.26 A writeable PDF format of the Application Form will be made available on the ComReg website.
- 3.27 A complete Application Form represents a binding offer to pay the SAF and annual SUFs linked to each of the Lots specified in this IM in exchange for a Licence for those Lots, in accordance with the outcome of the Award Process and the IM.
- 3.28 ComReg is mindful of the complexities involved in the Award Process. Accordingly, during the time between publication of this document and the deadline to submit an Application, ComReg will provide a presentation on the Award Process and Auction Rules. This presentation will seek to provide as much clarity around the Award Process and Auction Rules as possible, taking into account the fact that some Interested Parties may not have previously participated in any similar process. Further details will be published on ComReg’s website regarding this presentation and ComReg would welcome

⁹² ComReg is under no obligation to consider Applications that have not been submitted in full by the Application Date but reserves the right to do so.

⁹³ If the deadline for submitting an Application in this Information Memorandum and that published on ComReg’s website differ, the deadline for submitting an Applications published on ComReg’s website takes precedence.
ComReg is under no obligation to consider Applications that have not been submitted in full by this deadline.

⁹⁴ See Annex 3.

feedback from Interested Parties in advance of this presentation as to what would be useful to address. ComReg will also facilitate the submission of questions regarding the Award Process and Auction Rules and will respond publicly to these questions on an anonymised basis (see Section 3.3.1 below in this regard).

- 3.29 For logistics purposes, Interested Parties that wish to attend the presentation or view the presentation via the live webinar format must e-mail joseph.coughlan@comreg.ie and cc patrick.bolton@comreg.ie by *[a time and date will be specified in the final Information Memorandum]*, providing the name(s), and e-mail address(es) of those that wish to attend and indicating if attendance will be via webinar or in person.
- 3.30 An Interested Party that submits an Application is herein referred to as an Applicant.

Joint Bidding

- 3.31 Prior to the Application Date for the submission of Applications, Interested Parties can decide, if they wish, to bid jointly in the Award Process as a consortium. This consortium will be deemed to be a single entity for the purposes of the Award Process and, in the event of this single entity becoming a Winning Bidder in the Award Process, a MBSA2 Liberalised Use Licence would be issued to this consortium as a single entity. ComReg envisages that this could be a useful option for smaller potential Bidders. See further rules that apply to joint bidding in Section 3.3.5 below.

3.3.1 Questions

- 3.32 ComReg will facilitate the submission of written questions by Interested Parties in order to promote clarity and understanding of the Award Process and Auction Rules (see also Section 5.2.5 on errors).
- 3.33 All questions received in due time will be replied to on an ongoing basis and as far as possible within 10 Working Days. The deadline date for the submission of questions is *[a date will be specified in the final Information Memorandum]*. ComReg anticipates publishing all questions and associated answers no later than *[a date will be specified in the final Information Memorandum]*.
- 3.34 For this process, questions must be submitted in written, hardcopy format only and cannot be submitted in any electronic format⁹⁵. Questions should be

⁹⁵ ComReg may revisit this requirement as appropriate at the relevant time having regard to governmental public health measures to tackle the Covid-19 pandemic.

delivered by hand or courier to ComReg's offices and addressed as follows:

Mr Joseph Coughlan (RE: MBSA2 Award Process)
Cc Mr Patrick Bolton
Market Framework Division
Commission for Communications Regulation
One Dockland Central
Guild Street
Dublin 1
Ireland
D01 E4X0

- 3.35 Questions should be submitted in a sealed envelope. Interested Parties submitting questions control delivery of any submission, including the anonymity of same. Please ensure that the envelope does not contain any marks which could identify the Interested Party. Interested Parties are required to identify themselves on the question sheet within the sealed envelope.
- 3.36 Receipt of questions will be acknowledged by ComReg.
- 3.37 ComReg will publish all questions together with their associated responses on an anonymous basis on its website.
- 3.38 ComReg reserves the right, where appropriate, to amend any previous responses to questions made by it up until *[a date will be specified in the final Information Memorandum]*, such that responses made before this date are for general guidance only and should not be considered as final, or be relied upon, until *[a date will be specified in the final Information Memorandum]*.

3.3.2 Application Form and Supporting Documents

- 3.39 Each Applicant must complete and sign the Application Form in Annex 3.
- 3.40 The Application Form consists of 3 parts:
- Part 1: Administrative Information;
 - Part 2: Applicant Declaration; and
 - Part 3: Initial Bid Form.
- 3.41 Part 1 of the Application Form concerns Administrative Information and requires the Applicant to provide, among other things, details of the person(s) identified as its direct point of contact for the purposes of the Award Process. In

completing this part of the Application Form, the Applicant must also submit appropriate evidence that the persons signing the Application Forms and the persons bidding on behalf of the Applicant (“**Authorised Agents**”) are duly authorised by the Applicant to do so. Appropriate evidence would include:

- where the Applicant is incorporated in the EU, evidence that the Authorised Agents are registered pursuant to the appropriate national implementing measures transposing Article 10 of Directive 2009/101/EC (Regulation 7 of S.I. 306 of 2014 in Ireland);
- a board resolution from an Applicant which is a company registered in Ireland;
- an irrevocable power of attorney; or
- equivalent evidence in respect of an Applicant from outside Ireland, supported by a legal opinion from a law firm in its jurisdiction, carrying in excess of €20,000,000 in professional indemnity insurance, addressed to ComReg, certifying that the Authorised Agents are entitled to bind the Applicant contractually.

3.42 The ‘Applicant Declaration’ in Part 2 of the Application Form, which must be signed by the Applicant or by a person duly authorised to sign the Applicant Declaration on behalf of the Applicant, requires the Applicant to agree to be bound by among other things:

- the provisions regarding agreements with third parties;
- the Award Rules relating to confidentiality;
- the rules around Applicant / Bidder behaviour applying for the duration of the Award Process⁹⁶;
- the Auction Rules; and
- the Transition Rules which form part of the Award Rules.

3.43 Part 3 of the Application Form, entitled “**Initial Bid Form**”, provides a table containing, for each Lot Category, the:

- Lot Category name;
- frequency range associated with the Lot Category;

⁹⁶ Which apply in addition to but without prejudice to Irish and EU competition law.

- Licence duration associated with Lots in the Lot Category;
- Time Slice pertaining to the Lot Category;
- number of Lots available in the Lot Category;
- size of each Lot (in MHz) in the Lot Category;
- Reserve Price per Lot (€) in the Lot Category;
- Annual SUF per Lot (€) in the Lot Category;
- Number of Eligibility Points per Lot in the Lot Category; and
- number of Lots applied for by the Applicant in the Lot Category.

3.44 Details of the Lot available are set out in Section 3.3.1 above.

3.45 On its Initial Bid Form, an Applicant must specify the number of Lots in each Lot Category it is willing to buy at the applicable Reserve Price. This selection of Lots at the Reserve Prices will be the Bidder's Initial Bid. In the event that the Main Stage of the Auction is not required, each Bidder will be awarded the Lots included in its Initial Bid. In the event that the Main Stage of the Auction is required, the Initial Bid will remain as a binding Bid that could become a Winning Bid. The Initial Bid is also relevant to the application of the Activity Rules for the Main Stage, as discussed below.

3.46 In order for an Application to be valid, it must include information regarding the ownership structure of the Applicant ("**Ownership Structure Document**").

3.47 Accompanying the Ownership Structure Document the Applicant must provide a document that:

(a) certifies to the best of its knowledge that the Ownership Structure Document is a detailed, complete and clear overview of its ownership structure;

(b) certifies that the Applicant's ownership structure complies with the rules set out in Section 3.3.5; and

(c) lists the Applicant's Insiders (as the term is defined at paragraph 3.75 below).

3.48 If at any point during the Award Process an Applicant/Bidder is found by ComReg to have submitted information on its ownership structure which is

materially incomplete or incorrect, ComReg shall have the discretion to take whatever measures it deems appropriate, including requiring Applicants/Bidders to verify information already provided and/or to provide additional information and supporting evidence. If ComReg is unable to determine to its reasonable satisfaction that two or more Applicants/Bidders are not connected or associated (in the terms as set out in Section 3.3.5) on the basis of information provided to it, it reserves the right to treat those Applicants/Bidders as being connected or Associated.

- 3.49 Applications are subject to Competition Caps (see Section 4.1.3). If an Application Form includes Lots that, if awarded, would exceed the relevant Competition Caps, ComReg may, at its discretion, contact the particular Applicant and seek to resolve the issue by having the Applicant amend its Initial Bid Form. If ComReg is unable to resolve the issue in this manner, ComReg shall reject the Application on the basis that it is invalid and shall notify the Applicant of its decision.
- 3.50 A completed valid Application Form represents an unconditional offer to buy the number of Lots specified by the Applicant in its Initial Bid Form, at the Reserve Prices, and to discharge the related SUFs over the term of the Licence.
- 3.51 In addition, in submitting its Application Form, an Applicant agrees to be bound by the terms and conditions of the Award Process as set out in this IM which, among other things, include the following:
- its acknowledgement that the commencement date of Lots may be delayed as specified by ComReg;
 - to the extent permitted by law, its agreement that ComReg's aggregate liability for all losses or damages of any nature arising from delayed access to Lots is expressly limited to the refunds or adjustments of Licence fees as set out in Section 2.3.7 of this Information Memorandum;
 - its agreement that in the event that it identifies or suspects an error or omission in the rules of the Award Process or the implementation of these rules by the EAS it shall notify ComReg at the earliest opportunity;
 - its agreement that if it becomes a Winning Bidder it will participate as required by the Award Rules and be bound by the outcome of the Assignment Stage;
 - its agreement that if it becomes a Winning Bidder, then its failure to obtain consents, approvals, Apparatus or funding necessary to deploy

a network or complete Transitional Activities shall be deemed to be a breach of the Award Rules by that Winning Bidder; and

- its agreement to participate in the development of the Transition Plan and to be bound by the Transition Rules of the Award Process.

3.3.3 Requests for a change in the content of an Application

3.52 Where Applicants wish to change any aspect of their Application, they should contact the persons referred to in paragraph 3.34 outlining the nature of the change and justification for same. The Applicant must set out in detail the reasons for the proposed change and the information which became available since its original Application that necessitated the change. ComReg will have regard to the information provided by the Applicant in determining whether any changes are permitted. ComReg reserves the right not to accept changes submitted after the Application Date.

3.3.4 Deposits

3.53 An Applicant must submit a monetary Deposit with its Application. The required amount of the Deposit shall at least correspond to the sum of the Reserve Prices of Lots requested by the Applicant in its Initial Bid Form.

3.54 All Deposits must be transferred only to the bank account nominated by ComReg as specified in the Application Form and must be received as cleared funds in that bank account before *[a date will be specified in the final Information Memorandum]*. Applicants/Bidders are cautioned to ensure that the cleared funds received by ComReg are required to be the amount of the Deposit specified in euro. Applicants/Bidders should ensure that the amount of funds received by ComReg is not diminished by bank charges, exchange rate fluctuations or similar matters. Please note that the bank account details provided in the Application Form are different to those used for other ComReg payments. Applicants/Bidders should ensure that Deposits are made to the bank account specified in this IM.

3.55 ComReg currently intends to use all monies received from each Applicant to purchase NTMA Exchequer Notes⁹⁷. Interest, if earned⁹⁸, will be paid by ComReg on funds held by it during the Award Process and Applicants will

⁹⁷ However, as noted previously, ComReg reserves the right to manage all monies held in accordance with good treasury management.

⁹⁸ The current rate of interest on NTMA Exchequer Notes is zero per cent. However, the rate of interest associated with the NTMA Exchequer Notes may be negative. In such circumstances, ComReg reserves the rights to calculate the refund paid to the Winning Bidder to be less the amount of negative interest accrued over the period a Deposit has been held by ComReg.

receive any interest accrued, if earned, less any financial fees and related taxation if applicable.

- 3.56 If a Deposit Call is issued (see Sections 4.2.2, 4.2.4 and 4.3.7), ComReg will specify a time period of not less than three consecutive Working Days during which the notified Bidder's additional Deposit funds must be received by ComReg as cleared funds in its nominated bank account (as specified in Annex 3).
- 3.57 If any Bidder who is subject to a Deposit Call does not provide the required additional cleared Deposit funds by the set deadline, ComReg at its discretion may void the Bidder's Bids.
- 3.58 Where any part of this IM indicates that:
- an Applicant or Bidder may in part or whole forfeit its Deposit; and/or
 - ComReg may impose a sanction on an Applicant/Bidder that includes forfeiture of all or part of the Deposit paid by that Applicant/Bidder on Application,

ComReg will adopt a proportionate and fair approach taking into account its statutory objectives and the circumstances of each case (including the nature and seriousness of any breach or non-compliance).

- 3.59 Where an Applicant/Bidder wishes to confirm receipt of a Deposit, it should contact **Mr. Joseph Coughlan** (copying **Mr. Patrick Bolton**) by letter using the method set out in paragraphs 3.34 – 3.35, or by telephone using the telephone number provided in paragraph 3.97. In order to ensure the rules on confidentiality and Applicant / Bidder behaviour are not breached an **Applicant/Bidder should not contact any other persons by letter or contact ComReg using any other telephone number**. ComReg will only receive such telephone calls between **16:00 – 17:00** on every Working Day between *[a date will be specified in the final Information Memorandum]* and *[a date will be specified in the final Information Memorandum]*.
- 3.60 Where a Deposit Call is issued during the Award Process, instructions on the method to confirm receipt of Deposit will be provided.

3.3.5 Ownership rules

- 3.61 Each Interested Party applying to take part in the Award Process and all Bidders are subject to the ownership rules.
- 3.62 The ownership rules apply from the submission of Applications until the public

announcement on the outcome of the Award Process by ComReg.

- 3.63 Bidders are subject to the ownership rules to help ensure that they both Bid for and, if applicable, win Licences as independent entities and in accordance with applicable law. In particular, the ownership rules ensure that the Competition Caps cannot be circumvented and prevent a Bidder from having any unfair advantage or distorting competition within the Award Process by being able to coordinate with another Bidder.
- 3.64 In essence, the ownership rules prohibit any entity in a “Bidding Group” (that is, a Bidder and its Connected Persons) from also participating in another Bidding Group or from being connected to or associated with any entity in another Bidding Group.
- 3.65 In particular, the following relations must not exist:
- a Bidder or Connected Person within one Bidding Group must not also be a Bidder or Connected Person in another Bidding Group;
 - two or more Bidders must not be Associated Bidders.
- 3.66 Before submitting its Application, the Applicant must take all reasonable measures to identify its Connected Persons, Associated Bidders and Insiders.
- 3.67 Annex 8 is illustrative of the types of relations that ComReg considers to fall within the concepts of Connected Persons and Associated Bidders (Insiders are discussed in the following section). If ComReg considers that one of the prohibited relations referred to above may exist, the procedure set out in Annex 8 will apply. Annex 8 also describes when ComReg may grant exemptions from the ownership rules, and the rules relating to joint bidding, restructuring and changes to ownership structure.
- 3.68 The rules set out above and in Annex 8 do not imply that ComReg has taken a position in this Information Memorandum on what Bidder connections, ownership structures or associations of a Bidder may or may not be lawful or permitted under Irish or EU competition law or other applicable law. Such assessment falls outside the scope of this Information Memorandum.

Joint bidding

- 3.69 A Bidding Group may be under the joint control of two or more persons. Persons wishing to Bid in consortium will be viewed as a single entity for the purposes of applying ownership rules (as detailed in this Section), rules on confidentiality and Applicant / Bidder behaviour (see Section 3.3.6) and the Award Rules. Note, in particular, that such an entity would be subject to the same Competition Caps

as other Bidders (see Section 4.1.3 below).

3.3.6 Confidential Information and Applicant/Bidder behaviour

- 3.70 This section sets out the rules (in addition to those rules under Irish and EU competition law which continue to apply regardless of this Award Process) that govern the behaviour of Applicants/Bidders from the time of submission of their Applications until the public announcement on the outcome of the Award Process by ComReg⁹⁹. These rules require that any Applicant/Bidder shall refrain from any action that could undermine the running of the Award Process. This section also sets out a number of specific rules in relation to Confidential Information and Applicant/Bidder behaviour, other restrictive practices capable of distorting the outcome of the Award Process, and the behaviour of employees, contractors and legal entities that are related or connected to the Applicant / Bidder.
- 3.71 As part of its Application to be awarded spectrum rights of use being made available in the Award Process, each Applicant is required to confirm that it has and will continue to comply with the Award Rules and that it has taken all reasonable measures to ensure that its Connected Persons, employees and Insiders¹⁰⁰ have and will continue to at all times comply with these rules. If at any point it becomes apparent that an Applicant/Bidder, its Connected Persons or its Insiders (as defined below) have failed to comply with the Award Rules, the Applicant Bidder, as appropriate, will be deemed responsible for that breach and may, depending on the nature and seriousness of the breach, be excluded from the Award Process and/or forfeit part or all of the Deposit it paid at the Application Stage. In certain circumstances, ComReg may also suspend or withdraw a Winning Bidder's Licence(s) if, after award of the Licence(s), it emerges that the Bidder, its Connected Persons or its Insiders breached the Award Rules.
- 3.72 Applicants should note that, even if they are unsuccessful in becoming Bidders, they remain bound by the Award Rules on release of Confidential Information until the public announcement on the outcome of the Award Process by ComReg. For the avoidance of doubt, this does not however release Interested Parties from their general obligations of confidence which persist outside the Award Rules.

⁹⁹ Note that, in the case where a Bidder were to submit multiple Applications (in which case the last Application only would be considered by ComReg), the period from which the rules on Confidential Information would apply is from the submission of the first Application.

¹⁰⁰ See paragraph 3.75 for a definition of an Insider.

Confidential Information and Insiders

3.73 “**Confidential Information**” means any information which is not in the public domain and which, if it became known to another Applicant/Bidder, may influence the amount that the Applicant/Bidder is willing to Bid for Lots or the strategy it adopts in Bidding for such Lots in the Auction. Confidential Information shall include (but not necessarily be limited to) information as to an Applicant’s/ Bidder’s business case, its pre-Auction activities, its Auction strategy, information as to the identity of an Applicant’s/Bidder’s Authorised Agents, or the prices it is willing to Bid for spectrum in the Award Process. Confidential Information relating to individual Applicants/Bidders shall also include:

- a) the Applicant’s/Bidder’s actual participation in the Award Process including the Auction itself;
- b) the Applicant’s/Bidder’s Eligibility to make Bids within the Auction; and
- c) the composition and value of any and all Bids made so far by the Applicant/Bidder within the Award Process including the Auction.

3.74 Confidential Information shall also include any information concerning the outcome of various stages of the Award Process (regardless of whether such information is specific to that Applicant/Bidder). The rules regarding Confidential Information set out in this section shall apply from the date of first Application or the Application Date, whichever is the earlier, until a public announcement on the outcome of the Award Process by ComReg. For the avoidance of doubt, while the rules regarding Confidential Information are relaxed to the extent necessary to achieve specified purposes including, for example, where Assignment Bidders wish to negotiate with other Assignment Bidders during the Negotiation Phase of the Assignment Stage¹⁰¹, confidentiality regarding the outcome of the Award Process must be maintained until ComReg makes a public announcement on the outcome of the Award Process.

3.75 An “**Insider**” includes an entity that is not a Connected Person and has:

- provided advice to the Applicant/Bidder in formulating its Bid strategy and/or business case in connection with the Award Process; or
- either by itself or in concert with another person or other persons undertaken, wholly or partly, to finance or assist a member of a Bidding Group in connection with the Award Process; or

¹⁰¹ See Sections 3.6.2 and 4.3.10 below for more information.

- otherwise received Confidential Information about an Applicant/Bidder.
- 3.76 An Insider can be a legal entity or a natural person. For example, an Insider could be a bank or other funder, with knowledge of an Applicant's/Bidder's business case, valuations or Bid ceilings, or it could be an auditor, consultant, lawyer, economic adviser, or other professional assisting in the preparation of a Bid. Each Applicant must submit a list of its Insiders to ComReg, at the time of its Application, and it shall inform ComReg thereafter of every change to its list of Insiders.
- 3.77 Except in accordance with the Exemption from Insider Rules as discussed below, Bidding Groups and Insiders must not convey Confidential Information to any other person, including another Bidding Group or its Insiders, either by making public such information, or by communicating such information directly to another Bidding Group or its Insiders or indirectly through an intermediate source.
- 3.78 It is possible that, at the Application Date, an Applicant is unaware that it has a common Insider with another Applicant. If ComReg becomes aware that two or more Applicants/Bidders have a common Insider, it shall:
- notify the Applicants/Bidders concerned, indicating a deadline for them to apply for exemption from the rules on common Insiders (see further below); or
 - require the relationship of one or more of the Applicants/Bidders with the common Insider to terminate insofar as the Award Process is concerned.
- 3.79 If the Applicants/Bidders concerned are not granted an exemption by ComReg and/or they do not alter the common Insider situation to ComReg's satisfaction, then ComReg shall exclude the Applicants/Bidders from further participation in the Award Process. If the relationship comes to light later in the Award Process, for example after the Auction has commenced, then ComReg may exclude the Bidders from further participation in the Award Process (see paragraph 3.103 below in that regard) and this may result in partial or whole Deposit forfeiture for the affected Bidders. In certain circumstances, ComReg may also suspend or withdraw a Winning Bidder's Licence(s) if, after grant of the Licence(s), it emerges that the Bidder, its Connected Persons or its Insiders breached the Award Rules or the agreement with ComReg described in Chapter 5. ComReg may also declare the result of the Award Process as not binding, wholly or partly, on it.
- 3.80 If two or more Applicants/Bidders have a common Insider, and it is not possible

to bring the situation to an end within the deadline set by ComReg, and ComReg does not grant an exemption, one or more of the Applicants/Bidders may withdraw from participation in the Award Process, before the deadline for doing so set by ComReg, so that it may not be necessary for ComReg to exclude all affected Applicants/Bidders from the Award Process.

Exemption from Insider rules

- 3.81 ComReg may, in exceptional circumstances and at its sole discretion, grant exemption from the rules relating to common Insiders described above. ComReg may attach terms to any such exemption.
- 3.82 In considering whether to grant an exemption and any terms to attach to an exemption, ComReg will consider the arrangements put in place by a common Insider to prevent the sharing of Confidential Information relating to one Bidding Group with individuals acting for or connected to another Bidding Group.
- 3.83 In considering whether or not to grant an exemption, ComReg will require certain information from each relevant Applicant/Bidder, including (but not necessarily limited to) the following:
- details of all individuals acting for each Applicant/Bidder within the common Insider;
 - an organisation chart showing the positions of each of these individuals within the common Insider;
 - a copy of any appropriate policies, procedures and manuals used by the common Insider in relation to the segregation of Applicant/Bidder data;
 - a written undertaking from the common Insider, in a form acceptable to ComReg, to put in place sufficient safeguards which ensure the segregation of all Confidential Information relating to the Applicants/Bidders that it is acting for and not to use any common personnel in relation to the different Applicants/Bidders.
- 3.84 If an Applicant/Bidder seeks an exemption, it will consent to ComReg contacting the managing director, managing partner, or person occupying an equivalent position in the common Insider, to seek the appropriate written undertaking, which shall be expressed to be for the benefit of ComReg.

Directors and employees

- 3.85 Circumstances may arise where Bidding Groups and their respective Insiders have common directors and/or employees. If this occurs, the Applicants/Bidders

concerned need to ensure that the respective persons:

- are not, directly or indirectly, involved in the preparation and/or submission of the Application for more than one Bidding Group, such that they are involved in the Award Process for one Bidding Group only; and
- are not in possession of, do not obtain, or have knowledge of any Confidential Information concerning more than one Bidding Group.

3.86 An Applicant/Bidder shall ensure that its Connected Persons take all reasonable measures to identify and inform the Applicant/Bidder if they have any board members or employees who are Insiders in relation to another Bidding Group, such that the Applicant/Bidder can take appropriate precautions to ensure that the rules on confidentiality and Applicant/Bidder behaviour are not breached.

Disruption to the Award Process

3.87 All Applicants/Bidders shall, and shall procure that their Connected Persons, refrain from undertaking any action that is intended to, or is likely to, distort the outcome of the Award Process.

3.88 Save, and only to the extent necessary, for the participation of Assignment Bidders in the Negotiation Phase, all Applicants/Bidders shall, and shall procure that their Connected Persons, refrain from doing any of the following:

- disclose any Confidential Information beyond the Bidding Group and its Insiders;
- disclose any Confidential Information in breach of undertakings made by the Bidder pursuant to any exemption to the rules on ownership and Insiders granted by ComReg;
- knowingly obtain Confidential Information in relation to any other Bidding Group;
- communicate with other Applicants/Bidders or their Connected Persons with the intention or effect of coordinating Bidding within the Auction;
- enter into agreements with other Applicants/Bidders or their Connected Persons in relation to the Award Process;
- for the duration of the Award Process, exchange information, coordinate or enter into agreements with other Applicants/Bidders and their

Connected Persons regarding the Applicant's/Bidder's strategy for use of the Licence.

- 3.89 The above requirements shall be binding upon all Applicants/Bidders until ComReg has received all SAFs payable and applicable first SUFs and has publicly announced the outcome of the Award Process.
- 3.90 Subject to ComReg's discretion to conclude otherwise, any merger or acquisition that may occur during the Award Process shall not be considered an act that could adversely affect the Award Process, provided that such a merger or acquisition would not result in a member of one Bidding Group also being a member of another Bidding Group.
- 3.91 Notwithstanding the provisions of the paragraphs above, any member of a Bidding Group or its Insiders may disclose Confidential Information to its employees, agents or other representatives, and vice versa, where this is necessary for the purposes of:
- determining the Applicant's/Bidder's participation and preparing for its participation in the Award Process, including its Bid strategy;
 - assisting the Applicant/Bidder during the Auction in relation to its participation in the Auction; and
 - dealing with commercial and regulatory matters following, and directly concerned with, the outcome of the Award Process, including for example liaison with ComReg prior to the grant of Licences.
- 3.92 However, such disclosure shall not include disclosure to any members of another Bidding Group or its Insiders except with ComReg's prior written consent.

Restrictive agreements

- 3.93 A Bidding Group or its Insiders may neither prior to the submission of an Application, nor after the submission of an Application and not until ComReg publicly announces the final outcome of the Award Process, enter into any agreement or establish any understanding with a provider of equipment or software, which directly or indirectly:
- restricts the provider's ability to supply equipment or software to another Applicant/Bidder or its Connected Persons regarding the planning, establishment or operation of a network in Ireland involving the frequencies which are subject to this Award Process; or

- restricts the prices or other terms and conditions that the provider can offer another Applicant/Bidder or its Connected Persons regarding the planning, establishment or operation of a network in Ireland involving the frequencies which are subject to this Award Process.

3.94 An Applicant/Bidder, its Connected Persons or Insiders may not either prior to or during the Auction enter into any agreement or establish any understanding with a third party if the agreement or understanding directs such third party not to participate in the Award Process, restricts the ability of such third party to participate in the Award Process, or holds out the expectation that such third party will receive any financial or other benefit as a result of not participating, or restricting its participation in the Award Process.

Reporting breaches of the Award Rules

3.95 If any Applicant/Bidder becomes aware of an actual or potential breach of the Award Rules or other offending behaviour that may distort the outcome of the Award Process, it must notify ComReg at the earliest opportunity using the process described below and outline the nature of the potential breach or other offending behaviour.

3.96 ComReg will be available to receive such a notification on every Working Day from *[date to be specified in the final Information Memorandum]* until the public announcement by ComReg on the outcome of the Award Process.

3.97 Such notifications should be made by telephone using the number *[a number will be specified in the final IM]* as follows:

- other than during the Main Stage, between *[a time will be specified in the final IM]*.
- during the Main Stage, between *[a time will be specified in the final IM]* if the Main Stage is currently in progress or **before** *[a time will be specified in the final IM]* the following Working Day if the Bidder becomes aware of the breach following the last scheduled Round of the day.

3.98 ComReg will record all phone calls made or received during the Award Process in order to manage technical issues and risks arising, and to ensure the integrity and administrative efficiency of the Award Process. These recordings, which shall be stored securely, shall be retained and used only for these purposes and shall be deleted once they are no longer required by ComReg for these purposes. In the event of a dispute arising, ComReg may rely on the contents of these recordings.

3.99 The Applicant/Bidder must also at the earliest opportunity follow up such a notification in writing, setting out specific details and evidence supporting the notification made. This information should be sent to **Mr. Joseph Coughlan** (copying **Mr Patrick Bolton**) using the method as set out in paragraphs 3.34 – 3.35. The Applicant/Bidder must strictly follow the above process for making such a notification and must not use any other means to contact ComReg or its personnel for such purposes.

Sanctions

3.100 As part of their Applications, Applicants agree to be bound by a series of possible administrative sanctions for infringement of the Award Rules.

3.101 Interested Parties should also note that certain breaches of the Award Rules and other behaviours that Applicants/Bidders could engage in may entitle other Applicants/Bidders to seek redress under civil law and, moreover, may also constitute offences relating to, among other things, competition law, fraud, conspiracy and unlawful use of a computer. In respect of certain such behaviours, liability can be imposed on the individual(s) engaging in the behaviour as well as on the organisation(s). For the avoidance of doubt, in the event that any such behaviour (i.e. other than behaviour which amounts to a breach of the Award Rules) comes to the attention of Applicants/Bidders during the Award Process, they are obliged to notify ComReg immediately to enable appropriate action to be taken.

3.102 In the event that an Applicant/Bidder, its Connected Persons or Insiders breaches any of the Award Rules, it can also face, subject to ComReg's discretion, a number of administrative sanctions, including exclusion from the Award Process, depending on the severity of the breach. Specifically, the list of possible sanctions may include, but is not limited to:

- exclusion from the Award Process; and/or
- forfeiture of part or all of the Deposit which was paid on Application.

3.103 If an Applicant/Bidder is excluded from the Award Process, then ComReg, at its discretion, may void some or all Bids made up to that point by the Applicant/Bidder in question, in addition to preventing further Bids by that Applicant/Bidder. For the avoidance of doubt, on exclusion of a Bidder, ComReg may continue with the Auction unchanged, save for the exclusion of that Bidder. In the event that ComReg considered it appropriate, all Bids and calculations made up to that point may remain valid and binding, although it reserves the right to make such alterations to the Auction as it considers appropriate at its discretion with a view to maintaining the integrity and efficacy of the Auction. In

particular:

- if a Bidder were excluded during the Primary Bid Rounds, ComReg would typically expect to not re-run Primary Bid Rounds already completed, although it reserves the right to do so;
- if a Bidder were excluded after the Main Stage of the Auction had been completed and results of the Main Stage had been made known to all Bidders, ComReg would not typically expect to re-run the Main Stage, although it reserves the right to do so; and
- if a Bidder were excluded after the Main Stage of the Auction had been completed but results of the Main Stage had not yet been made known to all Bidders, ComReg would typically expect to re-calculate the outcome of the Main Stage excluding the Bids of the excluded Bidder¹⁰².

3.104 A breach by an individual Applicant/Bidder, its Connected Persons or Insiders of any of the Award Rules may lead to the forfeiture of part or all of the Deposits paid by that Applicant/Bidder during the Award Process.

3.105 For illustrative purposes only, actions which may lead to an Applicant's/Bidder's exclusion from the Award Process and/or the forfeiture of an Applicant's/Bidder's Deposit include the following:

- submitting materially¹⁰³ false or misleading information to ComReg;
- failing to update ComReg, in a timely manner, in relation to any change to material information submitted as part of its Application or during the Award Process;
- failure to report a breach of the Award Rules or other offending behaviour that may distort the outcome of the Award Process;
- an Applicant/Bidder, its Connected Persons or Insiders colluding or attempting to collude with any other person to distort the outcome of the Award Process, or acting in a way which is likely to distort the outcome of the Award Process;

¹⁰² The issue of exclusion of a Bidder at the end of the Main Stage is addressed in Section 4.2.5.

¹⁰³ Where reference is made in this Information Memorandum to matters being material, ComReg, acting reasonably, shall be entitled to decide whether or not a matter is material. Accordingly, where an Applicant has any doubt as to the materiality of a matter, it should be reported to ComReg.

- an Applicant/Bidder, its Connected Persons or Insiders disclosing Confidential Information to others during the period of restrictions on communications, other than in accordance with this Information Memorandum;
- an Applicant/Bidder, its Connected Persons or Insiders knowingly obtaining or attempting to obtain Confidential Information in relation to any other Applicant / Bidder;
- any member, director or employee of a member of an Applicant/Bidder, its Connected Persons or Insiders being involved in the participation by another Bidding Group in the Award Process;
- an Applicant/Bidder, its Connected Persons or Insiders canvassing directly or indirectly any member of ComReg or any person associated in any way with the Award Process; and
- any other breach of the Award Rules or the agreement with ComReg described in Chapter 5 that is not a trivial or inconsequential breach.

3.106 In certain circumstances, ComReg may also suspend or withdraw a Winning Bidder's Licence(s) if, after grant of the Licence(s), it emerges that the Bidder, its Connected Persons or its Insiders breached the Award Rules or the agreement with ComReg described in Chapter 5.

3.107 In cases where breaches are caused not by the Applicant/Bidder, but by its Connected Persons or Insiders, then ComReg has discretion to waive or limit the Application of sanctions set out in this section if it can be shown that the breach occurred without the Applicant's/Bidder's knowledge, that the Applicant/Bidder has taken all reasonable steps to avoid the breach and/or minimise its effects and that the breach has not caused material detriment to the Award Process.

3.108 Nothing in this Information Memorandum shall preclude ComReg from seeking alternative remedies for breach of the Award Rules or the agreement with ComReg described in Chapter 5, including, but not limited to, a claim for damages, or the bringing of proceedings under the Competition Act 2002, the Communications Regulation Act 2002 or the Specific Regulations.

3.3.7 Application Procedure

3.109 In order to participate as a Bidder in the Award Process, an Interested Party must submit the following original documents in paper format:

- a completed and signed Application Form;
- an Ownership Structure Document along with appropriate certification in relation to same in accordance with paragraphs 3.46 and 3.47 of the IM; and
- appropriate evidence in respect of Authorised Agents in accordance with paragraph 3.41 of the IM.

3.110 An Interested Party must also submit five identical paper copies of each of the above documents. The original documents should be identified as such.

3.111 The container(s) in which the above paper documentation are submitted must not in any way disclose the identity of the Interested Party.

3.112 ComReg will only accept Applications submitted between **09.00 hours and 17.30 hours** (Irish time) on any of the following five Working Days:

[five dates will be specified in the final Information Memorandum]

3.113 Interested Parties must make appointments with ComReg to submit their Applications. To make an appointment, an Interested Party must contact **Mr Joseph Coughlan or Mr. Patrick Bolton** by telephone between **10:00 to 13:00 and 14:00 to 16.00 hours (Irish time)** on Working Days between *[dates will be specified in the final Information Memorandum]* inclusive.

3.114 The number for telephoning Mr. Coughlan or Mr. Bolton is: *[number will be specified in final IM]*. ComReg will record all phone calls made or received during the Award Process in order to manage technical issues and risks arising, and to ensure the integrity and administrative efficiency of the Award Process. These recordings, which shall be stored securely, shall be retained and used only for these purposes and shall be deleted once they are no longer required by ComReg for these purposes. In the event of a dispute arising ComReg may seek to rely on the contents of these recordings.

3.115 All submitted Applications will be date and time stamped upon being received by ComReg.

3.116 Once an Application is received by ComReg, the Interested Party is deemed to be an Applicant.

3.117 Each Applicant will be given a receipt acknowledging the submission of its Application.

3.118 An Application can be replaced at any time up to 16.00 hours (Irish time) on the

Application Date, *[date will be specified in the final Information Memorandum]*. In the event that an Applicant submits more than one Application prior to 16.00 hours on the Application Date, only the latest Application received from that Applicant will be taken into consideration.

- 3.119 On the submission of a second or subsequent Application prior to the Application Date, the Applicant must return the receipt for the prior Application to ComReg. This receipt will be endorsed to indicate that the earlier Application has been superseded and will not be evaluated. However, any superseded Applications will not be returned until after the Qualification Stage of the Award Process.
- 3.120 No Applications will be opened by ComReg before *[a date will be specified in the final Information Memorandum]* (the Application Date). All Applications will be opened at the same time and place and in the presence of an independent auditor.
- 3.121 The deadline for receipt of all Deposits, in cleared funds, will be **23:59 hours (Irish time)** on *[a date will be specified in the final Information Memorandum]* (The Application Date).
- 3.122 As noted at Section 3.3.1 above, ComReg will facilitate the submission of questions regarding the Award Process up until *[a date will be specified in the final Information Memorandum]*. Following that date, and onwards through to the conclusion of the Notification and Grant Stage, no questions will be accepted from Applicants or Interested Parties, save for those that would qualify as permitted communications of the type set out in Section 4.1.4 of this document (Communicating with ComReg) and save for those communications and responses which are specifically requested by ComReg or its agents in accordance with the Information Memorandum.
- 3.123 Once Applications have been submitted they constitute binding offers to purchase the Lots applied for on the Initial Bid Form. However, an Applicant may withdraw its Application on or before *[a date will be specified in the final Information Memorandum]* without forfeiture or partial forfeiture of Deposits, subject to that Applicant's compliance with the Award Rules.
- 3.124 If a Bidder were to opt to not bid during the Main Stage of the Auction, its Initial Bid would still be included in the set of Bids considered in the determination of Winning Bidders and Base Prices.

3.4 Qualification Stage

3.4.1 Process for approval of Applications

3.125 Once the Application Date has passed, ComReg will evaluate all Applications received within the specified time window on or before the Application Date, evaluate which Applications are valid¹⁰⁴ and assess the level of Aggregate Demand associated with valid Applications. Applicants that submit valid Applications at the Application Stage which are approved by ComReg become Bidders.

3.126 Upon completion of its assessment of Applications, ComReg will:

- inform each Applicant whether or not it has been approved by ComReg to become a Bidder;
- inform each Bidder whether an Auction is required and, if so, whether a Main Stage of the Auction is required; and
- in the event that a Main Stage of the Auction is required, inform each Bidder of its Initial Eligibility.

The start date of the Auction will be notified to Bidders with at least ten clear Working Days prior notice.

3.127 ComReg will not inform Bidders about the identity of other Bidders, the Initial Bids made by other Bidders or the Initial Eligibility of other Bidders. ComReg will not inform Bidders about unsuccessful Applicants who fail to become Bidders or Applicants who withdraw an Application.

3.128 Applicants are reminded that, even if they are unsuccessful in becoming Bidders or withdraw their Application, they remain bound by the Award Rules on release of Confidential Information until the public announcement on the final outcome of the Award Process by ComReg.

3.4.2 Assessment of Applications

During the Qualification Stage

3.129 If an Applicant fails to ensure that ComReg receives the full Deposit for the Lots for which the Applicant has applied (in its Initial Bid Form)¹⁰⁵ by the specified

¹⁰⁴ Details of what constitutes a valid Application is set out in Section 3.3.

¹⁰⁵ See Section 3.3.3.

deadline date and time, ComReg, at its discretion, may decide that the Applicant's Application is not valid and that the Applicant is not eligible to participate as a Bidder in the Award Process. Alternatively, ComReg may provide a short additional period of time for the full amount of the required Deposit to be paid by the Applicant.

- 3.130 If any aspect of an Application (other than the partial payment of a Deposit) is found to be incomplete, unclear or otherwise invalid, ComReg has the discretion to decide what measures to take, reflecting the nature of the ambiguity, omission or invalidity. These measures include seeking clarification or verification of information already provided, requesting further information from the Applicant or deeming that Application invalid.
- 3.131 In the event that an Application is in any material way incomplete, inaccurate, invalid, or untrue, ComReg reserves the right to directly and immediately exclude the Applicant concerned from becoming a Bidder i.e. ComReg may do so without providing the Applicant with an opportunity to clarify or correct its Application.
- 3.132 In the case where an Applicant is declared unsuccessful in its Application or withdraws its Application any Deposit which it has paid will be returned to it in accordance with the Award Rules and the timeline for the return of Deposits set out in Table 18 of Chapter 3 above.

Subsequent to the Qualification Stage

- 3.133 If, having determined that an Applicant may participate in the Award Process as a Bidder, ComReg should subsequently become aware that the Bidder's original Application was incomplete, inaccurate, invalid, or untrue, ComReg may, at its discretion, allow the Bidder opportunity to clarify or correct the information already provided.
- 3.134 In the event that any material inaccuracy or untruth in an Application is identified, ComReg reserves the right to exclude the Bidder directly without providing opportunity for the Bidder to clarify or correct the information already provided.
- 3.135 If such a Bidder cannot provide correction or clarification to ComReg's satisfaction, within the time limit specified by ComReg, that Bidder may be excluded from the Award Process with return of all, part, or none of its Deposit depending on the nature and seriousness of the deficiency in its Application.
- 3.136 Where a Bidder is informed that it cannot participate further in the Award Process ComReg will endeavour to return part or all of its Deposit within one week of the Bidder being notified.

3.137 Applicants and Bidders have an on-going obligation to inform ComReg of any material changes to information provided in their Applications. If an Applicant/Bidder becomes aware of any material error, omission, or inaccuracy in its Application, the Applicant/Bidder shall inform ComReg of same as soon as reasonably possible. This obligation shall remain in effect for the duration of the Award Process and for the duration of any Licence granted on foot of the Award Process.

3.138 For the avoidance of doubt, the options available to ComReg outlined above are without prejudice to any other appropriate action that ComReg may take in accordance with its statutory objectives and duties.

3.4.3 Progress of the Award Process

3.139 Based on ComReg's assessment of Aggregate Demand for each Lot Category as expressed in the Initial Bids of Bidders, the Award Process will progress in one of the following ways:

- a Main Stage and an Assignment Stage will be held, followed by a Notification and Grant Stage;
- an Assignment Stage will be held, followed by a Notification and Grant Stage; or
- only a Notification and Grant Stage will be held.

3.140 A Main Stage of the Auction is required if, for one or more Lot Categories, the total number of Lots in that Lot Category specified in Bidders' Initial Bids exceeds the number of Lots available in the Lot Category. I.e. if there is at least one Lot Category for which Aggregate Demand exceeds supply.

3.141 If a Main Stage of the Auction is required:

- all Lot Categories will be included in the Main Stage of the Auction, regardless of whether there was excess demand in the respective Lot Category expressed in the Initial Bids of Bidders;
- ComReg will inform each Bidder of its Initial Eligibility to Bid for Lots in each Time Slice in the first Primary Bid Round; and
- each Bidder's Initial Bid will be included in the set of Bids considered when determining the Winning Bids and associated Base Prices for the Main Stage.

- 3.142 If a Main Stage is not required, each Bidder will automatically become a Winning Bidder and will be awarded the Lots it applied for with its Initial Bid.
- 3.143 At the end of the Main Stage, or the Qualification Stage if a Main Stage is not required, the Award Process will progress to the Assignment Stage, if required. An Assignment Stage is required whenever at least one frequency-generic B-Lot is won by a Bidder during the Main Stage or the Qualification Stage if a Main Stage is not required.
- 3.144 The purpose of the Assignment Stage is to determine the specific frequencies to be assigned to the Winning Bidders of (frequency-generic) B-Lots and any Additional Prices they will have to pay. If there is more than one feasible frequency assignment for at least one Winning Bidder (in accordance with the rules for determining Assignment Options), the Assignment Stage will include a process (the Assignment Round) in which Winning Bidders are able to express their preferences for specific frequencies (potentially competing with other Winning Bidders where there might be a conflict in demands for particular frequencies). Following an Assignment Round, the Assignment Stage will include a Negotiation Phase, during which Winning Bidders are given the opportunity to negotiate between themselves an alternative frequency assignment to that established in the Assignment Round (subject to a number of constraints and approval from ComReg).
- 3.145 If only A-Lots are to be awarded in accordance with the outcome of the Main Stage, or the Qualification Stage if a Main Stage is not required, an Assignment Stage is not required as the frequencies for A-Lots are fixed.
- 3.146 Following completion of the Assignment Stage (if required), the Award Process will progress to the Notification and Grant Stage.

3.5 Main stage

3.5.1 General

- 3.147 This section outlines the key features of the Main Stage. The detailed Auction Rules applying to the Main Stage are provided in Chapter 4 (Section 4.2). For completeness and transparency, ComReg has set out the details of how the Auction and Auction Rules will work, much of which involves complex Auction theory. Interested Parties are assured, however, that, in practice, the EAS that will be used by Bidders to submit Bids in the Auction will only permit the submission of a Bid that complies with the detailed Auction Rules.
- 3.148 The function of the Main Stage is to determine how many Lots each Bidder will

be awarded in each of the available Lot Categories, and the price to be paid by each Winning Bidder (its Base Price). Specific frequency assignments for Winning Bidders of frequency-generic B-Lots will be determined subsequently in the Assignment Stage.

3.149 The Main Stage will follow a Combinatorial Clock Auction (CCA) format and will progress in discrete Rounds, consisting of:

- one or more **Primary Bid Rounds**; followed by
- one further round of bidding – the **Supplementary Bids Round**.

3.150 The open, multiple Round, structure of the Primary Bid Rounds is intended to allow Bidders to learn about Aggregate Demand for Lots and to provide an opportunity for Bidders to revise their assessment of the value of Lots in light of this information.

3.151 All Bids in the Main Stage are for Packages of Lots (i.e. a package of one or more Lots). A Bid for a Package of Lots will not be subdivided by the Auctioneer, so a Bidder will only win an entire Package of Lots it has bid for, or nothing. As a result, Bidders do not face risks associated with winning some, but not all, of the Lots within a Package of Lots for which they have bid.

3.5.2 Primary Bid Rounds

3.152 The Primary Bid Rounds follow a clock auction format. Bidding proceeds in discrete Rounds, with all Bidders invited to submit Bids within the same fixed time window (subject to the provisions for Extensions, described further below).

3.153 Before the start of each Primary Bid Round, ComReg will announce a price per Lot for each Lot Category in that Round (the 'Round Prices').

3.154 In any given Primary Bid Round, each Bidder can submit at most one Primary Bid for a single Package of Lots, where the Bidder specifies the number of Lots it wishes to acquire in each Lot Category. The Bid Amount for this Package of Lots is determined automatically as the sum total of the prevailing Round Prices for the Lots included.

Round Prices

3.155 For the first Primary Bid Round, the Round Price per Lot in each Lot Category for which there was no excess demand¹⁰⁶ on the basis of Initial Bids will be the

¹⁰⁶ Excess demand for a Lot Category is defined as the aggregate demand for Lots in the Lot Category less the number of Lots available in that Lot Category.

Reserve Price per Lot in the Lot Category. The Round Price per Lot in each Lot Category for which there was excess demand on the basis of Initial Bids will be the Reserve Price per Lot in the Lot Category plus a Price Increment determined by ComReg.

- 3.156 For subsequent Primary Bid Rounds, Round Prices are increased (relative to previous Round Prices) for all Lot Categories for which there was excess demand in the previous Round. The magnitude of the Price Increment applicable to each Lot Category will be determined by ComReg, taking into account factors such as the level of excess demand in the previous Round (for that or other Lot Categories). In the case where there was no excess demand in a Lot Category at previous Round Prices, no Price Increment shall be applied to Lots in that Lot Category.

Activity Rules

- 3.157 Primary Bids are subject to Activity Rules that may limit the composition of the Package of Lots a Bidder may bid for in a Round, depending on the Primary Bids submitted in previous Rounds by that Bidder. The Activity Rules are used to ensure that Bidding is progressive, with Bidders reducing demand as prices increase, and to prevent Bidders from only revealing their true demand for Lots late in the Auction. Activity in the Auction is measured in Eligibility Points for each Time Slice. Each Lot has been assigned a number of Eligibility Points (set out in Tables 16 and 17).
- 3.158 A Bidder starts each Primary Bid Round with a number of Eligibility Points for each Time Slice (the Bidder's 'Eligibility'). Each Package of Lots has an associated Eligibility, calculated separately for each Time Slice as the sum of the Eligibility Points of the Lots pertaining to that Time Slice included in the Package of Lots¹⁰⁷. The Activity of a Primary Bid in a Primary Bid Round is the Eligibility of the Package of Lots subject to the Bid (and is also determined separately for each Time Slice).
- 3.159 The Initial Eligibility of each Bidder in each Time Slice will be the sum of the Eligibility Points associated with the Lots selected in its Application Form in that Time Slice (where any 700 MHz Duplex Lots count towards the Initial Eligibility in both Time Slices).
- 3.160 In subsequent rounds, the Eligibility of each Bidder in a Time Slice will be equal to the smaller of:

¹⁰⁷ Note that any 700 MHz Duplex Lots included in the Package of Lots contribute to the Eligibility of the Package of Lots in both Time Slices.

- (i) the Bidder's Eligibility in that Time Slice¹⁰⁸ at the start of the preceding Round; and
- (ii) the Eligibility of the Package of Lots subject to its Primary Bid in that Time Slice¹⁰⁹ in the preceding Round.

Therefore, a Bidder's Eligibility in a Time Slice can never increase during the Main Stage.

- 3.161 In any Primary Bid Round, a Bidder may submit a Primary Bid for any Package of Lots with an Eligibility that does not exceed the Bidder's Eligibility at the start of the Round. This means that a Bidder can always switch its demand to Packages of Lots with Eligibility no greater than its Eligibility at the start of the Round. For instance, a Bidder may be able to reduce demand in one Lot Category and use the associated Eligibility to increase its demand in other Lot Categories.
- 3.162 Under certain conditions, a Bidder may be able to submit a Primary Bid for a Package of Lots with an Eligibility that exceeds its Eligibility at the start of the Round. Such Bids are termed Relaxed Primary Bids, and are allowed only in the specific circumstances where such a Bid is consistent with the preferences implied by the Bidder's previous bidding behaviour¹¹⁰.
- 3.163 The possibility of submitting Relaxed Primary Bids provides an opportunity for Bidders to respond to the changing relative prices of Lots in different Lot Categories, consistently with the Bidder's implied preferences across various Packages of Lots¹¹¹. Without Relaxed Primary Bids, Bidders would only be able to switch back and forth between Packages of Lots with exactly the same Eligibility. However, by using Relaxed Primary Bids, a Bidder may be able to switch back and forth between Packages of Lots with different Eligibility.
- 3.164 For instance, suppose that a Bidder starts by Bidding for Package A, but at some point Package A becomes too expensive relative to an alternative Package B that has a smaller Eligibility and so the Bidder switches to Bidding on Package B. Without the provisions for submitting Relaxed Primary Bids, the Bidder would not be able to switch back to submitting Primary Bids for Package A, even if Package A again became relatively cheap when compared with Package B. The facility to make Relaxed Primary Bids allows the Bidder to bid

¹⁰⁸ For the avoidance of doubt, the eligibility associated with the 700 MHz Duplex would be counted in that Time Slice if a Bidders Package of Bids includes the 700 MHz Duplex.

¹⁰⁹ Ibid.

¹¹⁰ Strictly, this consistency is only required in respect of the Bidder's Initial Bid and Bids made for Packages of Lots submitted in Primary Bid Rounds where the Bidder dropped Eligibility.

¹¹¹ A worked example of the Activity Rules for the Primary Bid Rounds and caps on Supplementary Bids is set out in Annex 5 of this document.

again for Package A, provided certain conditions are met to ensure bidding for Package A is consistent with Bids submitted in earlier Primary Bid Rounds. See Annex 5 for an example of how to submit a Relaxed Primary Bid.

- 3.165 In some cases, to submit a Bid for Package A that is consistent with the preferences implied by the Bidder's previous Primary Bids, it might be necessary to raise a Bidder's previous Bid for some Package B. Such a Bid is called a "Chain Bid". Chain Bids are additional Bids on certain Packages of Lots that have already been the subject of Bids submitted by the Bidder¹¹². Where Chain Bids are required, these Chain Bids are at the minimum amount necessary to ensure consistency with the Bids made for Packages of Lots in Primary Bid Rounds where the Bidder dropped Eligibility.
- 3.166 If a Bidder were to select a Relaxed Primary Bid within the EAS during a Primary Bid Round, the EAS would provide details of any Chain Bid(s) required and the associated Bid Amounts that would need to be submitted alongside the Relaxed Primary Bid¹¹³. Therefore, making a Relaxed Primary Bid simply requires the selection of the Package of Lots by the Bidder. Bid Amounts for the Relaxed Primary Bid and any associated Chain Bids would be non-discretionary and calculated by the EAS.

Restrictions on the submission of certain Primary Bids

- 3.167 In the 2.6 GHz Band, as the fixed frequency A-Lots are best utilised by Bidders also obtaining 2.6 GHz TDD Generic Frequency Lots, a Bidder will be prevented from submitting a Bid for a Package of Lots which includes the 2.6 GHz TDD Fixed Frequency Lot (Lower) and the 2.6 GHz TDD Fixed Frequency Lot (Upper) in a given Time Slice unless the Bidder also places a bid for all Lots in the 2.6 GHz TDD Band in the same Time Slice.

End of the Primary Bid Rounds

- 3.168 The Primary Bid Rounds will end following the first Primary Bid Round in which there is no excess demand for any Lot Category at the prevailing Round Prices¹¹⁴.

3.5.3 Supplementary Bids Round

- 3.169 The Supplementary Bids Round consists of a single Round of bidding in which Bidders may submit a number of Bids (Supplementary Bids) for Packages of

¹¹² These will be either the Package of Lots subject to the Bidder's Initial Bid or a Package of Lots subject to a Primary Bid in an earlier Primary Bid Round when the Bidder reduced Eligibility.

¹¹³ In practice, there would typically be only a small number of such Chain Bids needed.

¹¹⁴ Subject to certain provisions for exceptional circumstances (see Section 4.1.5).

Lots across all Lot Categories, subject to certain constraints (discussed further below).

3.170 The Supplementary Bids Round provides an opportunity for Bidders to:

- submit Bids for Packages of Lots for which they are willing and eligible to Bid, but for which they did not Bid in the Primary Bid Rounds; and/or
- increase their Bids for Packages of Lots that they Bid for in the Primary Bid Rounds.

3.171 Bidders are not required to submit any Bids during the Supplementary Bids Round if they do not wish to do so.

3.172 Supplementary Bids submitted for any Package of Lots must satisfy the Bidding Restrictions set out in Section 4.1.3.

3.173 Unlike in the Primary Bid Rounds, Bid Amounts are discretionary and can be freely chosen by the Bidder, subject to constraints on the minimum and maximum amounts allowed and Bids being a multiple of EUR 1000. If a Bidder submitted a Primary Bid for a non-empty Package of Lots in the final Primary Bid Round (the Final Primary Package), the maximum Bid Amount associated with a Supplementary Bid for this Package of Lots is unrestricted.

3.174 For all other Packages of Lots, there are restrictions on the Bid Amounts that can be specified for Supplementary Bids that arise due to the Bids previously submitted during the Primary Bid Rounds. All Supplementary Bid Amounts are subject to a floor. The restrictions on Supplementary Bid amounts, together with the Activity Rules for the Primary Bid Rounds, aim to ensure that Bidders are not able to conceal their true demand for Lots in early Primary Bid Rounds only to reveal this demand later on¹¹⁵.

Floors on Supplementary Bids

3.175 Where a Bidder has submitted a Bid for a Package of Lots in the Primary Bid Rounds, this represents a floor on the Bid Amount that the Bidder can submit for the same Package of Lots in the Supplementary Bids Round. Where a Bidder has submitted multiple Bids for a Package of Lots during the Primary Bid Rounds (for example, submitting a Bid for the same Package of Lots in consecutive Rounds), the applicable floor for the Supplementary Bid amount on this Package of Lots will be the highest Bid Amount for that Package of Lots

¹¹⁵ Note that the EAS will not allow Bidders to submit invalid Supplementary Bids, and will provide assistance with identifying Bids that violate the constraints. Nevertheless, it is the sole responsibility of Bidders to ensure that the Bids they submit are valid and compliant with the Auction Rules.

submitted by the Bidder during the Primary Bid Rounds.

- 3.176 Therefore, Supplementary Bids can only increase the highest Bid made so far for a Package of Lots (which might have been submitted as a standard Primary Bid, a Relaxed Primary Bid or a Chain Bid during the Primary Bid Rounds).
- 3.177 Where a Bidder has not submitted a Bid for a particular Package of Lots during the Primary Bid Rounds, the floor on the Bid Amount that the Bidder may submit for that Package of Lots during the Supplementary Bids Round will be equal to the sum of the Reserve Prices associated with the Lots included.

Caps on Supplementary Bids

3.178 Supplementary Bid amounts may be subject to two caps:

- a Relative Cap; and
- a Final Price Cap¹¹⁶.

3.179 The caps work in conjunction with the Activity Rules for the Primary Bid Rounds, and have been designed to encourage Bidders to submit Primary Bids for the Package of Lots that they prefer at the prevailing Round Prices¹¹⁷. In essence, the caps on Supplementary Bid amounts prevent a Bidder from submitting Supplementary Bids that are not consistent with the preferences implied by their Primary Bids.

3.180 The **Relative Cap** limits the Bid Amount that a Bidder can submit during the Supplementary Bids Round for any package of Lots which the Bidder did not have sufficient Eligibility to bid for in the final Primary Bid Round.¹¹⁸ This is intended to ensure that the preferences across different packages expressed by a Bidder's Bids submitted during the Supplementary Bids Round are consistent with the Bids that the Bidder submitted during the Primary Bid Rounds. This mechanism is intended to provide incentives for straightforward

¹¹⁶ Bids for any Package of Lots other than the Final Primary Package will be subject to a Final Price Cap. Supplementary Bids for Packages of Lots with an associated Eligibility greater than the Bidder's Eligibility in the final Primary Bid Round (including the Final Primary Package if the Bid submitted by the Bidder in the final Primary Round was a Relaxed Primary Bid) will be subject to a Relative Cap. Therefore, a Supplementary Bid may be subject to both a Final Price Cap and a Relative Cap.

¹¹⁷ The caps are based on the idea of revealed preference. Suppose that in a given Round Package X is more expensive than Package Y. If a Bidder Bids for Y instead of X, then it implicitly indicates that it is not willing to pay the extra cost for X, and so any additional value it may place on X over Y cannot exceed the difference in the prevailing Round Prices.

¹¹⁸ The Relative Cap and the Final Price Cap coincide for Packages that the Bidder is eligible to Bid for in the final Primary Round. Therefore, the relative cap can be ignored for such packages.

bidding during the Primary Bid Rounds.

- 3.181 The Relative Cap limits the Bid Amount of a Supplementary Bid for a package of Lots X relative to the highest Bid Amount submitted for its **Constraining Package** of Lots bid for in the **Constraining Round**. The procedure for defining the applicable Constraining Package and Constraining Round is described in Section 4.2.2.
- 3.182 The **Final Price Cap** is similar to the Relative Cap, but arises in the last Primary Bid Round (the final Primary Bid Round), and applies to the Bid Amount for any Packages of Lots, except for the Final Primary Package. The Bid Amount for any Package of Lots subject to the Final Price Cap will be capped at the highest Bid Amount that the Bidder makes for the Final Primary Package plus the difference in the price of the two Packages of Lots in the final Primary Bid Round¹¹⁹.
- 3.183 A detailed description of the caps is provided in Section 4.2.3. Annex 5 provides examples of how the caps are calculated and Annex 7 discusses the practical implications of the Final Price Cap.

3.5.4 Winner and Base Price determination

- 3.184 Following the Supplementary Bids Round, all valid Initial Bids, Primary Bids (including Relaxed Primary Bids and Chain Bids) and Supplementary Bids received from Bidders are then considered together to determine:
- the Winning Bids in the Main Stage; and
 - the Base Prices to be paid by the Winning Bidders (see Section 4.2.5).
- 3.185 The set of Winning Bidders (and Winning Bids) will be determined by selecting the combination of Bids that has the greatest total value, such that:
- in each Lot Category, no more Lots are awarded than are available in that Lot Category; and
 - at most one Bid is accepted from each Bidder.
- 3.186 This process of selecting the Winning Bids on the basis of optimisation is called Winner Determination.

¹¹⁹ Note that this difference is negative for those Packages of Lots that were cheaper than the Final Primary Package in the Final Primary Bid Round, and so the Bid Amount for these Packages of Lots must be lower than the Bid Amount for the final Primary Package.

- 3.187 ComReg will determine the Base Price payable by each Winning Bidder in respect of its Winning Bid in the Main Stage. These Base Prices will be determined using the Opportunity Cost pricing methodology set out in Chapter 4 (Section 4.2.5). In overview, each Winning Bidder will be required to pay a sufficient amount such that there is no other Bidder, or group of Bidders, that would be prepared to pay more for the Lots awarded to the Winning Bidder, based on the Bids submitted by all Bidders. In addition, each and every subset of Winning Bidders will be required to collectively pay a sufficient amount such that there is no other Bidder, or group of Bidders, that would be prepared to pay more for the Lots awarded to the subset of Winning Bidders.
- 3.188 Annex 6 provides a very simple example of the winner and price determination process. Annex 10 sets out the more formal mathematical description of the process of winner and price determination that will be used.
- 3.189 Bidders will be provided, well in advance of the Auction, with access to a standalone version of the winner and price determination software that can be used to process test cases. This should help Bidders with understanding the mechanics of the winner and price determination procedure, and to verify the algorithm used.

3.6 Assignment Stage

- 3.190 The purpose of the Assignment Stage is to determine the specific frequencies to be assigned to each Winning Bidder awarded B-Lots following the Main Stage (or the Qualification Stage if a Main Stage is not required) across all relevant bands. As the frequencies associated with A-Lots is fixed, the frequency associated with A-Lots are not affected by the Assignment Stage.
- 3.191 Participants in the Assignment Stage are referred to as 'Assignment Bidders'. At the start of the Assignment Stage, ComReg will determine the set of feasible frequency assignments for each Assignment Bidder which is to be awarded B-Lots in accordance with the outcome of the Main Stage (or Qualification Stage if a Main Stage is not required) ("Assignment Options").
- 3.192 The methodology for generating Assignment Options is set out in Annex 9.
- 3.193 The outcome of the Assignment Round, if required, will form the Provisional Assignment Plan, setting out frequency assignments within the frequency range in each band for each Assignment Bidder. However, if there is only one possible frequency assignment for every Assignment Bidder, an Assignment Round is not required and the Provisional Assignment Plan will consist of each Assignment Bidder's unique frequency assignment.

3.194 Following the determination of the Provisional Assignment Plan for each band, there will be a Negotiation Phase during which Assignment Bidders will be given a period of ten Working Days to negotiate and submit a request to ComReg for a reassignment of the frequencies they were assigned in the Provisional Assignment Plan.

3.195 The Assignment Round and Negotiation Phase are discussed in more detail below.

3.6.1 Assignment Round

3.196 If there is more than one feasible frequency assignment identified for any given Assignment Bidder, it will be necessary to determine which options will form the Provisional Assignment Plan. In this case, an Assignment Round will be run to determine a frequency assignment for each Assignment Bidder that is compatible with the frequency assignments for all other Assignment Bidders.

3.197 The Assignment Round consists of a single Round in which:

- Assignment Bidders whose preferred frequency assignment might conflict with the preferred assignment of at least one other Assignment Bidder¹²⁰ are able to submit Bids ('Assignment Bids') to express their preferences over their possible assignments. The potential conflicts are resolved, and frequency assignments determined, on the basis of these Assignment Bids. Assignment Bidders may be required to pay an additional amount on top of their Base Price (an 'Additional Price') for their specific frequency assignment; and
- Assignment Bidders whose feasible frequency assignments do not conflict with the feasible frequency assignments for any other Assignment Bidder¹²¹ in any band will be able to choose their preferred option from amongst the set of frequency assignments presented to them.

Winner and Additional Price determination

3.198 The Winning Combination of Assignment Bids in the Assignment Stage will be the combination of valid Assignment Bids submitted during the Assignment Round that has the highest total value of Assignment Bid amounts, and is

¹²⁰ This will be the case for any Assignment Bidder awarded B-Lots in at least one band in which another Assignment Bidder has been awarded B-Lots.

¹²¹ This will be the case if there is no other Winner of B-Lots in any band in which that Bidder won B-Lots in the Main Stage. The Bidder may, however, still have alternative feasible frequency options that meet the relevant requirements, and it will have to choose between them.

compatible with one of the Candidate Frequency Plans.

- 3.199 Depending on the outcome of the Assignment Round and the Assignment Bids submitted, Assignment Bidders may be required to pay an additional amount on top of their Base Price for the specific frequencies to be assigned to them. ComReg will determine the amounts (Additional Prices) payable by the relevant Assignment Bidders according to an Opportunity Cost pricing rule. The key features of this rule are similar to those set out in relation to determination of the Base Prices to be paid by Winning Bidders in the Main Stage.
- 3.200 Winning Assignment Bidders and Additional Prices are determined independently for each band. A winning Assignment Bidder's total Additional Price will be the sum of its Additional Prices for each band in its assignment.

3.6.2 Negotiation Phase

- 3.201 Following the Assignment Round and the determination of the Provisional Assignment Plan for each band, Assignment Bidders will be permitted a period of ten clear Working Days in which they may communicate with each other to negotiate a re-organisation of the Provisional Assignment Plan and notify ComReg of any revised frequency assignments. Negotiations are only over the location of frequencies associated with the B-Lots. Winners of fixed frequency lots cannot swap those frequencies or swap their B-Lots so that they are no longer contiguous with their A-Lot(s).
- 3.202 Any such re-organisation is subject to all Assignment Bidders receiving blocks of spectrum in accordance with the amount of spectrum awarded to them in each band in the Main Stage (or Qualification Stage).
- 3.203 The rules relating to the negotiation of alternative frequency assignments are further set out in Chapter 4.
- 3.204 In order to provide a starting point for the Negotiation Phase, following the completion of the Assignment Round, ComReg will inform Winning Bidders of the Provisional Assignment Plan (i.e. the frequencies to be assigned to each Assignment Bidder in each of the bands and time slices) and any Additional Prices to be paid.
- 3.205 If Bidders are able to successfully negotiate and agree on an alternative frequency plan and notify ComReg within the ten Working Day period, ComReg will consider and, at its discretion, adopt that frequency plan as the Final Assignment Plan.
- 3.206 If Bidders are unable to come to an alternative configuration of frequency

assignments for a band, ComReg will treat the Provisional Assignment Plan for that band as the Final Assignment Plan for that band.

- 3.207 Following receipt of any requests for alternative frequency assignments, ComReg will determine the Final Assignment Plan, setting out the specific frequencies to be assigned to all Winning Bidders in each band.
- 3.208 Note that ComReg reserves the right to refuse any request for a reassignment of frequencies between two or more Winning Bidders. In this case the frequencies involved will be assigned according to the Provisional Assignment Plan. In particular, without prejudice to the generality of the foregoing, revised frequency assignments proposed by Assignment Bidders may be rejected if such assignments would result in non-contiguous unassigned spectrum in a band.

Post-Auction frequency reassignment

- 3.209 ComReg notes that some Winning Bidders may have a preference for an alternative frequency plan that was not possible to establish under the rules of the Assignment Stage. In particular, this may involve the location of any unassigned frequencies.
- 3.210 In this case, one or more Licensees may submit an application to ComReg, following the completion of the Award Process, to request a reassignment of the frequencies assigned. For example, this could involve:
- a swap of frequencies between two Licensees; and/or
 - a swap of frequencies assigned to a Licensee for currently unassigned spectrum.
- 3.211 Frequency reassignment requests are strictly subject to the approval of ComReg.
- 3.212 In accordance with standard procedure for frequency reassignment, ComReg will consider each request on a case-by-case basis and in light of its statutory functions, objectives and duties, including public consultation on the matter as appropriate.
- 3.213 ComReg reserves the right to refuse any request to reassign frequencies, and to assign unused frequencies in any other way, if it considers appropriate in order to meet its statutory functions, objectives and duties.

3.7 Notification and Grant Stage

- 3.214 Once ComReg has determined the Base Prices for Winning Bids and Additional Prices to be paid for specific frequency assignments have been determined in the Assignment Stage, ComReg will notify each Bidder in writing whether or not it has been successful in acquiring Lots in the Award Process.
- 3.215 In the case of Bidders who do not win any Lots in the Award Process, ComReg will return the relevant amount of their Deposit to them (less any Deposit forfeiture imposed in accordance with the Auction Rules¹²²) within approximately two weeks of this notification.
- 3.216 In the case of Winning Bids, ComReg will notify the Winning Bidders of their entitlement to apply for a MBSA2 Preparatory Licence and a MBSA2 Liberalised Use Licence, subject to compliance with certain upfront obligations, as set out in paragraphs 3.221 and 3.222 below, including their obligation to pay the SAF and first SUF.
- 3.217 The SAF to be paid by each Winning Bidder prior to a receipt of a MBSA2 Liberalised Use Licence or a MBSA2 Preparatory will be the sum of its Base Price and its Additional Price.
- 3.218 The notification to the Winning Bidder will specify the date for the payment of the SAF and first SUF (the “Payment Deadline”), and this date will be approximately two weeks after the release of the results of the Assignment Stage to Bidders. The payment of each Winning Bidder’s SAF and first SUF (in line with paragraph 2.79 of Chapter 2) is a pre-requisite condition to that Winning Bidder being entitled to apply for a MBSA2 Preparatory Licence and a MBSA2 Liberalised Use Licence.
- 3.219 If the amount of a Winning Bidder’s SAF and first SUF is more than the amount of its Deposit, then the net amount of funds due must be received by ComReg in the relevant bank account as cleared funds no later than 23:59 hours (Irish time) on the date of the Payment Deadline. If the amount of a Winning Bidder’s SAF and first SUF, less any applicable rebates, is less than the amount of its Deposit, the relevant amount of its Deposit will be returned to this Winning Bidder by ComReg by the same date as the Payment Deadline (less any Deposit forfeiture imposed in accordance with the Auction Rules).
- 3.220 In respect of a MBSA2 Preparatory Licence, the notification will state that, upon grant of such a Licence, the Winning Bidder is obliged to comply with the terms

¹²² This would include any associated interest earned on the NTMA Exchequer Notes, whether positive or negative, if applicable.

and conditions associated with the MBSA2 Preparatory Licence (as detailed in draft form in Annex 2 and as described in Section 2.4 of this Information Memorandum) and will among other things specify the due date by which the Winning Bidder shall pay the Licence fee associated with the MBSA2 Preparatory Licence.

3.221 Where the Winning Bidder has submitted the SAF plus first SUF along with the Licence fee associated with the MBSA2 Preparatory Licence, ComReg will issue a MBSA2 Preparatory Licence to the Winning Bidder.

3.222 In respect of a MBSA2 Liberalised Use Licence, the notification will state that, upon grant of such a Licence, the Winning Bidder is obliged to comply with the terms and conditions associated with the MBSA2 Liberalised Use Licence (as detailed in draft form in Annex 2 and as described in Section 2.4 of this Information Memorandum) and will among other things:

- specify the Lots to be included in the MBSA2 Liberalised Use Licence in accordance with the Lots awarded to the Winning Bidder in the Award Process;
- specify the expected MBSA2 Liberalised Use Licence commencement date and the commencement date of each Lot in the MBSA2 Liberalised Use Licence notwithstanding the possibility for the commencement date of the Licence and the Lots in a MBSA2 Liberalised Use Licence to be delayed beyond the expected start date;
- specify the expiry date of each Lot in the MBSA2 Liberalised Use Licence and the expiry date of the MBSA2 Liberalised Use Licence;
- note that the Winning Bidder is required to pay the SUF associated with the MBSA2 Liberalised Use Licence in advance of the issue of its MBSA2 Liberalised Use Licence;
- specify the expected date on which ComReg will issue an invoice to the Winning Bidder in respect of the SUF to be paid in connection with the grant of its MBSA2 Liberalised Use Licence, noting the possibility for the commencement date of Lots and a MBSA2 Liberalised Use Licence to be delayed beyond the expected start date;
- specify the information required by ComReg to populate Part 2 and Part 3 of the MBSA2 Liberalised Use Licence and state that the Winning Bidder is obliged to provide such information to ComReg in advance of the commencement date of its MBSA2 Liberalised Use Licence; and

- note that the Winning Bidder is required to comply with Transition Rules as set out in Section 3.8 in order to be entitled to the grant of a MBSA2 Liberalised Use Licence.

3.223 Where the Winning Bidder has submitted the SAF and first SUF by the Payment Deadline and complies with the conditions set out in paragraph 3.222 above, ComReg will issue a MBSA2 Liberalised Use Licence to the Winning Bidder.

3.224 ComReg may at its discretion extend the time limit in order for Bidders to fulfil these obligations. If a Winning Bidder does not comply with the conditions relating to an Application for a MBSA2 Preparatory Licence or the MBSA2 Liberalised Use Licence as set out in this Section, including relating to the payment of the SAF and first SUF, it may forfeit its Deposit and entitlements to a MBSA2 Liberalised Use Licence and a MBSA2 Preparatory Licence, without prejudice to ComReg's entitlement to recover the full amount due in respect of all Lots won as a simple contract debt.

3.225 Once a MBSA2 Liberalised Use Licence has been issued to a Winning Bidder, ComReg will publish on its website the text of the MBSA2 Liberalised Use Licence and subsequent amendments to same.

3.8 Transition Rules

3.226 As explained in Chapter 8 of ComReg Document 19/124, the Existing 2.1 GHz Band Licensees, the Existing 2.3 GHz Band Licensee and Winning Bidders may be required to make adjustments to their networks ('Transition Activities') in order to comply with the outcome of the Award Process.

3.227 Three separate Transitions may be required, being a Transition for:

- i. Existing 2.1 GHz Band Licensees **in advance of the commencement date for Time Slice 1 for the 2.1 GHz Band**. This is because any new 2.1 GHz Band spectrum rights of use won in Time Slice 1 may be different, in terms of frequency location and/or quantum of spectrum, to the 2.1 GHz Band spectrum rights of use of Existing 2.1 GHz Band Licensees (and any spectrum rights of use that may be granted in a 2.1 GHz Band Interim Licence);
- ii. the Existing 2.1 GHz Band Licensee with a 2027 expiry date¹²³ and Winning Bidders in **the 2.1 GHz Band, 2.3 GHz Band and/or 2.6 GHz Band in advance of the commencement date of Time Slice 2**. This is because any new 2.1 GHz Band, 2.3 GHz Band and/or 2.6 GHz Band

¹²³ Meteor is the only Existing 2.1 GHz Band Licence with a 2027 expiry date.

rights of use won in Time Slice 2 may be different, in frequency location and/or quantum of spectrum, to the spectrum rights of use in Time Slice 1; and

- iii. the Existing 2.3 GHz Band Licensee **in the 2.3 GHz Band**. This is because the Existing 2.3 GHz Band Licensee may apply for, and be granted, a MBSA2 2.3 GHz Band Transition Licence in order to provide for the orderly migration of its RurTel Services out of the 2.3 GHz Band.

3.228 All Winning Bidders, Existing 2.1 GHz Band Licensees¹²⁴, and applicants for a MBSA2 2.3 GHz Band Transition Licence¹²⁵ are obliged to abide by the Transition Rules as set out in this Information Memorandum, including the Transition Plan(s).

3.8.1 Transition in the 2.1 GHz Band in advance of Time Slice 1

3.229 Upon completion of the Assignment Stage, ComReg will issue a notification to Winning Bidders of Lots in the 2.1 GHz Band and Existing 2.1 GHz Band Licensees informing them of the specific frequency assignments resulting from the Assignment Stage.

3.230 In addition, this notification will require Winning Bidders and Existing 2.1 GHz Band Licensees to formulate Transition Plan Proposals, and to submit them to ComReg. Each such party may formulate its own individual Transition Plan Proposal or any number of such parties may collaborate to formulate a common Transition Plan Proposal.

3.231 The Transition Plan Proposals, and the Transition Plan as subsequently adopted by ComReg, should identify and consider all the Transition Activities required by the Existing 2.1 GHz Licensees.

3.232 The deadline for the submission of Transition Plan Proposals will be set at 4 weeks from the above notification, although ComReg reserves the right to specify a different date.

3.233 Transition Plan Proposals are to be submitted to ComReg for its consideration (including the consideration of any of its agents or servants) and the consideration of other Winning Bidders and Existing 2.1 GHz Band Licensees.

3.234 A Transition Plan Proposal should address, to ComReg's satisfaction, at least

¹²⁴ See first bullet of paragraph 8.11 of Document 19/124. *"an obligation that all participants (including existing licensees) in the Proposed Award would agree to abide by the transition rules;"*

¹²⁵ See paragraph 3.15.13 of the draft Decision in Chapter 9 of ComReg Document 19/124.

the following matters:

- the identification of all Transition Activities to be undertaken by Existing 2.1 GHz Band Licensees and the order in which each activity will be taken;
- the setting of milestone dates for each Transition Activity. Unless otherwise identified by ComReg in determining the Transition Plan, all Transition Activities are to be completed sufficiently prior¹²⁶ to the commencement date of Time Slice 1 for the 2.1 GHz Band, and the Transition Plan Proposal will ensure same;
- where the Transition Activities of one Existing 2.1 GHz Band Licensee is dependent upon the Transition Activities of another, this will be clearly identified in the Transition Plan Proposal such that any consequential delays by one party due to the delay of another party can be clearly attributable to the responsible party;
- a robust and transparent mechanism to allow ComReg (including any of its agents or servants), Existing 2.1 GHz Band Licensees, Winning Bidders and other Interested Parties to monitor compliance with the Transition Activity milestones and deliverable dates (subject to non-disclosure of Confidential Information);
- the completion of Transition Activities prior to the deadline dates as determined by ComReg in the Transition Plan; and
- attribution and acceptance of liability for liquidated damages that may be payable by the Existing 2.1 GHz Band Licensee(s) in the event of non-compliance with the Transition Activity milestones identified in the Transition Plan, where such Existing 2.1 GHz Band Licensee(s)' actions or omissions caused the non-compliance with the relevant milestone.

3.235 Following receipt of Transition Plan Proposals ComReg will progress the matter in consultation with Winning Bidders and Existing 2.1 GHz Band Licensees with a view to finalising a Transition Plan¹²⁷. This may take the form of written

¹²⁶ This is to facilitate Transition within the licensing framework of the Existing 2.1 GHz Band Licences and 2.1 GHz Band Interim Licences.

¹²⁷ As set out in paragraph 9.33 of Document 19/59R, principles that would guide ComReg in setting out a final transition plan include:

- the minimisation of the potential for significant disruption to existing consumer services; and
- the commencement of new spectrum rights as soon as practicable, thereby not unnecessarily delaying the delivery of new services to end users.

consultation and/or multilateral and/or bilateral meetings with same.

- 3.236 In the event that any parties bound by the Transition Rules are unable or unwilling to submit a Transition Plan Proposal by the stipulated time, ComReg will formulate and implement a Transition Plan, following appropriate consultation or discussion with Winning Bidders and Existing 2.1 GHz Band Licensees. In any case, ComReg will take appropriate and effective measures to ensure that there is no undue delay in the availability of new spectrum rights of use.
- 3.237 ComReg reserves the right to make a final and binding decision on any and all matters pertaining to Transition Rules, including the Transition Plan, following appropriate consultation.
- 3.238 Once the Transition Plan is finalised, it may be published on ComReg's website, having regard to the provisions of ComReg's guidelines on the treatment of Confidential Information as set out in ComReg Document 05/24. ComReg reserves and retains the discretion to vary the Transition Plan as appropriate.

3.8.2 Transition in advance of Time Slice 2

- 3.239 A similar Transition process may be adopted by ComReg for Time Slice 2 where it appears possible that delays may be caused to the commencement date of Lots in Time Slice 2 by the Transition activities of the Existing 2.1 GHz Band Licensee with an expiry date of 2027 or Winning Bidders of Lots in Time Slice 1.
- 3.240 Depending upon the nature and extent of Transition activities required between Time Slice 1 and Time Slice 2, ComReg reserves the right to apply the Transition Rules set out in section 3.8.1 above to the Existing 2.1 GHz Band Licensee and Winning Bidders.
- 3.241 If it is necessary to adopt such a Transition process, it will be based upon the Transition Rules set out in sections 3.8.1 with the exception that:
- the deadline for the completion of all Transition activities is 11 March 2027;
 - in order to ensure that Transition Activities are given the fullest consideration, the deadline for the submission of Transition Plan Proposals for Time Slice 2 will be:

- one year in advance of 11 March 2027 for Transition Scenario A¹²⁸;
- two years in advance of 11 March 2027 for Transition Scenario B¹²⁹; and
- three years in advance of 11 March 2027 for Transition Scenario C¹³⁰.

3.8.3 Transition of RurTel Services from the 2.3 GHz Band

3.242 Upon completion of the Assignment Stage, ComReg will issue a notification to the Existing 2.3 GHz Band Licensee:

- confirming that its Existing 2.3 GHz Band Licence will expire on the commencement date of Time Slice 1 for the 2.3 GHz Band; and
- requesting that it submit an application for a MBSA2 2.3 GHz Transition Licence in advance of the commencement date of Time Slice 1 (see Section 2.3.3 above) should it wish to continue to provide RurTel Services in the 2.3 GHz Band¹³¹.

3.243 Following receipt of any application for a MBSA2 2.3 GHz Transition Licence, ComReg will issue a notification to the MBSA2 2.3 GHz Band Transition Licensee requiring it to formulate Transition Plan Proposals, and to submit them to ComReg.

3.244 The Transition Plan Proposals, and the Transition Plan as subsequently adopted by ComReg, should identify and consider all the Transition Activities required by the MBSA2 2.3 GHz Band Transition Licensee in order to transition RurTel Services out of the 2.3 GHz Band.

3.245 The deadline for the submission of Transition Plan Proposals will be set at 4 weeks from the above notification, although ComReg reserves the right to specify a different date.

3.246 Transition Plan Proposals are to be submitted to ComReg for its consideration

¹²⁸ Transition Scenario A refers to the scenario where an Existing 2.1 GHz Band Licensee or a Winning Bidder of Lots in Time Slice 1 wins an equal or greater amount of new spectrum rights in the same band in Time Slice 2 but these spectrum rights are in a different frequency location.

¹²⁹ Transition Scenario B refers to the scenario where an Existing 2.1 GHz Band Licensee or a Winning Bidder of Lots in Time Slice 1 wins a reduced amount of new spectrum rights in the same band in Time Slice 2.

¹³⁰ Transition Scenario C refers to the scenario where an Existing 2.1 GHz Band Licensee or a Winning Bidder of Lots in Time Slice 1 wins no new spectrum rights in the same band in Time Slice 2.

¹³¹ ComReg observes that other licensing options (e.g. spectrum leasing) may also be available.

(including the consideration of any of its agents or servants) and the consideration of other Winning Bidders and MBSA2 2.3 GHz Band Transition Licensee.

3.247 A Transition Plan Proposal should address, to ComReg's satisfaction, at least the following matters:

- the identification of all Transition Activities to be undertaken by the MBSA2 2.3 GHz Band Transition Licensee and the order in which each activity will be taken;
- the setting of milestone dates for each Transition Activity identified;
- where the Transition Activities of the MBSA2 2.3 GHz Band Transition Licensee is dependent upon the Transition Activities of another party, this will be clearly identified in the Transition Plan Proposal such that any consequential delays by one party due to the delay of another party can be clearly attributable to the responsible party;
- a robust and transparent mechanism to allow ComReg (including any of its agents or servants), Winning Bidders and other Interested Parties to monitor compliance with the Transition Activity milestones and deliverable dates (subject to non-disclosure of Confidential Information)¹³²; and
- the completion of Transition Activities prior to the deadline dates as determined by ComReg in the Transition Plan. ComReg observes that based on current information and noting the rural locations of the existing customers, this could be informed by the ability of the RurTel customers to avail of the services that would be provided via the National Broadband Plan (NBP).

3.248 Following receipt of Transition Plan Proposals ComReg will progress the matter in consultation with Winning Bidders and the MBSA2 2.3 GHz Band Transition Licensee with a view to finalising a Transition Plan¹³³. This may take the form of

¹³² For Transition of RurTel Services from the 2.3 GHz Band, ComReg envisages the submission of regular progress reports and the holding of regular progress meetings.

¹³³ As set out in paragraph 9.52 of Document 19/59R, ComReg observes that the following transition principles would appear relevant to the Transition of RurTel Services from the 2.3 GHz Band:

- minimise the potential for disruption to existing consumer services;
- introduce new rights of use in the 2.3 GHz Band as soon as possible without unnecessarily delaying the delivery of future liberalised services;
- maximise benefits to end-users; and
- ensuring the efficient use of spectrum during the Transition period.

written consultation and/or multilateral and/or bilateral meetings with same.

- 3.249 In the event that any parties bound by the Transition Rules are unable or unwilling to submit a Transition Plan Proposal by the stipulated time, ComReg will formulate and implement a Transition Plan, following appropriate consultation or discussion with Winning Bidders and the MBSA2 2.3 GHz Band Transition Licensee. In any case, ComReg will take appropriate and effective measures to ensure the migration of RurTel Services to alternative platform(s) in a timely, efficient and orderly manner.
- 3.250 ComReg reserves the right to make a final and binding decision on any and all matters pertaining to Transition Rules following appropriate consultation.
- 3.251 Once the Transition Plan is finalised, it may be published on ComReg's website, having regard to the provisions of ComReg's guidelines on the treatment of Confidential Information as set out in ComReg Document 05/24. ComReg reserves and retains the discretion to vary the Transition Plan as appropriate.

3.8.4 Liquidated Damages

- 3.252 An essential part of ensuring that Existing 2.1 GHz Band Licensees and Winning Bidders are appropriately incentivised to complete their respective Transition Activities in an effective and timely manner, is the identification of, and agreement to pay, liquidated damages to ComReg where such Existing 2.1 GHz Band Licensee or Winning Bidder fails to discharge its obligations in accordance with the milestones and deadlines set out in the Transition Plan.
- 3.253 The total amount of liquidated damages payable by these Existing 2.1 GHz Band Licensees or Winning Bidders will be based on the refunds or adjustments of Licence fees that ComReg pre-estimates that it may have to make to Winning Bidders in the event that ComReg may be unable to make Lots available for use due to the delays caused to the completion of Transitional Activities in the Transition Plan.
- 3.254 Section 2.3.7 of this document contains details of the nature of refunds or adjustments payable by ComReg and shall be used by ComReg in pre-estimating the payable liquidated damages pursuant to the Transition Plan. These liquidated damages are payable immediately on request and are non-refundable.

Chapter 4

4 The Auction Rules

4.1 General

4.1.1 The Electronic Auction System

- 4.1 Both the Main Stage (including the Primary Bid Rounds and the Supplementary Bids Round) and the Assignment Round will be run using an Electronic Auction System (EAS). Bidders will use the EAS to submit Bids and any decisions on preferred frequency assignments, where applicable.
- 4.2 For completeness and transparency, ComReg has set out the details of how the Auction and Auction Rules will work, much of which involves complex economic auction theory. As noted in Chapter 3, however, Interested Parties are assured that, in practice, the EAS will be relatively simple to use as it will automatically work out the application of rules during the Auction for Bidders. For example, the EAS will allow Bidders to determine which Bids Bidders can and cannot make under the Auction Rules.
- 4.3 Bidders will be able to access the EAS over the internet using a web-browser. There will be no onerous technical requirements for accessing the system.
- 4.4 Bidders are recommended to have back-up bidding facilities in place, including alternative computers and internet connections, to ensure that they can access the EAS reliably. ComReg is not able to provide specific advice on this matter, as this depends on the systems in use by any particular Bidder. Bidders should perform their own review of their bidding facilities prior to the start of the Auction.
- 4.5 Bidders may not submit Bids through any means other than the EAS, other than in exceptional circumstances and only then with the explicit permission of ComReg. In particular, before granting permission for Bids to be made through other means, ComReg must be satisfied that a Bidder was unable to access the EAS due to circumstances beyond its reasonable control. Procedures for the submission of Bids other than through the EAS are described in paragraph 4.11 below. It is in Bidders' own interests to submit Bids using the EAS as the EAS provides facilities for checking the compatibility of Bids with the Auction Rules prior to submission of Bids.
- 4.6 Bidders have a limited number of Extension rights, which will automatically grant them additional time for submitting their Bids in the event that they do not make

a submission before the scheduled end of a Round as notified by ComReg. The Extension rights provide Bidders with an opportunity to, for example, switch to back-up bidding facilities and to submit their Bids through the EAS in the event that they experience technical difficulties and are unable to make their submission within the scheduled Round time.

- 4.7 In the event that a Bidder perceives an error in the functioning of the EAS it is obliged to contact ComReg immediately. ComReg may, at its discretion, suspend or continue the Auction while investigating any such concerns.

4.1.2 Bid Submission

- 4.8 The process for submitting Bids in each of the Primary Bid Rounds, the Supplementary Bids Round and the Assignment Round is described in the relevant sections below. In each case, Bid submission involves a two-step process in which Bidders must first check their Bids and then confirm them:

- in the first step, Bidders enter their Bid(s) on the relevant Bid form provided by the EAS for that Round, and submit that form to the EAS for checking; and
- in the second step, which is only available if the Bid(s) submitted in the first step are valid according to the Auction Rules, Bidders must verify the Bid(s) checked by the EAS and confirm them (or alternatively revert to the Bid form if they wish to make any amendments).

- 4.9 A Bid is only valid if it is submitted in accordance with the process outlined above and received by the EAS before the deadline for Bid(s) submission (taking into account any Extension rights, as explained below).

- 4.10 Bidders should be aware that the transmission of Bid data from a client computer to the EAS will take a short, but material, time. Submissions can only be accepted if they are received by the EAS before the relevant deadline, regardless of the time at which they are sent from the Bidder's computer. Therefore, data transmission delays could lead to a Bidder missing the deadline for making a submission (which might trigger an Extension right, or prevent the Bidder from making a submission in the Round). Bidders are responsible for making their own assessments of such risks and ensuring that they have access to the necessary infrastructure and equipment to allow reliable and timely submission.

- 4.11 Once a confirmation has been received by the EAS it is irrevocable. Upon receipt of a Valid Bid(s), the EAS will provide an acknowledgement page with details of the Bid(s) submitted. It is the responsibility of the Bidder to check this

acknowledgement page, and to alert ComReg if technical problems are suspected to have prevented successful submission. If a Bidder is unable to submit its Bid(s) using the EAS, then it should immediately notify ComReg and seek permission to make a submission using an alternative channel. Such permission will usually not be given if ComReg has been notified of difficulties in making a submission after the deadline for submissions has expired. Where notification of such difficulties is received before the deadline for submissions, ComReg may, at its absolute discretion, grant permission to make submissions using an alternative channel for one or more Rounds, and will provide directions to the relevant Bidder on how to make such submissions. Bidders must follow the express directions of ComReg for making submissions by alternative channels, such as email or telephone; otherwise ComReg will consider that no submission has been made.

4.1.3 Bidding Restrictions in Main Stage

4.12 During the Main Stage of the Auction, several constraints will apply to the Bids that Bidders will be allowed to submit. These Bidding Restrictions will be in the form of:

- Competition Caps, that restrict the amount of spectrum Bidders can win rights of use for in the Award Process; and
- constraints on the combinations of fixed frequency and frequency-generic Lots in the 2.6 GHz TDD Band that a Bidder can submit Bids for.

Competition Caps

4.13 All Bids in the Main Stage are subject to an Overall Competition Cap and a Sub-1 GHz Competition Cap that will apply to spectrum holdings immediately following the Award Process and therefore limit the rights of use that Bidder's may bid for/acquire in the Award Process. These Competition Caps are evaluated separately for each Time Slice, and include spectrum associated with existing licences held during the relevant time period(s). For the avoidance of doubt, these caps only apply for the duration of the Award Process. They do not affect the transfer of rights thereafter, for instance pursuant to spectrum leasing.

4.14 **Sub-1 GHz Competition Cap:** no Bidder may bid for/acquire spectrum rights of use in the Award Process that would result in it holding total spectrum rights of use for more than 70 MHz (2 × 35 MHz) of spectrum across the 700 MHz Duplex, 800 MHz and 900 MHz Bands at any time during either of the two Time Slices.

- 4.15 **Overall Competition Cap:** no Bidder may bid for/acquire spectrum rights of use in the Award Process that would result in it holding total spectrum rights of use for more than 375 MHz across the 700 MHz Duplex, 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz, 2.3 GHz, 2.6 GHz and 3.6 GHz Bands¹³⁴ at any time during either of the two Time Slices.

Restrictions relating to fixed frequency Lots

- 4.16 A Bidder will be prevented from submitting a Bid for a Package of Lots which includes the 2.6 GHz TDD Fixed Frequency Lot (Lower) and the 2.6 GHz TDD Fixed Frequency Lot (Upper) in a given time slice unless that Bid also includes all the 2.6 GHz TDD Generic Frequency Lots in the same time slice.

4.1.4 Communicating with ComReg

- 4.17 The EAS will provide a one-way messaging system, which will be used as the primary method for ComReg to communicate with Bidders during the Auction.
- 4.18 Bidders may contact ComReg by telephone, using designated telephone numbers, only to report technical problems or to report potential breaches of the Award Rules. In certain exceptional circumstances, Bidders may be given permission to submit Bid(s) through alternative means, such as email or telephone. Where ComReg has expressly granted permission to a Bidder, such a Bidder may submit Bids only by the means agreed with ComReg.
- 4.19 Contact details for ComReg and guidelines on the submission of Bids in exceptional circumstances will be made available to Bidders in advance of the Auction. ComReg may take steps to verify the authenticity of any communications from a Bidder using one-time passwords provided to the Bidder prior to the start of, or during, the Auction, or by other means as considered necessary by ComReg.

4.1.5 Exceptional Circumstances

- 4.20 If exceptional circumstances arise during any stage of the Auction, ComReg has the discretion to:
- postpone the scheduled start of a Round;
 - postpone the end of a Round in progress or the release of results of a Round;

¹³⁴ In the 3.6 GHz Band, the highest spectrum holding of a Bidder in any 3.6 GHz Band Region is used for the purposes of the Overall Competition Cap.

- postpone the scheduling of further Rounds;
- cancel a Round that has been scheduled, but not yet started;
- cancel a Round that is either underway or which has finished but for which Round results have not yet been released, and re-schedule that Round;
- void all Bids received in the Auction, and either suspend the Auction or restart the Auction;
- end the Primary Bid Rounds early (i.e. while there is still excess demand in more or more Lot Categories), and proceed directly to the Supplementary Bids Round; and/or
- take any other steps or measures in running the Award Process which are appropriate and proportionate to the exceptional circumstances which have arisen and which further the objectives of the Award Process.

4.21 ComReg, at its absolute discretion, will determine whether a situation of exceptional circumstances has arisen. Exceptional circumstances could include, for example, widespread technical failure or material concern about collusion amongst some Bidders or other material breaches of the Award Rules.

4.22 In the event that a Bidder is excluded from the Auction and some, or all, of its Bids made so far are deemed invalid, ComReg would typically expect not to exercise any of the above powers. However, ComReg would consider all of the circumstances in determining whether to exercise its powers in this regard.

4.1.6 Applicant and Bidder Behaviour

4.23 Applicants and Bidders are reminded that the Award Process and Award Rules prohibits Applicants and Bidders from, among other things:

- coordinating bidding decisions with other Applicants or Bidders; and
- sharing information with other Applicants or Bidders that could affect their bidding decisions.

4.24 Such behaviours may also be illegal under EU and Irish competition law. These prohibitions apply throughout the Award Process. ComReg also reminds all Interested Parties of their obligations under Irish and EU competition law noting that certain behaviours prior to the submission of an Application may be in

breach of same.

4.2 The Main Stage

4.25 This section provides a detailed description of the rules applying to the Main Stage of the Auction¹³⁵.

4.2.1 Information made available to Bidders before the start of the Main Stage

4.26 Before the start of the Main Stage, ComReg will announce to all Bidders:

- the Round Price per Lot for each Lot Category in the first Primary Bid Round;
- Aggregate Demand for each Lot Category, based on Initial Bids; and
- the provisional Round Schedule for the first few days of the Auction (that is, the scheduled start time and end time of Rounds, assuming no Extension rights are used).

4.27 ComReg will also inform each Bidder of its own Initial Eligibility in each Time Slice (as determined by its Initial Bid).

4.2.2 Primary Bid Rounds

Schedule for Primary Bids Rounds

4.28 Primary Bid Rounds are scheduled at ComReg's discretion.

4.29 There is no minimum or maximum length for a Primary Bid Round. However, ComReg does not anticipate scheduling Primary Bid Rounds with a Round duration of less than 30 minutes or greater than two hours. Subject to the constraints of the notification requirements below, the time between Primary Bid Rounds is discretionary and a matter for ComReg to determine Round-by-Round. Nevertheless, each Working Day prior to an Auction Day, ComReg would typically expect to issue a notice of its indicative plans with regard to the

¹³⁵ Interested Parties should note that ComReg reserves the right to make amendments to the Auction Rules after the finalisation of this Information Memorandum to correct any errors therein, or to further clarify matters, whether identified by ComReg, its consultants or Interested Parties, where such amendments are necessary or appropriate to ensure that the Auction Rules and the EAS operate in the manner intended by ComReg, as set out in the Information Memorandum. ComReg will promptly bring any such amendments to the attention of Interested Parties. Interested Parties are reminded that they are obliged to bring any errors to ComReg's attention promptly.

number of Rounds of the Auction to be run the following Auction Day. However, this will be issued as guidance only and will not be binding on ComReg. Due to the provisions for Extensions of Rounds and the potential for exceptional circumstances to arise, it is not possible to guarantee the start and end times of each Round in advance. The actual start time of a Round will be notified after the completion of the preceding Round, in line with the notice requirements.

- 4.30 All Primary Bid Rounds will be scheduled to run between 9.00 and 17.00 Irish time on Working Days¹³⁶, assuming that no Extension rights are used. For the avoidance of doubt, no specific times for scheduled breaks (for example lunch) will be set aside.
- 4.31 There will be a minimum of 30 minutes between Primary Bid Rounds.
- 4.32 Bidders will be notified of the Round Schedule for a Primary Bid Round via the EAS at least 15 minutes in advance of the scheduled start time of the Round.
- 4.33 Upon announcement of the start time of the next Primary Bid Round, each Bidder will also be informed about:
- the scheduled duration and end time for the next Primary Bid Round;
 - the Round Price per Lot for each Lot Category in the Round;
 - the Bidder's Eligibility to bid in the Round; and
 - the number of Extension rights the Bidder has remaining.
- 4.34 If no Extension rights are used, a Primary Bid Round will end at the scheduled end time. Under normal circumstances, Primary Bid Rounds will not end before their scheduled end time, even if all Bidders have already made their submissions for the Round.

Round Prices

- 4.35 For each Primary Bid Round, ComReg will specify a Round Price per Lot for each Lot Category.
- 4.36 For the first Primary Bid Round, the Round Price per Lot in each Lot Category for which there was no excess demand on the basis of Initial Bids will be the Reserve Price per Lot in the Lot Category. The Round Price per Lot in each Lot Category for which there was excess demand on the basis of Initial Bids will be

¹³⁶ Saturdays, Sundays and public holidays in Ireland will be treated as non-Working Days.

the Reserve Price per Lot in the Lot Category plus a Price Increment.

- 4.37 In subsequent Primary Bid Rounds, for each Lot Category the Round Price will be increased if in the previous Round there was excess demand in that Lot Category.
- 4.38 Excess demand in a Lot Category exists where the total number of Lots in that Lot Category included in all Valid Bids submitted in the Round is greater than the number of Lots available in that Lot Category.
- 4.39 For Lot Categories where there was no excess demand in a given Round, the Round Price per Lot for that Lot Category will remain unchanged for the following Round.
- 4.40 For the avoidance of doubt, it is not possible for the Round Price for any Lot Category to fall during the Primary Bid Rounds.
- 4.41 For each Lot Category, the amount by which the Round Price is increased in the case of excess demand is set at ComReg's discretion, and may vary across Lot Categories and across Primary Bid Rounds.
- 4.42 In any case, the Round Price for any Lot Category will not increase by more than 20% from one Primary Bid Round to the next.
- 4.43 Round Prices will be in multiples of EUR 1000.

Primary Bid Submission

- 4.44 During a Primary Bid Round, a Bidder may submit a Primary Bid for at most one Package of Lots. A Primary Bid is made by specifying the number of Lots in each of the Lot Categories that a Bidder wishes to acquire at the prevailing Round Prices. A Package of Lots may include any combination of Lots, subject to the constraints arising from the application of the Bidding Restrictions, and the Activity Rules described below.
- 4.45 The price offered for the Package of Lots subject to a Primary Bid (the Bid Amount) is determined as follows:
- for each Lot Category, the number of Lots in that Lot Category included in the Package of Lots subject to the Primary Bid is multiplied by the relevant Round Price for that Lot Category; and
 - these values are summed across all Lot Categories.
- 4.46 It is not possible for a Bidder to subsequently amend the Bid Amount for a

Primary Bid.

- 4.47 Bid submission follows the two-step check and confirm process described in Section 4.1.2.
- 4.48 A Primary Bid is a binding offer to buy the selected Package of Lots for any price not exceeding the Bid Amount. Each Primary Bid will be considered in its entirety and will not be sub-divided (i.e. into its component Lots).
- 4.49 During the Primary Bid Rounds, Bidders have the option to submit a Zero Bid, i.e. to bid for zero Lots in all of the available Lot Categories with a Bid Amount of zero. If a Bidder submits a Zero Bid in a Primary Bid Round, it will not be possible for the Bidder to submit any further Bids during subsequent Primary Bid Rounds. A Bidder that submits a Zero Bid during the Primary Bid Rounds may still submit Supplementary Bids in the Supplementary Bids Round, subject to the Final Price Cap and Relative Cap detailed in Section 4.2.3.
- 4.50 In some cases, as explained further below, a Bidder may be able to submit a so-called Relaxed Primary Bid. The EAS will assist Bidders in determining whether it is possible to make a Relaxed Primary Bid on particular Packages of Lots of interest.
- 4.51 The submission of a Relaxed Primary Bid may require that the Bidder also submits so-called Chain Bids at the same time. However, Bidders that wish to submit a Relaxed Primary Bid only need to select the Package of Lots subject to the Relaxed Primary Bid on their Bid form; any necessary Chain Bids will be identified and notified to the Bidder by the EAS. Provided that the Bidder can make these Bids in accordance with the Auction Rules, it will then be given the opportunity to submit the Relaxed Primary Bid and any necessary Chain Bids simultaneously.
- 4.52 If a Bidder fails to submit a Bid before the scheduled end of a Primary Bid Round or subsequent Extension period (if the Bidder had Extensions remaining), the EAS will automatically enter a Zero Bid on the Bidder's behalf.

Activity and Bidder Eligibility

- 4.53 Each Lot available in the Auction is assigned a number of Eligibility Points, as set out in Tables 16 and 17.
- 4.54 The **Eligibility of a Package of Lots** is determined independently for each Time Slice. Therefore, a Package of Lots has two Eligibility scores.
- 4.55 For each Time Slice, the associated Eligibility of a Package of Lots is equal to:

- the sum of the Eligibility Points of Lots in the 2.1 GHz, 2.3 GHz and 2.6 GHz bands in that Time Slice included in the Package of Lots; plus
- the sum of the Eligibility Points of the 700 MHz Duplex Lots included in the Package of Lots¹³⁷.

4.56 A Bidder starts each Primary Bid Round with a number of Eligibility Points for each Time Slice; this is the Bidder's **Eligibility** for the Round.

4.57 A Bidder is eligible to bid for a Package of Lots if:

- the Eligibility of the Package of Lots for Time Slice 1 is less than or equal to the Bidder's current Eligibility for Time Slice 1; *and*
- the Eligibility of the Package of Lots for Time Slice 2 is less than or equal to the Bidder's current Eligibility for Time Slice 2.

4.58 The **Activity** of a Bid is also determined independently for each Time Slice. For each Time Slice, the Activity associated with a Primary Bid is equal to the Eligibility of the Package of Lots that the Bidder bid for in the corresponding Time Slice.

4.59 In any Primary Bid Round, each Bidder may submit a Primary Bid with Activity less than or equal to its Eligibility in each Time Slice at the start of the Round, provided that the Bid satisfies the Bidding Restrictions.

4.60 Under certain conditions, a Bidder may submit a Primary Bid with Activity strictly greater than its Eligibility at the start of the Round in one or both of the Time Slices. Such a Bid is called a Relaxed Primary Bid. Such Bids are permitted where they express preferences that are consistent with earlier Bids made by the Bidder. The specific requirements for submission of a Relaxed Primary Bid are detailed below.

4.61 The Eligibility of a Bidder for the first Primary Bid Round (its Initial Eligibility) is equal to the Activity of its Initial Bid. For the avoidance of doubt, a Bidder may submit Bids (either as Primary Bids or Supplementary Bids) for Packages of Lots with Eligibility exceeding its Initial Eligibility (in one or both of the Time Slices), provided this is compatible with the Activity Rules. In the case of a Primary Bid, this would need to be by means of a Relaxed Primary Bid.

4.62 For each subsequent Primary Bid Round, a Bidder's Eligibility in a Time Slice is

¹³⁷ The 700 MHz Duplex is not subject to Time Slicing. Therefore, 700 MHz Duplex Lots count towards the Eligibility of the Package of Lots in both Time Slices.

set to the lesser of:

- the Bidder's Eligibility in that Time Slice at the start of the preceding Primary Bid Round; and
- the Activity in that Time Slice of the Bid submitted by the Bidder in the preceding Primary Bid Round.

4.63 Note that as a result of this rule, submission of a Relaxed Primary Bid does not increase the Bidder's Eligibility in the Time Slice(s) where the Bidder's Activity exceeds its Eligibility. Thus, over successive Primary Bid Rounds, a Bidder's Eligibility in each Time Slice could stay the same (if it Bids for a Package of Lots with Eligibility equal to its current Eligibility in that Time Slice, or makes a Relaxed Primary Bid for a Package of Lots with Eligibility exceeding its current Eligibility in that Time Slice) or fall (if it Bids for a Package of Lots with Eligibility strictly less than its current Eligibility in that Time Slice), but can never increase.

4.64 A Primary Bid which leads to a reduction in the Bidder's Eligibility in either of the two Time Slices is an Eligibility-reducing Primary Bid. In the case that a Bidder submits a Relaxed Primary Bid with Activity that strictly exceeds the Bidder's current Eligibility in one Time Slice but is strictly less than the Bidder's current Eligibility in the other Time Slice, its Eligibility in the former Time Slice will be maintained and its Eligibility in the latter Time Slice will be reduced for the subsequent Primary Bid Round. We refer to this as an Eligibility-reducing Relaxed Primary Bid. Note that an Eligibility-reducing Relaxed Primary Bid is a special case of Eligibility-reducing Primary Bid.

4.65 The EAS will warn a Bidder if it specifies a Primary Bid that would result in a reduction of Eligibility for the next Primary Bid Round.

4.66 The EAS will not allow any Bidder to submit a Bid that violates the Bidding Restrictions. Further, the EAS will not permit a Primary Bid with Activity greater than the Bidder's Eligibility at the start of the Round, unless it is compatible with the Activity Rules under the provisions for submitting Relaxed Primary Bids (discussed below). If a Bidder checks a Primary Bid that is invalid, the EAS will require the Bidder to revise the Bid and resubmit this for checking. The EAS will only allow confirmation of Bids that have satisfied the checking step.

Relative Caps

4.67 A Relative Cap on any Package of Lots X is defined by reference to the **Constraining Round** applying to X . Let Round R be the Constraining Round for X , when the Bidder bid for Package of Lots Y (referred to as the **Constraining Package** for X). The Relative Cap limits any Bid Amount that the

Bidder may subsequently submit for X to:

- the highest Bid submitted by the Bidder for the Constraining Package Y ; plus
- the difference in price between X and Y at the Round Prices prevailing in Round R .

4.68 This condition requires the Bidder to respect the preferences revealed by the choice it made in the Constraining Round, when it chose to bid for the Constraining Package in preference to X at prevailing Round Prices.

Relative Caps resulting from Eligibility-reducing Primary Bids

4.69 The submission of Eligibility-reducing Primary Bids will result in a Relative Cap being created on certain Packages of Lots that the Bidder could have Bid for in that Round, but chose not to. Specifically, when a Bidder submits an Eligibility-reducing Primary Bid Z , then:

- a) this will set a Relative Cap with respect to that Round on any Packages of Lots with Eligibility greater than the Activity of Z in any of the Time Slices and which were not yet subject to a Relative Cap; and
- b) if the Bidder had already submitted any Eligibility-reducing Primary Bids in earlier Rounds, then this will set a Relative Cap for one of the Packages of Lots for which the Bidder has already submitted an Eligibility-reducing Primary Bid – specifically the Package of Lots for which the Bidder submitted its most recent Eligibility-reducing Primary Bid (prior to Z) out of those Packages of Lots for which the Bidder would have been able to submit a Primary Bid (Relaxed or ordinary) in the in the Round in which the Bidder submits a Bid for Z .

4.70 If the Package of Lots identified in part b) of paragraph 4.69 above is already subject to a Relative Cap (set by an Eligibility-reducing Primary Bid submitted in an earlier Round), that pre-existing Relative Cap is replaced by the new Relative Cap created by the Eligibility-reducing Primary Bid for Z .

4.71 For any Package of Lots for which a Relative Cap is created as a result of an Eligibility-reducing Primary Bid for Z :

- Z is the Constraining Package; and
- the Round in which the Eligibility-reducing Primary Bid for Z is submitted is the Constraining Round.

4.72 The Relative Caps that apply for a Bidder must be respected when submitting Supplementary Bids and also when submitting Relaxed Primary Bids, as explained below. Specifically, the potential need for Chain Bids associated with a Relaxed Primary Bid arises from the requirement that Relative Caps already in force are respected throughout the Primary Bid Rounds.

Relaxed Primary Bids and Chain Bids

4.73 Under certain conditions, a Bidder ('B') will be permitted to make a Primary Bid with Activity greater than the Bidder's Eligibility in one or both Time Slices at the start of the Round. This is called a Relaxed Primary Bid. See Annex 5 for a worked example of Relaxed Primary Bids.

4.74 As for all Primary Bids, the Bid Amount for a Relaxed Primary Bid is determined by the Round Prices applied to the Package of Lots selected. The Bidder is not able to amend the Bid Amount associated with a Relaxed Primary Bid.

4.75 A Bidder cannot submit a Relaxed Primary Bid if its Eligibility at the start of the Round is zero in both Time Slices.

4.76 To make a Relaxed Primary Bid on some Package of Lots X at the current Round Prices, Chain Bids may be required on one or more Packages of Lots (other than X) that B bid for in previous Primary Bid Rounds (as specified below), if the Relaxed Primary Bid would not already be consistent with preferences expressed by the Bidder through its previous Bids.

4.77 Chain Bids may be required on the Packages of Lots which were subject to Bids by B submitted in a Primary Bid Round in which B reduced its Eligibility in one or both Time Slices, and/or the Package of Lots included in the Bidder's Initial Bid.

4.78 Let Primary Bid Round M_1 be the Constraining Round for X . A Chain Bid may be required on the Constraining Package Z_1 that was subject to a Bid in Primary Bid Round M_1 unless B has already made a Bid of a sufficiently large amount for the Constraining Package Z_1 . The amount of the required Chain Bid for Package of Lots Z_1 is equal to:

- a) the Bid Amount associated with the Relaxed Primary Bid for X (i.e. the price of Package of Lots X at current Round Prices); minus
- b) the difference in price between Package of Lots X and package of Lots Z_1 at the Round Prices in Primary Bid Round M_1 .

4.79 Where B has submitted a Bid for Z_1 previous to the current Primary Bid Round

with a Bid Amount that is at least this level, no Chain Bid for Z_1 is required in this Round in support of the Relaxed Primary Bid for X .

- 4.80 If B is currently eligible to bid for Z_1 , then no other Chain Bids are required in order to submit a Relaxed Primary Bid for X .
- 4.81 Conversely, if B is not currently eligible to bid for Z_1 , let M_2 be the Constraining Round for Z_1 . A Chain Bid may be required on the Constraining Package Z_2 that was subject to a Primary Bid in Round M_2 , unless B has already made a Bid of a sufficiently large amount for the Constraining Package Z_2 . The amount of this Chain Bid for Package of Lots Z_2 is equal to:
- a) the amount of the required Chain Bid for Z_1 (determined above);
minus
 - b) the difference in price between Z_1 and Z_2 at the Round Prices in Round M_2 .
- 4.82 Where B has submitted a Bid for Z_2 in a previous Primary Bid Round with a Bid Amount of at least this level, no Chain Bid for Z_2 is required in this Round.
- 4.83 If B is currently eligible to bid for Z_2 , then no further Chain Bids are required.
- 4.84 Conversely, if B is not currently eligible to bid for Z_2 then at least one further Chain Bid may be required. The further Chain Bids required are defined sequentially in the same manner as follows.
- 4.85 Assume that B is not eligible to bid for a previously defined Package of Lots, Z_k , that is subject to a required Chain Bid. Let M_{k+1} be the Constraining Round for Z_k . A Chain Bid may be required for Package of Lots Z_{k+1} that was subject to a Primary Bid in round M_{k+1} unless B has already made a Bid of a sufficiently large amount for the Constraining Package Z_{k+1} . The amount of this Chain Bid for Z_{k+1} is equal to:
- a) the amount of the required Chain Bid for Z_k (previously determined);
minus
 - b) the difference in price between Z_k and the Z_{k+1} at the Round Prices in Round M_{k+1} .
- 4.86 Where B has submitted a Bid for Z_{k+1} in a previous Primary Bid Round with a Bid Amount of least this level, no Chain Bid is required for Z_{k+1} in this Round.

- 4.87 If B is currently eligible to bid for Z_{k+1} then no further Chain Bids are required. Otherwise, repeat the procedure set out above.
- 4.88 For B to be permitted to make a Relaxed Primary Bid for Package of Lots X, it is necessary that none of the required Chain Bids defined above exceed the price of the Package of Lots subject to the Chain Bid at current Round Prices.
- 4.89 If any of the associated Chain Bids exceeds the price of the Package of Lots subject to the Chain Bid at current Round Prices, then it is not possible to make a Relaxed Primary Bid for Package of Lots X in the current Primary Bid Round. For the avoidance of doubt, this does not rule out the possibility that a Relaxed Primary Bid might be possible for X in some later Primary Bid Round, depending on the subsequent evolution of Round Prices.
- 4.90 When making a Relaxed Primary Bid, it is only necessary for a Bidder to enter a single Package of Lots that is the subject of its Bid into the Bid Form provided by the EAS. The associated Chain Bids that need to be made together with the Relaxed Primary Bid will be automatically identified by the EAS and notified to the Bidder when the Package of Lots is selected on the Bid Form. On submission of a Relaxed Primary Bid, any required Chain Bids will also be submitted by the EAS.

Validity of Primary Bids

- 4.91 All Bids submitted during the Primary Bid Rounds (including Primary Bids, Relaxed Primary Bids and Chain Bids) in accordance with the Auction Rules are Valid Bids. A Valid Bid represents a binding commitment to:
- buy the specified Package of Lots at any price not exceeding the specified Bid Amount; and
 - pay the appropriate SUFs over the duration of the Licence.
- 4.92 In respect of Bidders other than Winning Bidders, this commitment remains in force until ComReg announces the conclusion of the Award Process as specified in Section 5.2.10 of this document. In respect of Winning Bidders, this commitment remains in force in line with the terms and conditions as set out in this document.
- 4.93 A Bid will remain valid for the duration of the Award Process unless it is replaced by a Bid for the same Package of Lots by the same Bidder with a higher Bid Amount in a subsequent Primary Bid Round or in the Supplementary Bids Round, or it is voided by ComReg pursuant to the Auction Rules.

Extension rights for the Primary Bid Rounds

- 4.94 An Extension right allows a Bidder additional time in which to submit a Bid during a Primary Bid Round. Each Bidder starts the Primary Bid Rounds with two Extension rights for the duration of the Primary Bid Rounds.
- 4.95 Additional Extension rights for the Primary Bid Rounds may be granted either to all Bidders or to individual Bidders at the absolute discretion of ComReg. Additional Extension rights can only be granted in the period between Primary Bid Rounds. Additional Extension rights cannot be granted during a Primary Bid Round.
- 4.96 In the event that a Bidder with non-zero Eligibility in one or both Time Slices and at least one remaining Extension right fails to submit a Bid during a Primary Bid Round:
- the EAS will automatically extend the time within which the Bidder can submit a Bid by 30 minutes from the scheduled end of the Round; and
 - one of the Bidder's remaining Extension rights will be deducted.
- 4.97 The Extension will end 30 minutes after the scheduled end of the Round, or once all Bidders who are using Extensions have successfully submitted Bids, whichever occurs earlier.
- 4.98 Bidders that have already submitted a Bid during the Primary Bid Round cannot take any further action during the Extension; they will be informed that the Round has been extended and should wait for the announcement that the Round has ended.
- 4.99 Bidders that have not submitted a Bid during a Primary Bid Round and have no Extension rights remaining will not be able to submit a Bid during the Extension, and a Zero Bid will be entered automatically on their behalf.
- 4.100 Extension rights are provided to Bidders in order to protect them from unforeseen circumstances that would prevent them from submitting a Bid they would otherwise have submitted during a Round. Extensions are intended to provide a safeguard against technical failures, rather than to provide Bidders with extra time to consider their Bidding decisions.
- 4.101 Note that if a Bidder has exhausted its Extension rights and runs into technical difficulties during a Round, no additional Extension right will be granted at that point. Any Bidder seeking additional Extension rights, having exhausted its allowance, should contact ComReg prior to the start of the next Round. ComReg will not grant additional Extension rights unless it is satisfied that the Bidder has

taken all reasonable steps to avoid missing the Round deadlines and that previous Extensions were triggered through circumstances beyond the Bidder's reasonable control. However, even where there is evidence to support a case to grant additional Extension rights to a Bidder (or Bidders), ComReg retains its absolute discretion to extend a Round or to take alternative action in the event of significant technical difficulties.

4.102 A Bidder may notify ComReg, during a Primary Bid Round and through the telephone number specified in paragraph 3.97, that it is unable to submit a Bid during that Round and is likely to require use of an Extension; notification is not mandatory, but would assist administration of the Auction.

Deposit Calls during Primary Bid Rounds

4.103 During the Primary Bid Rounds, ComReg may give notice to one or more Bidders requiring them to increase their Deposits (a Deposit Call) to an amount specified by ComReg.

4.104 Where a Bidder's Deposit falls below 50% of its highest Bid made so far in the Auction, ComReg reserves the right to require the Bidder to increase its Deposit to at least 50% and not more than 100% of its highest Bid. ComReg will specify a deadline not less than three Working Days from giving notice by which time the required funds must have been received as cleared funds in the bank account specified by ComReg during the Award Process (details of which are provided in Annex 3).

4.105 In the case of a Bidder that is in the course of a restructuring process, ComReg reserves the right to make such Deposit Calls as it deems appropriate.

4.106 ComReg reserves the right to not schedule Primary Bid Rounds in the period between giving notice of a Deposit Call to one or more Bidders and the deadline for the receipt of funds or the actual receipt of cleared funds, whichever occurs earlier.

4.107 In the event that a Bidder fails to meet the Deposit Call requirement, ComReg may, among other things, restrict its ability to make further Bids and/or declare some or all of its Bids already submitted as being incapable of becoming Winning Bids.

Information available during Primary Bid Rounds

4.108 Before the start of the first Primary Bid Round, each Bidder will be informed of:

- its own Initial Eligibility in each Time Slice;

- the number of Extension rights it has for the Primary Bid Round;
- the Aggregate Demand for Lots in each Lot Category (based on all Initial Bids); and
- the Round Price per Lot for each Lot Category in the first Primary Bid Round.

4.109 Information about the Eligibility of other Bidders will not be disclosed.

4.110 At the end of a Primary Bid Round, each Bidder will be informed of:

- the Aggregate Demand for Lots in each Lot Category in the most recently completed Round;
- its own Bid(s) during the Round;
- its Eligibility in each Time Slice for the next Primary Bid Round; and
- the number of Extension rights it has remaining.

4.111 No information will be released to any Bidder about the Bids submitted by other Bidders during the Primary Bid Rounds.

4.112 The EAS will include the functionality to view and download information on Round Prices, Aggregate Demand and the Bidder's own demand in previous Primary Bid Rounds.

Discounts and Exposure Prices

4.113 A Bidder's '**Discount**' in a given Primary Bid Round is, for any Package of Lots on which the Bidder is eligible to Bid in that Round, the greater of zero and:

- the price of that Package of Lots at current Round Prices; less
- the maximum Base Price the Bidder would be required to pay for the Package of Lots it wins, under the assumption that the Primary Bid Rounds finish at the end of the current Primary Bid Round with demand equal to supply¹³⁸.

4.114 Note that the Discount applied in a particular Primary Bid Round is the same for all Packages of Lots (but may vary across Rounds and across Bidders).

¹³⁸ Where demand is based on the Lots included in the Primary Bids submitted by all Bidders in the current Primary Bid Round.

4.115 A Bidder's "**Exposure Price**" for a Package of Lots in a given Primary Bid Round is equal to the price of the Package of Lots at current Round Prices, less the Bidder's Discount in the Round. This is the maximum amount that the Bidder would need to pay for that Package of Lots on the assumptions that:

- the current Primary Bid Round is the final Primary Bid Round (because rival Bidders reduce demand); and
- there would be no unallocated Lots in this Primary Bid Round.

4.116 The Exposure Price arises because of the limitations on what rival Bidders can bid given their history of Primary Round Bids and the Activity Rules governing their Supplementary Bids.

4.117 During each Primary Bid Round, the EAS will inform each Bidder of its own Discount for that Round. Discounts are reported to Bidders to provide additional information that may assist with their bidding decisions and internal governance. However, Bidders must make their own judgments over how to best utilise this information and any associated risks. A Bidder's Discount may increase, decrease or stay the same from one Primary Bid Round to the next.

4.118 For the avoidance of doubt, in the event that at least one further Primary Bid Round is required or that the Primary Bid Rounds end with excess supply, there is no guarantee that the Bidder will not ultimately need to pay more for a Package of Lots than the Exposure Price resulting from the Discount reported in the current Round.

4.119 Examples demonstrating the methodology for calculating Discounts are provided in Annex 13.

End of the Primary Bid Rounds

4.120 The Primary Bid Rounds will end following a Round in which there was no excess demand for Lots in any Lot Category. At this point, ComReg will announce that the Primary Bid Rounds have ended and that the Auction will progress to the Supplementary Bids Round.

4.121 Alternatively, following the close of a Primary Bid Round, ComReg may at its absolute discretion announce that it is ending the Primary Bid Rounds early (i.e. while demand is still above supply in at least one Lot Category). In this case, the Auction will proceed directly to the Supplementary Bids Round, and there will be no further Primary Bid Rounds.

4.122 ComReg will only terminate the Primary Bid Rounds early if it believes that proceeding directly to the Supplementary Bids Round at that time is in the

general interest of running an efficient Award Process.

4.2.3 The Supplementary Bids Round

Schedule for the Supplementary Bids Round

- 4.123 The start time and duration of the Supplementary Bids Round will be announced by ComReg following the completion of the Primary Bid Rounds.
- 4.124 There will be at least three clear Working Days between the last Primary Bid Round and the start of the Supplementary Bids Round.
- 4.125 ComReg has discretion over the Round Schedule and duration of the Supplementary Bids Round. However, ComReg anticipates that the Supplementary Bids Round will take place between 09.00 and 18.00 hours on a single Working Day.
- 4.126 A single Extension right will be available to all Bidders in the Supplementary Bids Round. Extension rights in the Supplementary Bids Round will operate in the same way as Extension rights in the Primary Bid Rounds, except that there is no scope for additional Extensions rights to be granted. The Extension of the Supplementary Bids Round will be no longer than 30 minutes. For the avoidance of doubt, the Extension right available for the Supplementary Bids Round is distinct from the Extension rights available during the Primary Bid Rounds and no Extension rights can be carried over from the Primary Bid Rounds.

Supplementary Bids submission

- 4.127 When the Supplementary Bids Round is in progress, Bidders may submit Supplementary Bids for multiple Packages of Lots using the EAS.
- 4.128 Each individual Supplementary Bid specifies a Package of Lots (the number of Lots in each Lot Category that a Bidder wishes to acquire) and a Bid Amount for that Package.
- 4.129 The interface of the EAS will provide functionality for Bidders to:
- generate and amend a list of Packages of Lots for which the Bidder wants to submit Supplementary Bids (subject to the requirement that Packages of Lots Bid for in Bidders' Initial Bids and during the Primary Bid Rounds must all be included in the list); and
 - specify the Bid Amount for each of the Packages of Lots in the list.
- 4.130 The EAS will also report the value of any unsold Lots in the final Primary Bid

Round at final Primary Bid Round prices and at Reserve Prices to Bidders in order to assist with any Bids that a Bidder wishes to make in line with Annex 5.

- 4.131 The Bid Amount for each Supplementary Bid is discretionary, subject to the restrictions set out in the sections below.
- 4.132 A Supplementary Bids list may contain Bids for up to 1,000 Packages of Lots. This limit includes the Bidder's Initial Bid and all Packages of Lots for which the Bidder submitted Bids during the Primary Bid Rounds.
- 4.133 Bid submission will follow the two-step process described in Section 4.1.2.
- 4.134 The EAS will prevent a Bidder from submitting a Supplementary Bids list that contains invalid Bids. If a Supplementary Bids list is rejected by the EAS, the Bidder will be able to revise its set of Supplementary Bids; any necessary revisions must be completed within the time limits set for the Supplementary Bids Round (including any Extension as appropriate).

Restrictions on Bid Amounts for Supplementary Bids

- 4.135 Bid Amounts for Supplementary Bids must be specified in multiples of EUR 1000.
- 4.136 The Bid Amount for a Package of Lots must not be less than the sum of the Reserve Prices for all Lots included in the Package.
- 4.137 The Bid Amount for a Package of Lots for which the Bidder has made a Primary Bid must not be less than the highest Bid Amount submitted for the Package of Lots in the Primary Bid Rounds (regardless of whether this is a standard Primary Bid, Relaxed Primary Bid or Chain Bid).
- 4.138 Each Bidder has a Final Primary Package; this is the Package of Lots it Bid for in the final Primary Bid Round. If the Bidder submitted a Zero Bid in the Primary Bid Rounds (either during the final Primary Bid Round or in an earlier Round), the Final Primary Package is the Zero Package consisting of no Lots in any Lot Category (for which the Bid Amount is zero and cannot be changed). Bidders may submit a Supplementary Bid for any Package of Lots except the Zero Package (i.e. the Package of Lots consisting of no Lots in any Lot Category) subject to not breaching the Bidding Restrictions.
- 4.139 All Supplementary Bids for Packages of Lots other than the Final Primary Package are subject to a Final Price Cap (see below), which is a Relative Cap with respect to the final Primary Bid Round.
- 4.140 For all Packages of Lots with Eligibility greater than the Bidder's Eligibility at the

start of the final Primary Bid Round in one or both Time Slices, the Bid Amount is also subject to a Relative Cap (see below)¹³⁹.

4.141 As a consequence of the rules above, if a Bidder's Final Primary Package contains at least one Lot and the Bidder did not submit a Relaxed Primary Bid in the final Primary Bid Round, there is no cap on the Supplementary Bid Amount that can be submitted for the Final Primary Package.

Final Price Cap

4.142 For any Package of Lots X other than the Final Primary Package, the Supplementary Bid Amount for X may not exceed:

- the Bidder's highest Bid for the Final Primary Package (which may be a Primary Bid, Relaxed Primary Bid or a Supplementary Bid); plus
- the difference between the price of X and the Final Primary Package at the Round Prices in the final Primary Bid Round.

Relative Caps

4.143 Supplementary Bids for Packages of Lots that the Bidder was not eligible to bid for at the start of the final Primary Bid Round are subject to any Relative Caps that arose from the submission of Eligibility-reducing Primary Bids.

How caps apply to the Final Primary Package

4.144 If a Bidder's Final Primary Package is the Zero Package, then the Final Price Cap means that all Supplementary Bids are constrained to be at most the price of the corresponding Package of Lots in the final Primary Bid Round.

4.145 Otherwise, there are two cases to consider, depending on whether or not the Bidder made a Relaxed Primary Bid in the final Primary Bid Round:

- If a Bidder did not submit a Relaxed Primary Bid in the final Primary Bid Round, then there is no limit on the Supplementary Bid that can be submitted for the Final Primary Package;
- If the Bidder submitted a Relaxed Primary Bid in the final Primary Bid Round, the Supplementary Bid for the Final Primary Package is subject to a Relative Cap, as the Eligibility of the Final Primary Package is strictly greater than the Bidder's Eligibility in one or both of the Time

¹³⁹ This means that if the Bid submitted in the Final Primary Round is a Relaxed Primary Bid, the Bid Amount for the Final Primary Package is subject to a Relative Cap in the Supplementary Bids Round.

Slices at the start of the final Primary Bid Round. The effect of this rule is that increasing the Bid Amount for the Final Primary Package in the Supplementary Bids Round may require also increasing the Bid Amounts for the Packages of Lots subject to Eligibility-reducing Primary Bids (Constraining Packages) with Eligibility strictly less than the Eligibility of the Final Primary Package (in one or both Time Slices).

4.146 Examples of this situation are discussed in Annex 5, which includes a comprehensive worked example.

Validity of Supplementary Bids

4.147 Each Supplementary Bid submitted in accordance with the Auction Rules is considered to be a Valid Bid. A Valid Bid represents a binding commitment to:

- buy the specified Package of Lots at a price not exceeding the specified Bid Amount; and
- pay the appropriate SUFs over the duration of the Licence.

4.148 In respect of Bidders other than Winning Bidders, this commitment remains in force until ComReg announces the conclusion of the Award Process as specified in Section 5.2.10 of this document. In respect of Winning Bidders this commitment remains in force in line with the terms and conditions as set out in this document.

4.149 A Valid Bid will remain valid for the duration of the Award Process, unless it is voided by ComReg pursuant to the Auction Rules.

4.2.4 Deposit Calls following the Supplementary Bids Round

4.150 At the end of the Supplementary Bids Round, and prior to the notification to Bidders of the outcome of the Main Stage, ComReg may give notice to one or more Bidders that they need to increase their Deposits to an amount specified by ComReg.

4.151 ComReg reserves the right to issue a Deposit Call of up to 100% of a Bidder's highest Bid at this point.

4.152 If a Deposit Call is issued, ComReg will specify a deadline not less than three Working Days from giving notice by which time the required funds must have been received as cleared funds in ComReg's Nominated Bank Account (details of which are provided in Annex 3).

4.153 ComReg will not notify the outcome of the Main Stage in the period between

issuing notice of a Deposit Call to one or more Bidders and the deadline for the receipt of funds or the actual receipt of cleared funds, whichever occurs earlier.

4.154 In the event that ComReg issues a Deposit Call following the completion of the Main Stage of the Auction, but before the results of the Main Stage have been announced to Bidders, and one or more Bidders do not provide their required funds by the deadline set by ComReg, ComReg may at its sole discretion exclude any such Bidder and re-run the winner and price determination algorithm (described below) excluding some or all Bids submitted by any such Bidder during the Award Process.

4.2.5 Winner and Base Price Determination

4.155 Following the close of the Supplementary Bids Round, ComReg will determine the combination of Winning Bids, and the prices (the Base Prices) to be paid by Winning Bidders.

4.156 Only Valid Bids will be considered when determining the Winning Bidders and Base Prices. For the avoidance of doubt, any Bids that have been voided by ComReg pursuant to the Auction Rules will not be considered Valid Bids, and will not be included in the Winner and Base Price determination process.

4.157 Hereafter, within this section any reference to 'Bid' or 'Bids' is solely to Valid Bids.

Winner Determination

4.158 A Feasible Combination of Bids is one in which:

- in each Lot Category, no more Lots are awarded than are available in that Lot Category; and
- at most one Bid is accepted from each Bidder.

4.159 The value of a Feasible Combination of Bids is equal to the sum of Bid Amounts for all Bids in the combination, plus the Reserve Price of any Lots that would remain unassigned if only the Bids in the combination are accepted.

4.160 The Winning Combination of Bids is a Feasible Combination of Bids that has the greatest value across all Feasible Combinations of Bids, considering all the Bids submitted in the Auction (including Initial Bids, standard and Relaxed Primary Bids, Chain Bids and Supplementary Bids).

4.161 If there are multiple Feasible Combinations of Bids with equal greatest value that meet the conditions above, the Winning Combination of Bids will be the

Feasible Combination of Bids amongst these tied scenarios with greatest total price for the assigned Lots valued at Reserve Prices.

4.162 In the unlikely event that the rules outlined at paragraphs 4.155 – 4.161 do not identify a unique Feasible Combination of Bids, then the Winning Combination of Bids will be selected at random from all combinations of Bids that satisfy these rules.

Base Price determination

4.163 For each Winning Bid (and thus for each Winning Bidder), ComReg will determine a Base Price that must be paid by the Bidder. This is an overall price for the entire Package (i.e. the combination of Lots included in the Winning Bid).

4.164 Base Prices are the minimum amounts that each Winning Bidder, and each group of Winning Bidders jointly, could have bid without changing the outcome of the winner determination process, and are based on the concept of Opportunity Cost.

4.165 The Opportunity Cost of a Bidder, or a group of Bidders, is defined to be the difference between:

- the value of the hypothetical winning assignment in a scenario where all Bids from the Bidder(s) in question were excluded; and
- the value of the original winning assignment less the total Bid Amount from all Winning Bids from the Bidder(s) in question.

As above, the value of a winning assignment is the total of winning Bid Amounts plus the value of any unassigned Lots at corresponding Reserve Prices.

4.166 Base Prices are determined jointly for all Winning Bidders in a single calculation. A unique set of Base Prices is found by applying the following requirements:

- First requirement: the Base Price of a Winning Bid must be greater than or equal to the total Reserve Prices of the Lots in the Package associated with that Winning Bid, but less than or equal to the winning Bid Amount.
- Second requirement: the set of Base Prices must be sufficiently high such that the sum of prices to be paid by each possible subset of Winning Bidders must be at least their joint Opportunity Cost. If there is only one set of Base Prices that meets the first and second requirements, this determines the Base Prices for the Main Stage.

- Third requirement: If there are multiple sets of Base Prices that fulfil the first and second requirements, the set(s) of Base Prices that minimise(s) the sum of Base Prices across Winning Bidders is selected. If there is only one set of Base Prices satisfying the first, second and third requirements, this determines the Base Prices for the Main Stage.
- Fourth requirement: If there are multiple sets of Base Prices that satisfy the first three requirements, the set of Base Prices that minimises the sum of squares of differences between the Base Prices for each Winner and the individual Opportunity Cost for that Winner is selected.

4.167 These conditions characterise a unique Base Price for each Winning Bidder that is no more than their Winning Bid and is at least the Reserve Price for the Package of Lots assigned to the Bidder. Finally, if these Base Prices are not in multiples of EUR 1000 they are rounded up to an even multiple of EUR 1000.

4.2.6 End of the Main Stage

4.168 Once ComReg has determined the Winning Bids and the Base Prices, and any Deposit Calls issued have been fulfilled, the outcome of the Main Stage will be announced to Bidders.

4.169 All Bidders will be informed of the number of Lots won by each Bidder in each Lot Category.

4.170 Each Winning Bidder will be told the Base Price that applies to its own Winning Bid. This information will not be released to other Bidders at this stage.

4.3 The Assignment Stage

4.171 The purpose of the Assignment Stage is to determine the specific frequencies to be assigned to:

- Winning Bidders in the Award Process in relation to the frequency-generic B-Lots won in the Main Stage; and
- Eir in relation to its existing 2.1 GHz Band holdings in Time Slice 1¹⁴⁰.

4.172 A frequency band will be included in the Assignment Stage if there are any winners of frequency-generic B-Lots in the band based on the outcome of the Main Stage. This means that:

¹⁴⁰ Given the outcome of the Main Stage (or the Qualification Stage where there is no Main Stage and the Award Process progresses directly from the Qualification Stage to the Assignment Stage).

- the 700 MHz Duplex will be included if any Winning Bidder wins at least one 700 MHz Duplex Lot; and
- for the other bands (2.1 GHz, 2.3 GHz, 2.6 GHz TDD and 2.6 GHz FDD), the band will be included in the Assignment Stage if any Winning Bidder wins at least one frequency-generic B-Lot in the band in at least one Time Slice.

4.173 For the purpose of the Assignment Stage, Eir's existing 2.1 GHz Band holdings will be treated in the same way as Lots included in a Winning Bid in this Award Process (i.e. as if Eir had won three frequency-generic 2 × 5 MHz Lots in the 2.1 GHz Band in Time Slice 1, in addition to any other Lots it wins as part of the Winning Combination of Bids) unless no Winning Bidders win new 2.1 GHz Band rights of use in the Main Stage.

4.174 The frequencies associated with the fixed frequency A-Lots in the 2.3 GHz and 2.6 GHz TDD bands are already specified and therefore do not need to be determined in the Assignment Stage. However, if a Bidder wins frequency-generic Lots in the 2.3 GHz Band or the 2.6 GHz TDD Band, the specific frequencies it could be assigned in relation to those frequency-generic B-Lots may be affected by whether or not it also wins any of the fixed frequency A-Lots in the corresponding band.

4.175 The term '**Assignment Bidder**' refers to the Winning Bidders that win at least one B-Lot in the Main Stage and, in the case that at least one Winning Bidder wins new rights of use in the 2.1 GHz Band, Eir (irrespective of whether it wins additional rights of use in the Main Stage).

4.176 The specific frequency assignments will be determined independently (but simultaneously) for each band. This may require an **Assignment Round**, in which Assignment Bidders are able to express their preferences over various possible frequency assignments available to them (their 'Assignment Options') in each band.

4.177 The Assignment Options for each Assignment Bidder are established in accordance with the methodology set out in Annex 9. For a given band, the process establishes one or more '**Candidate Frequency Plan(s)**'. Each Candidate Frequency Plan for a band comprises an assignment of frequencies across all Assignment Bidders and both Time Slices in that band that meets the criteria set out in Section 4.3.1 below. The Assignment Options for a Bidder in a band correspond to the set of frequency ranges that the Bidder could be assigned in any of the Candidate Frequency Plans for that band.

4.178 An Assignment Round is required if multiple Candidate Frequency Plans are

identified for at least one band. Assignment Bidders with multiple Assignment Options for at least one band are then able to express preferences over their Assignment Options, as described below in Sections 4.3.4 and 4.3.5. The specific frequencies assigned to each Assignment Bidder are determined on the basis of these preferences, and in accordance with the winner determination process set out in Section 4.3.8.

- 4.179 Assignment Bidders may be required to pay an amount (the '**Additional Prices**') in addition to their Base Prices for the specific frequencies assigned to them. Additional Prices are calculated separately for each band and determined by applying the requirements set out in paragraph 4.227 below.
- 4.180 For a given band, the specific frequencies to be assigned to Assignment Bidders as a result of the Assignment Option generation process and the outcome of an Assignment Round (if required) give the **Band Frequency Plan** for that band. There will be a Band Frequency Plan for each frequency band included in the Assignment Stage (i.e. there may be up to five Band Frequency Plans¹⁴¹).
- 4.181 The Band Frequency Plan(s) established are then combined to give a **Provisional Assignment Plan**. This will comprise a specific frequency assignment for each Winning Bidder in each band in each Time Slice.
- 4.182 Following the determination of the Provisional Assignment Plan, Bidders will be given a period of ten clear Working Days (the **Negotiation Phase**) in which they may negotiate between themselves and agree on an alternative assignment of the frequencies within the frequency-ranges associated with frequency-generic Lots in one or more of the bands.
- 4.183 The frequency assignments established following the Negotiation Phase would form the **Final Assignment Plan**.

4.3.1 Need for an Assignment Round

- 4.184 Following the Main Stage (or Qualification Stage if a Main Stage is not required), ComReg will establish the ways in which specific frequencies can be assigned to Assignment Bidders that won B-Lots in each band included in the Assignment Stage, subject to the requirements set out below.
- 4.185 For the 700 MHz Duplex, the alternative ways of assigning specific frequencies to an Assignment Bidder that won frequency-generic Lots in the band will be

¹⁴¹ One for each of the bands, 700 MHz Duplex, 2.1 GHz Band, 2.3 GHz Band, 2.6 GHz FDD Band, and 2.6 GHz TDD Band.

established subject to the requirements that:

- the Assignment Bidder is awarded a contiguous block of spectrum in the band, in accordance with the number of 700 MHz Duplex Lots it won;
- any option for assigning frequencies to a particular Assignment Bidder is consistent with all other Assignment Bidders each receiving contiguous spectrum in the band;
- a winner of more than 2×10 MHz is not assigned the lowest 2×5 MHz block, provided no other Assignment Bidder has won more than 2×10 MHz in the 700 MHz Duplex¹⁴²; and
- any unassigned 700 MHz Duplex Lots will form a contiguous block of spectrum starting at 703/758 MHz.

4.186 For any of the other bands (2.1 GHz, 2.3 GHz, 2.6 GHz TDD or 2.6 GHz FDD), the alternative ways of assigning specific frequencies to an Assignment Bidder that won frequency-generic B-Lots in the band will be subject to the requirements that:

- for each Time Slice in which the Assignment Bidder won B-Lots in the band, the Assignment Bidder is awarded a contiguous block of spectrum in that Time Slice, in accordance with the number of B-Lots it won in that Time Slice;
- any option for assigning frequencies to a particular Assignment Bidder is consistent with all other Assignment Bidders each receiving contiguous spectrum in each Time Slice in the band according to the number of B-Lots they won;
- in the event that at least one Winning Bidder wins 2.1 GHz Band Lots in either Time Slice, Eir's current holdings in Time Slice 1 will be included in the Assignment Option generation process and may be repositioned within the band, subject to the requirement that it forms a contiguous block of spectrum with any 2.1 GHz Band Lots won by Eir in Time Slice 1;
- for each of the 2.1 GHz Band and 2.6 GHz FDD Band, any Assignment Bidder¹⁴³ that wins exactly the same number of frequency-generic Lots

¹⁴² If two Bidders won greater than 2×10 MHz (i.e. each bidder won 2×15 MHz) an Assignment Round would determine which Bidder obtained the lowest frequency block.

¹⁴³ This may include Eir in relation to its existing 2.1 GHz holdings in Time Slice 1.

in the band in both Time Slices will be awarded the same frequencies in that band in each Time Slice;

- for the 2.6 GHz TDD Band, for a given Time Slice, if the Assignment Bidder wins a single fixed frequency Lot in the band¹⁴⁴, any frequency-generic B-Lots won by that Assignment Bidder in the same band and Time Slice are positioned next to the single fixed frequency Lot won;
- for the 2.3 GHz Band:
 - for a given Time Slice, if the Assignment Bidder wins a single fixed frequency A-Lot in the band, any frequency-generic Lots also won by that Assignment Bidder in the same band and Time Slice are positioned next to the relevant A-Lot;
 - for a given Time Slice, if the Assignment Bidder wins both fixed frequency A-Lots in the band, the Assignment Options presented to the Assignment Bidder will include all options that position any frequency-generic B-Lots also won by that Assignment Bidder in the same band and Time Slice next to either the upper fixed frequency Lot or the lower fixed frequency Lot;
- unassigned B-Lots in a band in Time Slice 2 will form a contiguous block of spectrum;
- subject to the previous requirements being satisfied, for Assignment Bidders that win frequency-generic Lots in the band in both Time Slices, the options generated will be those that maximise the extent to which the same frequencies are assigned in each Time Slice¹⁴⁵; and
- subject to the previous requirements being satisfied, the extent to which unassigned B-Lots in Time Slice 1 can be combined into the fewest number of contiguous blocks is maximised¹⁴⁶.

4.187 In accordance with these principles, ComReg will establish the feasible frequency assignments for each band through the procedure set out in Annex 9. This procedure ensures that, where possible subject to the requirements set out above, Assignment Bidders are offered alternative positions within each

¹⁴⁴ Interested Parties are reminded of the Bidding Restriction that applies in respect of the 2.6 GHz TDD Band (See Section 4.1.3).

¹⁴⁵ This is implemented through the procedure presented in Annex 9.

¹⁴⁶ The unassigned B-Lots in Time Slice 1 may be used to improve the alignment of frequencies assigned to winning Bidders across the two Time Slices, and as such may be split into multiple non-contiguous blocks.

relevant band.

4.188 An Assignment Round is required if there are multiple Candidate Frequency Plans that satisfy the criteria above for at least one band.

4.3.2 Assignment Options

4.189 For a given band with multiple Candidate Frequency Plans that meet the criteria above, for each Assignment Bidder that has won frequency-generic Lots in the band the set of Candidate Frequency Plans identified has an associated set of unique frequency assignments that could be assigned to that Assignment Bidder. These are the Assignment Bidder's 'Assignment Options' for the band.

4.190 An Assignment Option specifies a specific frequency range within the band in each Time Slice. The number of Assignment Options available to an Assignment Bidder for a given band will be less than or equal to the number of Candidate Frequency Plans for that band¹⁴⁷.

4.191 During the Assignment Round, for a given band an Assignment Bidder with multiple Assignment Options will be invited to either:

- submit Assignment Bids for its Assignment Options in the case that its choice of option could conflict with the choice of option of another Assignment Bidder;¹⁴⁸ or
- select its most preferred frequency assignment from amongst the Assignment Options available to it, in the case that its choice of option cannot conflict with the choice of option of another Assignment Bidder (if any).¹⁴⁹

¹⁴⁷ For example, there may be five Candidate Frequency Plans for a given band that meet the requirements, but the specific assignments for a particular Bidder can only be accommodated in one of two ways in each of the Candidate Frequency Plans. In this case, the Bidder will have only two Assignment Options.

¹⁴⁸ For example, if Bidder A and Bidder B together win all of the B-Lots in a given Time Slice in a given band (and suppose they only win Lots in that Time Slice), one Bidder's frequency assignment would be positioned at the top of the available frequencies, with the other Bidder's assignment in the frequencies below. If both Bidders would prefer the lower frequencies, there is a conflict in their demand. The two Bidders will then be able to submit Assignment Bids for the two possible frequency assignments and the winner of the lower frequencies will be determined on the basis of these Assignment Bids.

¹⁴⁹ Suppose a Bidder is the only winner of B-Lots in a Time Slice in a band and there are no unsold B-Lots in the other Time Slice. The Assignment Option ultimately assigned to that Bidder has no effect on other Bidders' chances of being awarded their preferred frequencies, and so it is allowed to simply choose whether its Lots are positioned either at the top or at the bottom of the associated frequency-range (note that the provisions for contiguity of unsold B-Lots would prevent the Bidder from being given additional options).

- 4.192 In the case that only one Assignment Option is available for an Assignment Bidder for a given band, that Assignment Bidder will simply be assigned the corresponding frequencies and will not participate in the Assignment Round for that band.
- 4.193 Winners of specific Assignment Options and Additional Prices to be paid for these specific frequencies is determined on a band-by-band basis to determine the Band Frequency Plan. However, for each band, both Time Slices will be considered jointly.

4.3.3 Schedule for the Assignment Round

- 4.194 The Round Schedule and duration of the Assignment Round will be announced by ComReg after the completion of the Main Stage (or after the completion of the Qualification Stage if the Award progresses directly from the Qualification Stage to the Assignment Stage).
- 4.195 Upon scheduling of the Assignment Round, the EAS¹⁵⁰ will display for each Bidder its Assignment Options for each band, if applicable.
- 4.196 There will be at least two clear Working Days between the notification of the Assignment Options to Assignment Bidders and the start of the Assignment Round.
- 4.197 ComReg has discretion over the Round Schedule and duration of the Round. However, ComReg anticipates that this Round will take place between 9.00 and 18.00 hours on a single Working Day, and last for at least 2 hours.
- 4.198 A single Extension right will be available to each Assignment Bidder in the Assignment Round. The Extension right in the Assignment Round will operate in the same way as Extension rights in the Primary Bid Rounds and Supplementary Bids Round except that, unlike for the Primary Bid Rounds, there is no scope for additional Extension rights. The Extension of the Assignment Round, where relevant, will not be longer than 30 minutes. For the avoidance of doubt, the Extension right in the Assignment Round is distinct from the Extension rights in the Main Stage and no Extension rights can be carried over from the Main Stage.

4.3.4 Selection of Assignment Option without Bidding

- 4.199 When the Assignment Round is in progress, a participating Assignment Bidder

¹⁵⁰ Additionally, in exceptional circumstances, ComReg reserves the right to run the Assignment Round via other means (e.g. sealed envelopes).

with the option to select a frequency assignment from amongst the Assignment Options presented to it for any given band will be able to do so using the EAS.

- 4.200 The EAS will provide each relevant Assignment Bidder with the functionality to choose its preferred Assignment Option and submit the decision.
- 4.201 Submission of the decision in the Assignment Round follows a two-step process, similar to the Bid submission process described in Section 4.1.2. The Assignment Bidder must first check its decision, and then confirm the decision.
- 4.202 If an Assignment Bidder fails to submit a decision during the Assignment Round (or during the associated Extension), the Assignment Option it is awarded will be determined through random selection.
- 4.203 No Additional Price will be applicable to an Assignment Option selected in this manner.

4.3.5 Assignment Bid Submission

- 4.204 When the Assignment Round is in progress, a participating Assignment Bidder with the option to submit Assignment Bids may do so.
- 4.205 The EAS will provide each relevant Assignment Bidder with the functionality to check and confirm Assignment Bids through a two-step submission process.
- 4.206 For each Assignment Bidder, the Bid Form available on the EAS will provide a list of all of the Assignment Options available to it for each band in which it has been assigned frequency-generic Lots and for which Assignment Bids are possible. For any given band, an Assignment Bidder may submit an Assignment Bid for all, some, or none of its Assignment Options.
- 4.207 The Bid Amount associated with each Assignment Bid is discretionary. Assignment Bids must be in multiples of whole euros. The minimum Bid Amount for each Assignment Option is zero. There is no upper limit on the Bid Amount for Assignment Options.
- 4.208 Note that all Assignment Bidders are guaranteed to be assigned the amount of spectrum in each band that they were assigned in the Main Stage. Assignment Bids will only affect which of the possible Assignment Options will be awarded, and any Additional Prices to be paid.
- 4.209 Assignment Bids for different Assignment Options with the same Bid Amount indicate that the Assignment Bidder is indifferent between these options. It is recommended (but not obligatory) that Assignment Bidders submit an

Assignment Bid of zero euros for their least favoured option(s) in each band for which they can submit Assignment Bids.

- 4.210 If an Assignment Bidder submits Assignment Bids for some, but not all, of its Assignment Options, it will be deemed to have submitted a Bid Amount of zero for those Assignment Options for which it did not submit an Assignment Bid.
- 4.211 If an Assignment Bidder fails to submit Assignment Bids during the Assignment Round (or during the associated Extension), it will be deemed to have submitted a Bid Amount of zero for every Assignment Option.

4.3.6 Validity of Bids in the Assignment Round

- 4.212 Each Assignment Bid submitted in accordance with the Auction Rules is considered to be a Valid Bid.
- 4.213 Each Valid Bid represents a binding commitment to pay an Additional Price for the corresponding Assignment Option that is less than or equal to the Bid Amount submitted for that Assignment Option.
- 4.214 An Assignment Bid submitted during the Assignment Round and identified as valid under Section 4.1.2 remains valid unless voided by ComReg pursuant to the Award Rules. Assignment Bids may be voided, and no longer considered to be Valid Bids, if:
- an Assignment Bidder fails to provide the required funds to ComReg within the set deadline following a Deposit Call, in which case, at ComReg's absolute discretion, all of the Assignment Bidder's Assignment Bids may be voided (as set out in Section 4.3.7);
 - an Assignment Bidder is excluded from the Auction, pursuant to the Award Rules, in which case all of that Assignment Bidder's Assignment Bids may be voided; or
 - ComReg voids the Assignment Round or all Bids submitted in the Auction (as set out in Section 4.1.5), in which case all Assignment Bids submitted by every Assignment Bidder may be voided.

4.3.7 Deposit Call following the Assignment Round

- 4.215 At the end of an Assignment Round, and prior to the notification to Assignment Bidders of the outcome of the Assignment Round, ComReg may give notice to one or more Assignment Bidders that they need to increase their Deposit to an amount specified by ComReg. ComReg reserves the right to issue a Deposit

call of up to 100% of the amount required¹⁵¹ to ensure that the Assignment Bidder's Deposit is equal to its Base Price plus the sum of the highest Assignment Bids it submitted for each band it had Assignment Options for in the Assignment Round.

- 4.216 If a Deposit Call is issued, ComReg will specify a deadline not less than three Working Days from giving notice by which time the required funds must have been received as cleared funds in ComReg's Nominated Bank Account (details of which are provided in Annex 3).
- 4.217 ComReg will not notify the outcome of the Assignment Round in the period between issuing notice of a Deposit Call to one or more Assignment Bidders and the deadline for the receipt of funds or the actual receipt of cleared funds, whichever occurs earlier.
- 4.218 In the event that ComReg issues a Deposit Call following the completion of the Assignment Round but before the results of the Assignment Round have been announced to Bidders, and one or more Assignment Bidders do not provide their required funds by the deadline set by ComReg, ComReg reserves the discretion to void all of the Assignment Bidder's Assignment Bids (setting them to zero) before running the winner and price determination algorithm¹⁵².

4.3.8 Winner and Additional Price Determination

Winner Determination

- 4.219 Following the end of the Assignment Round, ComReg will determine the Assignment Option awarded to each Assignment Bidder for each band, based on Assignment Bids submitted during the Assignment Round.
- 4.220 The Winner Determination process is carried out independently for each band.
- 4.221 For a given band, the winning Assignment Bids are the combination of valid Assignment Bids of greatest total value amongst all valid Assignment Bids submitted, subject to the conditions that:

¹⁵¹This Deposit Call may reflect the fact that monies held by ComReg could be subject to either negative or positive interest rates. Any such increase would reflect the surplus/deficit in the Deposit held by ComReg which would otherwise result from a positive/negative interest rate applied to Exchequer Notes held by ComReg. See Section 3.3.4 above.

¹⁵²The Assignment Bidder will still be awarded spectrum in accordance with the Lots won in the Main Stage and one of the frequency assignments available to it, but any preferences it has expressed for specific frequencies through the submission of Assignment Bids will not be taken into account when determining the Provisional Assignment Plan.

- exactly one Assignment Bid (including Zero Bids) is accepted from each Assignment Bidder; and
- the specific frequency assignments corresponding to the set of winning Assignment Bids correspond to one of the possible Candidate Frequency Plans for the band identified by ComReg that satisfies the conditions set out in Section 4.3.1.

4.222 In the unlikely event that more than one combination of Assignment Bids meeting the conditions above have equal highest total value, one combination will be selected at random.

4.223 Each Bidder will have exactly one winning Assignment Bid in each band in which they won Lots in the Main Stage. This may be an automatically-generated Assignment Bid of zero euros for an Assignment Option on which the Bidder did not submit an Assignment Bid.

Additional Price Determination

4.224 For each band in which the preferences expressed by two or more Assignment Bidders over the Assignment Options available to them could conflict, Additional Prices will be determined.

4.225 Additional Prices are calculated separately for each band and are based on the principle of Opportunity Cost.

4.226 For a given band, the Opportunity Cost of an Assignment Bidder, or a group of Assignment Bidders, is defined to be the difference between:

- the total amount of all winning Assignment Bids in a hypothetical scenario in which all the Assignment Bids of the Assignment Bidder(s) in question were set to zero; less
- the total amount of the original winning Assignment Bid(s) less the total amount of the winning Assignment Bid(s) from the Assignment Bidder(s) in question.

4.227 For each band, Additional Prices are determined jointly for all Assignment Bidders in a single calculation. A unique set of Additional Prices for a band is determined by applying the following requirements:

- First requirement: the Additional Prices are required to be positive or zero, and no greater than the Bid Amount of the winning Assignment Bid.

- Second requirement: the set of Additional Prices must be sufficiently high such that the sum of Additional Prices to be paid by each possible subset of Assignment Bidders is at least their Opportunity Cost. If there is only one set of Additional Prices that satisfies the first two requirements, this determines the Additional Prices.
- Third requirement: if there are multiple sets of Additional Prices that fulfil the first and second requirements, the set(s) of Additional Prices that satisfy the first two requirements and minimise(s) the sum of Additional Prices across all Assignment Bidders is selected. If there is only one set of Additional Prices satisfying these three requirements, this determines the Additional Prices.
- Fourth requirement: If there are multiple sets of Additional Prices that satisfy the first three requirements, the set of Additional Prices that satisfies the first three requirements and minimises the sum of squares of differences between the Additional Prices for each Assignment Bidder and the Opportunity Cost for that Assignment Bidder is selected.

4.228 These requirements characterise a unique Additional Price for each Assignment Bidder for a band that is no more than their winning Assignment Bid for that band. Finally, if these Additional Prices are not amounts in whole euros, they are rounded up to the nearest whole euro.

4.229 An Assignment Bidder will be required to pay the sum of its Additional Prices for each band.

4.3.9 End of the Assignment Round

4.230 Once ComReg has determined specific frequency assignments for all Winning Bidders (whether an Assignment Round was required or not) and any Additional Prices, these will form the Provisional Assignment Plan.

4.231 Winning Bidders will be informed of the identity of other Winning Bidders and the specific frequency ranges assigned to each Winning Bidder in each band and, where relevant, in each Time Slice, according to the Provisional Assignment Plan.

4.232 Each Assignment Bidder will also be told the Additional Price(s) that will apply to its own winning Assignment Bid(s).

4.233 From this point, it is considered that the Negotiation Phase is in progress.

4.3.10 Negotiation Phase

- 4.234 Following the completion of the Assignment Round and the notification of the Provisional Assignment Plan and associated Additional Prices to be paid, Assignment Bidders will be allowed a period of ten clear working days (the Negotiation Phase) in which they may communicate with each other to negotiate a reorganisation of the frequency assignments within the frequency ranges associated with frequency-generic Lots in one or more of the bands.
- 4.235 Any alternative frequency assignment proposed to ComReg is subject to all Winning Bidders receiving contiguous spectrum within the frequency-ranges associated with frequency-generic Lots, in accordance with the number of frequency-generic Lots awarded to them in each Time Slice in each band in the Main Stage.
- 4.236 For the avoidance of doubt, Assignment Bidders will be required to pay the Additional Prices calculated as a result of Assignment Bids submitted in the Assignment Round, regardless of the outcome of the Negotiation Phase.

Negotiation of alternative frequency assignment

- 4.237 All Assignment Bidders will have the opportunity to agree amongst themselves an alternative configuration of the frequency assignments within the frequency-ranges associated with frequency-generic Lots in the relevant frequency bands (relative to the Provisional Assignment Plan) within each Time Slice.
- 4.238 Specifically, two or more Assignment Bidders awarded frequency-generic Lots for a given band (and where applicable in a particular Time Slice) may agree on a re-organisation of the frequencies assigned to them in the band (and Time Slice), provided that:
- following the re-organisation, each of the parties involved is assigned the same total amount of contiguous frequency-generic spectrum within the band (in that Time Slice) as was won by them in the Main Stage; and
 - the specific frequencies assigned to all other Assignment Bidders are unaffected by the re-organisation.
- 4.239 For the avoidance of doubt:
- Assignment Bidders will not be allowed to 'swap' frequencies across Time Slices or frequency bands;

- Assignment Bidders will only be allowed to 'swap' their frequencies (associated with the frequency-generic Lots won) in a given band/Time Slice as a whole; and
- Winners of the fixed frequency Lots in the 2.3 GHz and 2.6 GHz TDD bands will not be allowed to 'swap' any of the frequencies associated with the fixed frequency Lots.

4.240 If Assignment Bidders are able to successfully negotiate and agree on an alternative frequency plan for one or more bands, a request for the changes must be submitted to ComReg before the end of the Negotiation Phase. ComReg will assess each request received before deciding on the frequency reassignments it will allow. Successful requests will be adopted for the Final Assignment Plan.

4.241 ComReg reserves the right to refuse any or all requests for amendments to frequency assignments, relative to the Provisional Assignment Plan.

4.242 If Winning Bidders do not submit a request for an alternative configuration of frequency assignments, ComReg will rely on the Provisional Assignment Plan.

4.3.11 End of the Assignment Stage

4.243 Once ComReg has determined the Final Assignment Plan, the outcome of the Assignment Stage (that is, the outcome of the Assignment Round or the outcome of the Negotiation Phase) will be notified to Bidders. The following information will be released:

- each Bidder will be informed of the specific frequency ranges assigned to each Assignment Bidder in each band and Time Slice (where applicable); and
- each Assignment Bidder will be informed of the Additional Prices that will apply to its own winning Assignment Bid. This information will not be released to other Bidders at this point in the process.

4.4 End of Auction

4.244 Once ComReg has determined the Winning Bids and frequency assignments to be assigned to Winning Bidders, the outcome of the Award Process will be made public.

4.245 The following information will be released:

- a) the identities of Winning Bidders;
- b) the frequency (ranges) awarded to each Winning Bidder in each band and in each Time Slice (where applicable);
- c) the Base Price to be paid by each Winning Bidder; and
- d) any Additional Prices for specific frequency assignments to be paid by each Winning Bidder.

4.4.1 Spectrum Access Fees

4.246 The SAF for each Winning Bidder will be the sum of their Base Price plus any Additional Prices for the specific frequencies assigned to them (in the Assignment Stage).

4.247 Each Winning Bidder must pay its SAF in accordance with the Notification and Grant Stage as set out in Section 3.7.

Chapter 5

5 Legal Terms and Conditions

5.1 Important Notice

- 5.1 This Information Memorandum is being made available by ComReg solely for the purposes of assisting Interested Parties in deciding whether they wish to proceed to participate in the Award Process in accordance with the terms of this Information Memorandum and to assist them in understanding, preparing for and participating in the Award Process. This Information Memorandum may not be used for any other purpose and, when using it for the purposes stated above, Interested Parties are strictly subject to the terms and conditions set out in this Information Memorandum.
- 5.2 To the extent permitted by law, no representation or warranty or undertaking (express or implied) is or will be made by ComReg or its personnel or agents and no liability or responsibility is or will be accepted by ComReg or its personnel or agents as to:
- i. the adequacy, accuracy or completeness of the information, opinions or statements (or the basis on which they are premised) contained in this Information Memorandum or in any of the documents referred to herein;
 - ii. any omissions, errors or misstatements contained in this Information Memorandum or in any documents referred to herein;
 - iii. the software used to implement the Award Process' electronic Auction system; and
 - iv. the contents of any written or oral information made available by ComReg or its personnel or agents to Interested Parties or any third party relating to the Award Process.
- 5.3 To the extent permitted by law, any liability and/or loss of any nature arising from this Information Memorandum and its use by Interested Parties is expressly disclaimed.
- 5.4 Without prejudice to the foregoing and to the extent permitted by law, ComReg's aggregate liability for all losses or damages of any nature arising from delayed access to Lots is expressly limited to the refunds or adjustments of Licence Fees as set out in Section 2.3.7 of this Information Memorandum.
- 5.5 To the extent permitted by law, Interested Parties shall not be entitled to rely on the contents of this Information Memorandum to argue that they have rights or

expectations, pursuant to legitimate expectation, estoppel or other related legal arguments, that:

- i. ComReg will not exercise any of its rights reserved in Section 5.2.6 of this Chapter 5;
- ii. they will be granted any spectrum rights of use at the end of the Award Process;
- iii. Bidding in any particular manner will, of itself, guarantee success in the Award Process;
- iv. ComReg will, during the term of any Licence granted pursuant to the Award Process, modify the terms of such Licence, or the regulations affecting such Licence, in any manner and, without prejudice to the generality of the foregoing, that ComReg will permit the use of any particular new technologies in the spectrum rights of use licensed pursuant to the Award Process; or
- v. ComReg will reassign rights of use of spectrum licensed pursuant to the Award Process in any particular way at the termination of any Licences granted pursuant to the Award Process.

5.6 While ComReg, its personnel and agents intend to implement the Award Process, ComReg, its personnel and agents give no indication or commitment and make no statements as to the possible outcomes of this Award Process.

5.7 In accessing this Information Memorandum, Interested Parties acknowledge that they will be solely responsible for their own assessment of any matter connected with the Award Process to which the Information Memorandum relates. Interested Parties are responsible for forming their own views, deciding if they will partake in the Award Process, completing the relevant Application Forms and calculating any Bids.

5.8 All dates in this Information Memorandum are, unless specifically stated to the contrary, target or indicative dates only and may be subject to change at the sole discretion of ComReg acting in line with its statutory functions, objectives and duties.

5.9 Whilst the information in this Information Memorandum has been provided in good faith, it does not purport to be comprehensive nor to have been independently verified. Interested Parties should form their own views. ComReg reserves the right to amend this Information Memorandum and any information or documents contained or referred to herein in accordance with paragraph 5.31 of this Chapter 5.

- 5.10 Nothing in this Information Memorandum is, or should be relied upon as, a promise or representation as to ComReg's ultimate decision in relation to the award of a Licence or Licences. ComReg reserves the right to suspend or not to proceed with the Award Process or any part thereof and may terminate the Award Process or any part thereof at any time and, in such event, ComReg shall not be liable, howsoever, to any Interested Party save for ComReg's obligation to return Deposits in certain circumstances. ComReg also reserves the right, in accordance with law, to change any procedure in relation to the Award Process. ComReg reserves the right to reject any and all Applications received as part of the Award Process or not to select any Applicant for the grant of a Licence. It is recommended that Interested Parties seek their own financial, legal and technical advice at their own cost in relation to the Award Process. The publication of this Information Memorandum or any information made available in connection with the Award Process does not constitute nor is to be taken as constituting the giving of financial, legal, technical or investment advice by ComReg, its personnel or agents.
- 5.11 Any conflict of interest or potential conflict of interest – including but not limited to any conflict arising under the rules set out in Sections 3.3.5 and 3.3.6 of this Information Memorandum – must be disclosed to ComReg by any Interested Party as soon as such conflict of interest or potential conflict of interest becomes apparent. The appropriate course of action to be taken in such event shall be decided upon by ComReg, at its discretion acting in line with its statutory functions, objectives and duties.
- 5.12 This Information Memorandum should be read and construed in accordance with the previous documentation issued by ComReg as part of this process including:
- Consultation 14/101 (insofar as relevant to this Award Process);
 - Consultation 18/60;
 - Information Notice 18/103;
 - Consultation and Further Consultation 19/59R;
 - Response to Consultation and Draft Decision 19/124; and
 - Response to Consultation and Decision 20/XX [DOCUMENT TO WHICH THE FINAL DECISION WILL BE ATTACHED],

along with the associated consultants' reports and other relevant ComReg documents which are available on ComReg's website (the "Consultation Process Documents"). Noting that the consultation process has been complex and the views of ComReg and the respondents have evolved over time, in the

event of any conflict between the views expressed in any of the Consultation Process Documents, the view expressed in the later document shall take precedence. Where any draft document, for instance a draft statutory instrument, draft decision or draft Information Memorandum has been supplanted by a finalised document, the draft document should be discounted entirely. In the event of any conflict or inconsistency between the Consultation Process Documents and this Information Memorandum, this Information Memorandum shall take precedence.

- 5.13 No legal obligations on the part of ComReg to grant any Licences will arise unless and until the granting and commencement of a Licence or Licences by ComReg following the completion of the Award Process.
- 5.14 The legal and contractual obligations described in this Chapter of the Information Memorandum are imposed on Interested Parties who are furnished with or who download this Information Memorandum and ComReg reserves the right to enforce such obligations. Copyright (and any other intellectual property rights) in this Information Memorandum vest and remain in ComReg and its licensors, and recipients of this document, including Interested Parties, shall not use or copy this Information Memorandum other than in pursuit of the purposes described in paragraph 5.1 above, without the permission of ComReg. Applicants who submit Applications to enter the Award Process shall be obliged to express their acceptance to the provisions of this Chapter as part of the Application process (see Section 3.3 and Annex 3 of this Information Memorandum).
- 5.15 This Information Memorandum and all matters arising out of or in connection with or in any way related to this Information Memorandum shall be governed and construed in accordance with the laws of Ireland and shall be subject to, and Interested Parties hereby expressly submit to, the exclusive jurisdiction of the Irish courts.

5.2 Additional Conditions

5.2.1 Open Applications

- 5.16 All Applications (including Applications which do not ultimately become qualifying Applications) by Applicants comprise offers which must remain open and valid for six (6) months from the date of submission with the exception that an Applicant may withdraw its Application on or before *[a date will be specified in the final Information Memorandum]*. Applications are contractually binding offers and the submission of an Application shall mean the Applicant unconditionally offers to agree to:

- i. the provisions of this Chapter;
- ii. the Applicant Declaration which forms part of the Application (see Annex 3 of this Information Memorandum); and
- iii. the Award Rules.

- 5.17 Offers shall be deemed to be accepted (meaning that an agreement covering (i), (ii) and (iii) above has been formed between the Applicant and ComReg) once they are submitted to ComReg in accordance with the Information Memorandum and an acknowledgment of receipt has been issued by ComReg even if they subsequently do not become qualifying Applications.
- 5.18 All Applications will be assessed in accordance with Section 3.4 of this Information Memorandum.
- 5.19 For the avoidance of doubt, the contract described in this Section 5.2.1 is in addition to and not in substitution for the contract described in paragraph 5.14 of this Chapter 5 which binds all parties in receipt of this Information Memorandum to the provisions of this Chapter. In the event that an Applicant withdraws its Application on or before *[a date will be specified in the final Information Memorandum]*, such Applicant will remain bound by the contract described in paragraph 5.14 of this Chapter 5.

5.2.2 Canvassing

- 5.20 Interested Parties must not canvass directly or indirectly any staff or the Commissioners of ComReg or any person associated in any way with the Award Process. Failure to comply with this requirement may result in an Application being deemed invalid or disqualification from the Award Process. This does not restrict an Applicant from making any representations through the communications channels specified in this Information Memorandum.

5.2.3 Award Rules / Improper Influence

- 5.21 The Award Rules described in this Information Memorandum and its Annexes shall form part of the agreement between ComReg and Applicants described in Section 5.2.1 of this Chapter 5 and, by submitting an Application, the Applicant agrees to be bound by and to comply with the Award Rules. Without prejudice to the detailed Award Rules around Bidder behaviour and for the avoidance of doubt, any attempt by Interested Parties to improperly influence, in any way, the Award Process, may result in the disqualification of that/those Interested Parties or, where the party engaging in such behaviour is an agent, that agent's principal. Non-exhaustive examples of such improper influence are collusion, price fixing, Bid rigging, Bid rotation, market division or breach of Award Process

confidentiality.

5.2.4 Publicity / Information Disclosure

- 5.22 No publicity whatsoever regarding this Information Memorandum and/or Award Process is permitted until the public announcement on the outcome of the Award Process by ComReg, unless and until ComReg has consented in writing, at its discretion, to the relevant communication. For the avoidance of doubt, this publicity prohibition shall prevent Interested Parties and/or their agents from making any public statements or statements likely to be made public whatsoever concerning the Award Process and/or this Information Memorandum.
- 5.23 ComReg may issue such communications and generate such publicity in relation to the Award Process as it considers appropriate and without notice to Interested Parties. ComReg, subject to its guidelines on the treatment of confidential information¹⁵³, in particular, has the right to publicise or otherwise disclose any information regarding the Award Process, the identity of Applicants (including the identity of their members, sub-contractors and agents), successful Bidders or the granting of a related Licence or Licences at any time.
- 5.24 Before, during or after the Award Process ComReg may receive a request made pursuant to applicable law (including the Freedom of Information Act 2014) to disclose particular information. ComReg is not liable or responsible under any circumstances for any losses, claims or damages of any kind incurred as a result of the good faith disclosure of any information purportedly pursuant to law, which occurs before, during or after the Award Process. It is the sole responsibility of an Interested Party to determine if any of the information it supplies in the course of the Award Process should not be disclosed because of its sensitivity.

5.2.5 Errors

- 5.25 If Interested Parties discover any error or omission or lack of clarity in this Information Memorandum, such Interested Parties must immediately notify ComReg in writing of such error, omission or lack of clarity which will be resolved by ComReg in such manner as it considers appropriate.

5.2.6 No Warranty and Termination

- 5.26 The publication of this Information Memorandum does not warrant or imply that any Interested Party will be awarded a Licence or Licences.
- 5.27 ComReg will act at all times to a standard expected of a public body and in line

¹⁵³ ComReg Guidelines on the treatment of confidential information, Document 05/24.

with its statutory functions, objectives and duties. ComReg reserves the right, for any reason whatsoever at its discretion:

- to reject Applications which do not comply with the Award Rules;
- not to proceed with any part of the Award Process described in this Information Memorandum;
- not to provide an Interested Party with any additional information;
- not to implement any arrangement contemplated by this Information Memorandum;
- to withdraw from any discussions or consultation which ComReg might engage or have engaged in;
- to suspend the Award Process at any time;
- not to award any Licence or Licences;
- to procure the award of a Licence or Licences by alternative means; and/or
- to terminate the Award Process at any time.

5.2.7 Own Costs

5.28 Each Interested Party shall be fully responsible for the entirety of all expenses and/or costs it incurs in the preparation or submission of an Application or in participating in the Award Process. Save as otherwise expressly stated in this Information Memorandum, ComReg is not responsible for and will not pay for any expense or cost incurred or loss suffered by an Interested Party in the preparation or submission of its Application, its participation in the Award Process (including mock Auctions and workshops) or otherwise. Further, ComReg is not responsible for any travel or accommodation costs incurred by Interested Parties unless previously agreed in writing by ComReg.

5.29 This applies in all cases, including if the Award Process is suspended or terminated for any reason whatsoever.

5.2.8 Waiver

5.30 The failure or neglect by ComReg to enforce any provision of the Information Memorandum is not (and will not be deemed to be) a waiver of that provision and does not prejudice ComReg's right to take subsequent action in respect of such provision.

5.2.9 Amendments

- 5.31 ComReg reserves, at its discretion, the right, at any time until the conclusion or termination of the Award Process, to amend or modify this Information Memorandum or Award Process in any respect, including the shortening or extension of any and all timelines, by way of clarification, addition, deletion or otherwise. ComReg will inform Interested Parties of any such amendments or modifications, if appropriate.

5.2.10 Conclusion of Process

- 5.32 The conclusion of the Award Process, as set out in Section 4.4 of this Information Memorandum, shall be without prejudice to the accrued rights and obligations of ComReg and Interested Parties pursuant to this Chapter 5. The provisions of this Information Memorandum shall continue to bind ComReg and/or Interested Parties, to the extent that each of these provisions has become applicable to an Interested Party during the Award Process, after the conclusion of the Award Process.
- 5.33 Additional continuing obligations are imposed on Applicants pursuant to the contract formed by Section 5.2.1 of this Chapter 5.

Annex: 1 Glossary

A1.1 Definitions

A 1.1 The definitions in this glossary shall apply to this IM as a whole save that they shall not apply to the Draft Regulations in Annex 2.

A 1.2 Where a term in this glossary is defined by reference to a definition in a section or paragraph and an explanation of that term is provided in this glossary, the latter explanation is for convenience only and reference should be made to the appropriate part of the document for the definitive meaning of that term in its appropriate context.

A 1.3 Any reference to any provision of any legislation shall include any modification re-enactment or extension thereof.

A 1.4 Any reference to an Interested Party shall include that Interested Party's successors and assigns.

A 1.5 The headings contained in this IM are inserted for convenience of reference only and shall not in any way form part of or affect or be taken into account in the construction or interpretation of any provision of this IM or the Annexes or Schedules hereto.

A 1.6 Terms defined in this IM shall, unless the context otherwise requires or admits, have the meaning set out below:

1800 MHz Band	Means spectrum in the range 1710 – 1785 MHz paired with 1805 – 1880 MHz.
1926 Act	The Wireless Telegraphy Act 1926 (No. 45 of 1926) as amended.
2.1 GHz Band	Means spectrum in the range 1920 – 1980 MHz paired with 2110 – 2170 MHz.
2.1 GHz Band Block	Means a 2 × 5 MHz block of spectrum in the 2.1 GHz Band

2.1 GHz Lot	Means a 2 × 5 MHz block of spectrum in the 2.1 GHz Band available for award, with the specific frequencies of such Lots being determined in the Assignment Stage of the competitive selection procedure described in this IM.
2.1 GHz Band Interim Licence	Means a licence of the type set out in draft form in Schedule 1 or 2 of the 2.1 GHz Band Interim Licence and Early Liberalisation Regulations.
2.1 GHz Band Interim Licence and Early Liberalisation Regulations	Regulations to be made by ComReg, subject to obtaining the prior consent of the Minister, in the form of the Wireless Telegraphy [THIRD GENERATION AND GSM LICENCE (AMENDMENT) AND INTERIM LICENSING] Regulations, 2020, as may be amended prior to enactment. See Annex 2 of this document.
2.3 GHz Band	Means spectrum in the range 2300 – 2400 MHz.
2.3 GHz Band Block	Means a block of spectrum in the 2.3 GHz Band.
2.3 GHz Band Fixed Frequency Block (Lower)	Means a 1 × 30 MHz block of spectrum from 2300 – 2330 MHz.
2.3 GHz Fixed Frequency Lot (Lower)	Means a 1 × 30 MHz block of spectrum from 2300 – 2330 MHz available for award.
2.3 GHz Band Fixed Frequency Block (Upper)	Means a 1 × 10 MHz block of spectrum from 2390 – 2400 MHz.
2.3 GHz Fixed Frequency Lot (Upper)	Means a 1 × 10 MHz block of spectrum from 2390 – 2400 MHz available for award.

2.3 GHz Band Generic Frequency Block	Means a 1 × 5 MHz block of spectrum in the range 2330 – 2390 MHz.
2.3 GHz Generic Frequency Lot	Means a 1 × 5 MHz block of spectrum in the range 2330 – 2390 MHz available for award, with the specific frequencies of such Lots being determined in the Assignment Stage of the competitive selection procedure described in this IM
2.6 GHz Band	Means the spectrum in the range 2500 – 2690 MHz.
2.6 GHz Band Block	Means a 2 × 5 MHz block of spectrum in the 2.6 GHz Band.
2.6 GHz FDD Band	Means spectrum in the 2.6 GHz FDD Blocks.
2.6 GHz FDD Lot	Means a 2 × 5 MHz block of spectrum in the 2500 – 2570 MHz paired with 2620 – 2690 MHz range available for award, with the specific frequencies of such Lots being determined in the Assignment Stage of the competitive selection procedure described in this IM
2.6 GHz TDD Band	Means spectrum in the 2.6 GHz Fixed Frequency Block (Lower), 2.6 GHz Fixed Frequency Block (Upper) and 2.6 GHz Band TDD Generic Frequency Blocks.
2.6 GHz Band FDD Block	Means a 2 × 5 MHz block of spectrum in the range 2500 – 2570 MHz paired with 2620 – 2690 MHz.
2.6 GHz Band TDD Fixed Frequency Block (Lower)	Means a 1 × 5 MHz block of spectrum from 2570 – 2575 MHz.

2.6 GHz TDD Fixed Frequency Lot (Lower)	Means a 1 × 5 MHz block of spectrum in the 2570 – 2575 MHz range available for award.
2.6 GHz Band TDD Fixed Frequency Block (Upper)	Means a 1 × 5 MHz block of spectrum from 2615 – 2620 MHz.
2.6 GHz TDD Fixed Frequency Lot (Upper)	Means a 1 × 5 MHz block of spectrum in the 2615 – 2620 MHz range available for award.
2.6 GHz Band TDD Generic Frequency Block	Means a 1 × 5 MHz block of spectrum in the range 2575 – 2615 MHz.
2.6 GHz TDD Generic Frequency Lot	Means a 1 × 5 MHz block of spectrum in the 2575 – 2615 MHz range available for award, with the specific frequencies of such Lots being determined in the Assignment Stage of the competitive selection procedure described in this IM.
3.6 GHz Band	Means spectrum in the range 3410 – 3435 MHz and 3475 – 3800 MHz.
3.6 GHz Band Liberalised Use Licence	Licences issued under Wireless Telegraphy (3.6 GHz Band Licences) Regulations 2016 (S.I. No. 532 of 2016).
3G	Third Generation Mobile System.
700 MHz Duplex	Means spectrum in the range 703 – 733 MHz paired with 758 – 788 MHz.
700 MHz Duplex Block	Means a 2 × 5 MHz block of spectrum in the 700 MHz Duplex.
700 MHz Duplex Lot	Means a 2 × 5 MHz block of spectrum in the 700 MHz Duplex available for award, with the specific frequencies of such Lots being determined in the Assignment Stage of the competitive selection procedure described in this IM..

800 MHz Band	Means spectrum in the range 791 – 821 MHz paired with 832 – 862 MHz.
900 MHz Band	Means spectrum in the range 880 – 915 MHz paired with 960 – 925 MHz.
Activity	The Activity of a Bid is determined independently for each Time Slice. For each Time Slice, the Activity associated with a Primary Bid is equal to the Eligibility of the Package of Lots that the Bidder Bid for in the corresponding Time Slice.
Activity Rules	Rules governing the Bids that each Bidder can make in successive Rounds based on Bids submitted by the Bidder in previous Rounds and their associated Activity.
Additional Price	The Additional Price for a Winning Bidder, if any, is the price associated with the assignment of specific Lots to this Winning Bidder as determined in the Assignment Stage of this Award Process. This price will be determined using the methodology as detailed in Chapter 4.
Aggregate Demand	The sum of demand for Lots in a Lot Category expressed by all Applicants at the Application Stage or by all Bidders in a Primary Bid Round in the Auction.
A-Lot	<p>A single fixed frequency Lot in the:</p> <ul style="list-style-type: none"> • 2.3 GHz Fixed Frequency Lot (Lower) Time Slice 1 (“A2.3L/1”); • 2.3 GHz Fixed Frequency Lot (Lower) Time Slice 2 (“A2.3L/2”) • 2.3 GHz Fixed Frequency Lot (Upper) Time Slice 1 (“A2.3U/1”); • 2.3 GHz Fixed Frequency Lot (Upper) Time Slice 2 (“A2.3U/1”); • 2.6 GHz TDD Fixed Frequency Lot (Lower) Time Slice 1 (“A2.6TL/1”); • 2.6 GHz TDD Fixed Frequency Lot (Lower) Time Slice 2 (“A2.6TL/2”) and

	<ul style="list-style-type: none"> • 2.6 GHz TDD Fixed Frequency Lot (Upper) Time Slice 1 (“A2.6TU/1); and • 2.6 GHz TDD Fixed Frequency Lot (Upper) Time Slice 2 (“A2.6TU/2).
Apparatus	Apparatus for wireless telegraphy as defined in section 2 of the Act of 1926 for terrestrial systems capable of providing Electronic Communications Services in the Award Spectrum.
Applicant	An entity that submits an Application to ComReg to be assigned at least one of the Lots being made available in the Award Process.
Applicant Declaration	Part 2 of the Application Form.
Application	<p>The Application to participate in the Award Process made by an Applicant.</p> <p>A valid Application is a binding commitment to pay up to the highest value Bid Amount submitted for any Bid specified on the Applicant’s Initial Bid Form.</p>
Application Date	The date by which Interested Parties must submit an Application to participate in the Award Process together with the required monetary Deposit.
Application Form	<p>The Application Form, as set out in Annex 3 of this Document, to be delivered as part of an Application consisting of:</p> <ul style="list-style-type: none"> • Part 1: Administrative Information • Part 2: Applicant Declaration • Part 3: Initial Bid Form • Ownership Documents

Application Stage	The stage of the Award Process described in Section 3.3 of this IM, which runs from the day on which the IM is published up to and including the Application Date.
Assignment Bids	Bids submitted by Assignment Bidders to express their preferences over their possible assignments.
Assignment Bidder	Each individual entity considered for determining the Provisional Assignment Plan in the Assignment Stage. An Assignment Bidder refers to the Winning Bidders that win at least one B- Lot in the Main Stage and, in the case that at least one Winning Bidder wins new rights of use in the 2.1 GHz Band, Eir.
Assignment Stage	Determines the specific frequencies to be assigned to each Winning Bidder of frequency-generic B-Lots (i.e. Assignment Bidders) and the Additional Prices to be paid by each Assignment Bidder.
Assignment Option	The set of unique feasible assignments that could be assigned to each Assignment Bidder. The number of Assignment Options available to an Assignment Bidder will be less or equal to the possible number of Candidate Frequency Plans.
Assignment Round	The single Round of bidding in the Assignment Stage, during which Assignment Bidders may submit one or more Assignment Bids to be assigned specific Lots.
Associate	As defined in Annex 8 of the Information Memorandum.
Associated Bidders	As defined in Annex 8 of the Information Memorandum.
Associated Unassigned Allocation ('AUA')	A hypothetical assignment of unassigned Time Slice 1 Lots to winners that achieves the CPS.
Auction	The mechanism, consisting of the Main Stage and Assignment Stage, within the Award Process used to

	determine Winning Bidders and winning prices in the event that there is insufficient supply in at least one Lot Category to meet the demand expressed by Applicants for Lots, overall and/or for specific Lots, at the stated Reserve Prices at the Application Stage of the Award Process.
Auction Rules	“Auction Rules” shall refer to the rules and procedures relating specifically to the Auction itself, as presented in Chapter 4 only, and to any other material to which the rules in Chapter 4 directly refer.
Auction Day	A day upon which one or more Rounds of the Auction are scheduled to run.
Auctioneer	The Commission for Communications Regulation.
Authorisation Regulations	The European Communities (Electronic Communications Networks and Services) (Authorisation) Regulations, 2011 (S.I. No. 335 of 2011).
Authorised Agent	A person who the Applicant has notified ComReg is entitled to bind an Applicant contractually in relation to the Award Process.
Award Process	The overall process through which it is intended that rights of use of spectrum will be awarded in the Award Spectrum in the event that at least one Applicant submits a valid Application for at least one Lot at the stated Reserve Prices.
Award Rules	Award Rules refers to rules and procedures relating to the Award Process, as presented in Chapters 3 and Chapter 4 of this Information Memorandum, and to any other material to which the rules in Chapters 3 and 4 directly refer.

Award Spectrum	<p>The spectrum in respect of which rights of use are being made available in the Award Process.</p> <p>The Award Spectrum consists of the:</p> <ul style="list-style-type: none"> • 700 MHz Duplex, • 2.1 GHz Band, • 2.3 GHz Band; • 2.6 GHz FDD Band; and • 2.6 GHz TDD Band.
Band Frequency Plan	<p>For a given band, the specific frequencies to be assigned to Assignment Bidders as a result of the Assignment Option generation process and the outcome of an Assignment Round (if required) give the Band Frequency Plan for that band.</p>
Base Price	<p>Base Prices are the minimum amounts that each Winning Bidder, and each group of Winning Bidders jointly, could have bid without changing the outcome of the winner determination process, and are based on the concept of Opportunity Cost.</p> <p>The Base Price for a Winning Bidder is determined as follows:</p> <ul style="list-style-type: none"> • where the Main Stage of the Award Process is not required, the Base Price is the sum of the Reserve Prices for all Lots to be included in the Licence; • where the Main Stage of the Award Process is required, the Base Price is determined by the Main Stage of the Auction as detailed in Chapter 4 of this document. The Base Price will be no less than the sum of the Reserve Prices for all Lots to be included in the Licence.
BEM	Block Edge Mask.

Bid	A binding offer to buy a number of Lots at a price not exceeding a specific monetary amount (the Bid Amount).
Bid Amount	The monetary amount associated with an offer made by a Bidder for a specified Package of Lots.
Bid Form	The Bid Form provided by the EAS for entry of Bids.
Bidder	An Applicant that submitted a valid Application in the Application Stage that was approved by ComReg in the Qualification Stage, qualifying them to bid for Lots in the Award Process.
Bidding Group	A Bidder and its Connected Persons as defined in Annex 8 of the Information Memorandum.
Bidder Materials	Information made available to Bidders regarding the EAS.
Bidding Restrictions	<p>Bidding Restrictions are in the form of:</p> <ul style="list-style-type: none"> • Competition Caps, that restrict the amount of spectrum Bidders can win rights of use for in the Award Process; and • constraints on the combinations of frequency-specific and frequency-generic Lots in the 2.6 GHz TDD Band that a Bidder can submit Bids for.
B-Lot	<p>Is a single frequency-generic Lot as follows:</p> <ul style="list-style-type: none"> • 700 MHz Duplex Lots (“B700”); • 2.1 GHz Lots Time Slice 1 (“B2.1/1”); • 2.1 GHz Lots Time Slice 2 (“B2.1/2”); • 2.3 GHz Generic Frequency Lots Time Slice 1 (“B2.3/1”);

	<ul style="list-style-type: none"> • 2.3 GHz Generic Frequency Lots Time Slice 2 (“B2.3/2”); • 2.6 GHz FDD Lots Time Slice 1 (“B2.6/1”); • 2.6 GHz FDD Lots Time Slice 2 (“B2.6/2”); • 2.6 GHz TDD Generic Frequency Lots Time Slice 1 (“B2.6T/1”); and • 2.6 GHz TDD Generic Frequency Lots Time Slice 2 (“B2.6T/2”).
Candidate Frequency Plans	A frequency plan constructed from the Assignment Bidder orderings and re-arrangements of unassigned blocks in accordance with the rules on Assignment Option generation.
CCA	Combinatorial Clock Auction.
CEPT	The European Conference of Postal and Telecommunications Administrations.
Chain Bid	A Bid at a non-discretionary level for a Package of Lots previously subject to the Bidder’s Initial Bid or a Package of Lots subject to a Primary Bid in a Primary Bid Round where the Bidder dropped Eligibility and which is submitted alongside a Relaxed Primary Bid.
ComReg	The Commission for Communications Regulation.
ComReg’s Nominated Bank Account	As specified in the Application Form.

Communications Regulation Act 2002	Communications Regulation Act 2002 (No. 20 of 2002), as amended ¹⁵⁴ .
Competition Act 2002	Competition Act 2002 (No. 14 of 2002), as amended.
Competition Cap	Explicit maximum limits set on the amount of spectrum that any one Bidder can bid for/acquire in the Award Process. All Bidders are subject to a Competition Cap consisting of an Overall Competition Cap and a Sub-1 GHz Competition Cap.
Confidential Information	Details of what may constitute Confidential Information for the purposes of this Award Process are provided in subsection Section 3.3.5 and 3.3.6 of the IM.
Connected Person	Shall have the meaning ascribed to it in Annex 8 of the Information Memorandum.
Constraining Round	The Primary Bid Round associated with a particular Constraining Package.
Constraining Package	Packages of Lots subject to Eligibility-reducing Primary Bids. Shall have the meaning ascribed to it in Chapter 4 of the Information Memorandum.
Controlled Person	As defined in Annex 8 of the Information Memorandum.
Corrected Partition Score ('CPS')	The lowest value of the Partition Score that can be achieved by hypothetically assigning all of the unallocated Lots in the first Time Slice (if any) to winners (in any possible way)
Coverage Compliance Report	Licensees in the 700 MHz Duplex under a MBSA2 Liberalised Use Licence shall measure outdoor

¹⁵⁴ Amendments include but are not limited to those effected by the Communications Regulation (Amendment) Act 2007 and the Communications Regulation (Premium Rate Services and Electronic Communications Infrastructure) Act 2010.

	<p>coverage every twelve months and submit an annual report to ComReg regarding its compliance with its coverage obligations.</p> <p>Details of this compliance reporting condition are set out in Chapter 2 of this document, and Schedule 1 of the indicative MBSA2 Liberalised Use Licence contained in Annex 2 of this document.</p>
CPI	Consumer Price Index published from time to time by the Central Statistics Office.
CPI Adjustment	Means a negative or positive adjustment to a Spectrum Usage Fee, calculated using the CPI according to the methodology set out in the Information Memorandum.
CSO	Central Statistics Office of Ireland or its successor.
Decision	Refers to ComReg's substantive proposals as currently set out in its draft Decision (Chapter 9 of Document 19/124).
Deposit	A monetary amount submitted by an Applicant as part of its Application to be assigned Lots in the Award Process. For an Application to be valid, the amount of an Applicant's Deposit must, at a minimum, be equal to the highest Bid Amount specified by the Applicant in its Initial Bid Form.
Deposit Call	A notice given by ComReg to one or more Bidders that they need to increase their Deposits as described in this Information Memorandum.
Discount	As specified in paragraph 4.113.
DotEcon Report	Refers to Annex 12 of this document.

Draft Regulations	Includes the MBSA2 Licence Regulations, and the 2.1 GHz Band Interim Licence and Early Liberalisation Regulations.
EC	European Commission.
EC Decision 2016/687	Commission Implementing Decision of 28 April 2016 on the harmonisation of the 694-790 MHz frequency band for terrestrial systems capable of providing wireless broadband electronic communications services and for flexible national use in the Union.
EC Decision 2012/688	Commission Implementing Decision of 5 November 2012 on the harmonisation of the frequency bands 1920 – 1980 MHz and 2110 – 2170 MHz for terrestrial systems capable of providing electronic communications services in the Union.
EC Decision 2008/477	Commission Decision of 13 June 2008 on the harmonisation of the 2500-2690 MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community.
ECC	Electronic Communications Committee.
ECC Decision 14(02)	Harmonised technical and regulatory conditions for the use of the band 2300-2400 MHz for Mobile/Fixed Communications Networks (MFCN).
Edge Lots	Where a Lot Category consisting of frequency-generic Lots has frequency-specific Lots at adjacent frequencies, these frequency-specific Lots are the Edge Lots associated with that particular Lot Category.
Electronic Communications Service (ECS)	Electronic Communications Service as defined under the Framework Regulations.

Electronic Auction System (EAS)	The system used for running the Auction. Specifically, this will be used by Bidders to check and submit Bids during the Assessment Stage (where required) and the Assignment Stage of the Auction (both except in exceptional circumstances).
Eligibility	<p>The extent of a Bidder's capacity to Bid for Lots in the current Round of the Auction.</p> <p>In the first Round, the Bidder's Eligibility is equal to the number of Lots specified in its applicable Initial Bid for the Auction.</p> <p>In subsequent Rounds, the Bidder's Eligibility is equal to its Activity in the previous Round.</p>
Eligibility Points	The numerical expression of a Bidder's ability to make further Bids.
Eir	Eircom Limited and Meteor Mobile Communications Limited (trading as 'eir' and 'open eir'), collectively referred to as 'eir Group' or 'eir'.
Equivalent Isotropically Radiated Power (EIRP)	Means the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna.
European Union (Radio Equipment) Regulations 2017	S.I. No. 248/2017 – European Union (Radio Equipment) Regulations 2017.
European Communities (Electromagnetic Compatibility) Regulations 2017	S.I. No. 69/2017 – European Communities (Electromagnetic Compatibility) Regulations 2017.
Exchequer Notes	The Exchequer Note programme is a Euro denominated programme which provides short-term funding with

	maturities up to 1 year. They are sold directly through the NTMA.
Existing 2.1 GHz Band Licence	Means a licence pursuant to the Wireless Telegraphy (Third Generation and GSM Mobile Telephony Licence) Regulations, 2002 (S.I. No. 345 of 2002), as amended by the Wireless Telegraphy (Third Generation and GSM Mobile Telephony Licence) (Amendment) Regulations, 2003 (S.I. No 340 of 2003), or the 2.1 GHz Band Interim Licence and Early Liberalisation Regulations, as appropriate.
Existing 2.1 GHz Band Licensee	Means a person holding one, or more, Existing 2.1 GHz Licences.
Existing 2.3 GHz Band Licence	Means a licence issued pursuant to the Wireless Telegraphy (Radio Link Licence) Regulations, 2009 (S.I. No 370 of 2009) by which rights of use are assigned within the frequency range 2307 – 2327 MHz.
Existing 2.3 GHz Band Licensee	Means a person holding one, or more, Existing 2.3 GHz Band Licences.
Existing Licensee	Means an Existing 2.1 GHz Band Licensee and/or an Existing 2.3 GHz Band Licensee, as appropriate.
Existing MNO	Means a Winning Bidder that on 1 January 2020 was a holder of one or more of the following licences: <ul style="list-style-type: none"> • a Liberalised Use Licence for terrestrial systems capable of providing Electronic Communications Services under the Wireless Telegraphy (Liberalised Use and Preparatory Licences in the 800 MHz, 900 MHz and 1800 MHz bands) Regulations 2012 (S.I. No. 251 of 2012); and/or • a licence to keep and have possession of apparatus for wireless telegraphy for the purpose of providing 3G and GSM mobile telephony under the Wireless Telegraphy (Third Generation and

	<p>Gsm Mobile Telephony Licence) (Amendment) Regulations 2003 (S.I. No. 340 of 2003).</p> <p>Existing MNOs include only Vodafone Ireland Limited, Three Ireland (Hutchison) Limited and collectively Eircom Limited and Meteor Mobile Communications Limited, or their successors, in relation to these licences.</p>
Existing Operator	Existing Operators refers to the existing licensees in the 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz and 3.6 GHz Bands.
Existing Operator (other than an Existing MNO)	<p>Means a Winning Bidder that on 1 January 2020 was a holder of a 3.6 GHz Band Liberalised Use Licence for terrestrial systems capable of providing Electronic Communications Services under the Wireless Telegraphy (3.6 GHz Band Licences) Regulations 2016 (S.I. No. 532 of 2016) and is not an Existing MNO.</p> <p>Existing Operators (other than an Existing MNO) include only Dense Air Limited and Imagine Communications Ireland Limited, or their successors, in relation to these licences.</p>
Exposure Price	A Bidder's Exposure Price for a Package of Lots in a given Primary Bid Round is equal to the price of the Package of Lots at current Round Prices, less the Bidder's Discount in the Round.
Extension	<p>Bidders have a limited number of Extension rights, which will automatically grant them additional time for submitting their Bids in the event that they do not make a submission before the scheduled end of a Round as notified by ComReg</p> <p>An Extension right of a Bidder will be exercised automatically in a Round if the Bidder has at least one Extension right remaining and has not submitted a Bid by the scheduled end time of the Round.</p>

FDD	Frequency Division Duplex.
Feasible Combination of Bids	<p>A Feasible Combination of Bids is one in which:</p> <ul style="list-style-type: none"> • in each Lot Category, no more Lots are awarded than are available in that Lot Category; and • at most one Bid is accepted from each Bidder. <p>The value of a Feasible Combination of Bids is equal to the sum of the Bid Amounts for all Bids in the combination, plus the Reserve Price of any Lots that would remain unassigned if only the Bids in the combination are accepted.</p>
Final Assignment Plan	The frequency assignments established following the Negotiation Phase.
Final Price Cap	A cap applying to all Supplementary Bids (except for a Final Primary Package which is non-zero or a Relaxed Primary Bid) limiting the maximum Bid Amount for a Package of Lots to the highest Bid made for the Final Primary Package plus the difference in prices between the Package of Lots in question and the Final Primary Package at the Round Prices in the final Primary Bid Round.
Final Primary Package (FPP)	The Package of Lots Bid for by a Bidder in the final Primary Bid Round.
Framework Regulations	European Communities (Electronic Communications Networks and Services) (Framework) Regulations 2011 (S.I No. 333 of 2011).
General Authorisation	An authorisation for an undertaking to provide an electronic communications network or service under and in accordance with Regulation 4 of the Authorisation Regulations.

GSM	Global System for Mobile Communications.
Harmful Interference	Bears the meaning ascribed to it in the Framework Regulations.
Hertz ('Hz')	Unit of Frequency.
Initial Bid	A Bidder's Initial Bid is the Package defined by the Lots specified by the Bidder on its Initial Bid Form and the corresponding Bid Amount calculated as the sum of the Reserve Prices for the Lots specified on the Bidder's Initial Bid Form.
Initial Bid Form	Part 3 of the Application Form.
Initial Eligibility	The number of Eligibility Points that a Bidder has in the first Primary Bid Round. This is based on the number of Eligibility Points associated with the Package of Lots the Bidder specified on its Application Form, submitted to ComReg at the Application Stage.
Information Memorandum (IM)	This Information Memorandum (currently in draft form) including all of the Annexes and Schedules thereto.
Insider	Shall have the meaning ascribed to it in paragraph 3.75.
Interested Party	Includes, to the extent that the context requires or admits, any of the following: <ul style="list-style-type: none"> (i) a respondent to Consultation Document 14/101, 18/60, 18/103, 19/59R or 19/124; (ii) a prospective Bidder; (iii) an Applicant; (iv) a Bidder; or an agent of any of the foregoing.
kHz	One kilohertz (kHz) is equal to 1,000 Hertz (Hz).

Lease	Means the assignment by a Licensee (“the Lessor”) of some or all of a right of use for radio frequencies granted under a MBSA2 Liberalised Use Licence for a period less than the remaining duration of the right of use to another party (“the Lessee”), after which the right of use for radio frequencies reverts to the Lessor.
Licence	A MBSA2 Liberalised Use Licence, a MBSA2 Preparatory Licence, a MBSA2 2.3 Band Transition Licence, a MBSA2 Spectrum Lease Licence or an Existing Licence as the case may be and “Existing Licensee” and “Licensee” shall be construed accordingly.
Licensee	Means the holder of a Licence.
Lot	A 2 × 5 MHz block of spectrum, a 1 × 30 MHz block of spectrum, a 1 × 5 MHz block of spectrum, or a 1 × 10 MHz block of spectrum in the 700 MHz Duplex, 2.1 GHz Band, 2.3 GHz Band or 2.6 GHz Band as appropriate and as detailed in section 2.2. of the IM
Lot Category	<p>There are 17 Lot Categories, where A-Lots refer to the fixed frequency Lots, B-Lots refer to the frequency-generic Lots and the suffix “/1” or “/2” indicates the relevant Time Slice.</p> <p>The Lot Categories for the purposes of this Award Process are:</p> <ul style="list-style-type: none"> • B700; • B2.1/1; • B2.1/2; • A2.3L/1; • A2.3L/2; • B2.3/1;

	<ul style="list-style-type: none"> • B2.3/2; • A2.3U/1; • A2.3U/2; • B2.6F/1; • B2.6F/2; • A2.6TL/1; • A2.6TL/2; • B2.6T/1; • B2.6T/2; • A2.6TU/1; and • A2.6TU/2.
Lot Types	An A-Lot or B-Lot as appropriate.
LTE	Long Term Evolution of 3G.
Main Stage	Determines the number of Lots to be awarded to each Bidder in each Lot Category, and the Base Prices that Winning Bidders will have to pay for their Lots. This consists of a number of Primary Bid Rounds, a Supplementary Bids Round, and an announcement to all Bidders of the Winning Bidders and the number of Lots won by each Winning Bidder in each Lot Category and, for each Winning Bidder, its own Base Price.
MBSA2 Liberalised Use Licence	A Licence in the form set out in Schedule 1 of the MBSA2 Licence Regulations which will allow a Licensee to keep, possess, install, maintain, work and use Apparatus in the portion of the Award Spectrum assigned thereunder for terrestrial systems capable of providing ECS subject to the terms and conditions set out therein..

MBSA2 Licence Regulations	Regulations to be made by ComReg, subject to obtaining the prior consent of the Minister, in the form of the Wireless Telegraphy [LIBERALISED USE AND RELATED LICENCES IN THE 700 MHZ DUPLEX, 2.1 GHZ, 2.3 GHZ AND 2.6 GHZ BANDS] Regulations, 2020, as may be amended prior to enactment. See Annex 2 of this document.
MBSA2 Preparatory Licence	A Licence in the form as set out in Schedule 3 of the MBSA2 Licence Regulations, which will allow the Licensee to install networks and associated equipment in advance of the commencement date of their MBSA2 Liberalised Use Licence, subject to the terms and conditions set out therein, but will not allow any wireless telegraphy transmissions..
MBSA2 Spectrum Lease Licence	A Licence in the form as set out in Schedule 2 of the MBSA2 Licence Regulations, which will allow the Licensee to keep, possess, install, maintain, work and use Apparatus in the portion of the Award Spectrum assigned thereunder for terrestrial systems capable of providing ECS, subject to the terms and conditions set out therein.
MBSA2 2.3 GHz Band Transition Licence	A Licence in the form as set out in Schedule 4 of the MBSA2 Licence Regulations, which will allows the Licensee to keep and have possession of, install, maintain, work and use Apparatus for point to multi-point radio links for the provision of RurTel Services in the 2.3 GHz Band, , subject to the terms and conditions set out therein.
MBSA2 2.3 GHz Band Transition Licence Price A	The existing fees set out in the Wireless Telegraphy (Radio Link Licence) Regulations (S.I. No. 370 of 2009) but updated to present day prices using the overall CPI.
MBSA2 2.3 GHz Band Transition Licence Price B	A reasonable approximation of the opportunity cost of RurTel Services remaining in the 2.3 GHz Band beyond

	the commencement date of new rights of use in the 2.3 GHz Band.
MFCN	Mobile Fixed Communication Network.
MoU	Memorandum of Understanding.
MVNO	Mobile Virtual Network Operator. A mobile operator with no spectrum assignment and with, or without, network infrastructure.
Native Wi-Fi	Native Wi-Fi technology, allows calls and texts to be made on a device utilising a Wi-Fi connection rather than through the mobile network directly.
NBP	National Broadband Plan.
Negotiation Phase	The two week period allowed after the Assignment Round where Assignment Bidders can attempt to agree an alternative frequency plan.
New Entrant	Means a Licensee that is not an Existing Operator.
New Entrant (Mobile)	Means a Winning Bidder that is not an Existing Operator and which will provide mobile Electronic Communications Services under its MBSA2 Liberalised Use Licence.
New Entrant (Other)	Means a Winning Bidder that is not an Existing Operator and which will provide Electronic Communications Services other than mobile Electronic Communications Service under its MBSA2 Liberalised Use Licence.
Non-exclusive	Means that ComReg is not precluded from authorising the keeping and having possession by persons other than the Licensee, on a Non-Interference and Non-

	Protected Basis, of Apparatus on the radio frequency spectrum specified in the Licence.
Non-Interference and Non-Protected Basis	The use of Apparatus is subject to no Harmful Interference being caused to any Radiocommunication Service, and that no claim may be made for the protection of Apparatus used on this basis against Harmful Interference originating from Radiocommunication Services.
Notional Winner	A hypothetical Bidder unassigned all Time Slice 2 B-Lots in a particular band for the purpose of determining winner orderings in that band.
Notification and Grant Stage	The stage of the Award Process during which Deposits (minus any applicable SAF or portion of Deposits forfeited for breaches of the Award Rules) are returned to Bidders and Licences are granted to Winning Bidders.
NTMA	National Treasury Management Agency.
Opportunity Cost	Shall have the meaning ascribed to it in paragraph 4.165.
Overall Competition Cap	No Bidder may bid for/acquire spectrum rights of use in the Award Process that would result in it holding total spectrum rights of use for more than 375 MHz across the 700 MHz Duplex, 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz, 2.3 GHz, 2.6 GHz and 3.6 GHz Bands at any time during either of the two Time Slices.
Ownership Structure Document	Shall have the meaning ascribed to it in Section 3.3.2.
Package	A selection of one or more Lots: <ul style="list-style-type: none"> • Specified in a Bidder's Application Form; • Bid for in one or more of the Bid Rounds.

Partition Score	A measure of how evenly a given partition of winners splits the available frequency-generic Lots.
Payment Deadline	The last day upon which Winning Bidders can increase their Deposits to the level of their SAF in order to apply for a Licence for the Lots assigned to them within the Award Process.
Performance Bands	Blocks in the 2.1 GHz Band, 2.3 GHz Band and the 2.6 GHz Band.
Price Increment	The increase of the price of Lots in a Lot Category from one Primary Bid Round of the Auction to the next based on demand expressed for Lots in that Lot Category in the previous Primary Bid Round (or in the case of the Price Increment applicable to Reserve Prices for the first Primary Bid Round, demand expressed by Bidders at the Application Stage).
Primary Bid	A Bid made by a Bidder in a Primary Bid Round.
Primary Bid Round	A Round of the Main Stage during which Bidders each have the opportunity to submit a single Bid for a Package of Lots for a Bid Amount equal to the sum of the Round Prices associated with each Lot within the Package of Lots upon which it submits a Bid.
Provisional Assignment Plan	<p>A specific frequency assignment for each Assignment Bidder, awarded frequency-generic B-Lots and is determined by the outcome of the Assignment Round.</p> <p>If an Assignment Round is not required, the Provisional Assignment Plan will be the unique frequency assignments for each Assignment Bidder.</p>
QoS	Quality of Service.

QoS Compliance Report	A Licensee shall, every twelve months, measure and submit an annual report to ComReg regarding its compliance with (a) the availability of the network standard and (b) the voice call QoS standard and (c) the VoLTE availability obligation.
Qualification Stage	A stage of the Award Process during which ComReg assesses the Applications submitted before the Application Date, evaluates which Applications are valid, and determines which Applicants qualify to become Bidders in the Award Process.
Radiocommunication Service	A service as defined in the Radio Regulations of the International Telecommunication Union involving the transmission, emission or reception of radio waves for specific telecommunication purposes.
Relative Cap	A cap applying to a Supplementary Bid, which limits the Bid Amount for a Package of Lots as described in Section 4.2.3.
Relaxed Primary Bid(s)	A Primary Bid submitted by a Bidder whose Activity exceeds the Bidder's Eligibility to Bid but is permitted because it satisfies certain specified constraints. These conditions surrounding the submission of Relaxed Primary Bids and the associated Bids they may require in order to preserve relative preferences are detailed in Section 4.2.
Relocation	An Existing Licensee relocating to a different spectrum assignment within a spectrum band compared to its existing spectrum assignment.
Relocation Rebate	A rebate given to Eir in relation to its Existing 2.1 GHz Band Licence if it incurs a relocation cost as a result of the Assignment Stage that it would not have incurred otherwise, as detailed in Annex 14.

Reserve Price	The Reserve Price indicates the minimum SAF for each Lot included in the Licence and does not include the first or any subsequent payment of SUFs.
Rollout Compliance Report	An annual report that a Licensee submits to ComReg regarding its compliance with its rollout obligation.
Round	A Round is a period of time set by ComReg within which Bidders submit their Bids. A Round may be extended by a Bidder exercising a right to use an Extension right.
Round Price	The price per Lot in a given Round.
Round Schedule	The scheduled start time and end time of Rounds.
RSRP	Reference Signal Received Power which is defined as the linear average of the reference signal power (in Watts) within a number of specific resource elements across a specified bandwidth within a LTE downlink signal. LTE specific equipment is required to decode the LTE downlink signal to make this measurement.
RSPP	Radio Spectrum Policy Programme.
RurTel Service	This is a service provided by Eir to users using its RurTel network.
RurTel	RurTel is a wireless point-to-multipoint telephony solution operating in the frequency range 2307 – 2327 MHz.
SI	Statutory Instrument.
Specific Regulations	Specific Regulations has the same meaning as set out in Regulation 2 of the Framework Regulations 2011 (S.I. No. 333 of 2011).

Spectrum Access Fee (SAF)	The sum of the Base Price and any Additional Price to be paid by a Winning Bidder for the spectrum assigned to it within the Award Process.
Spectrum Block	Means: 700 MHz Duplex Blocks; 2.1 GHz Band Blocks; 2.3 GHz Band Fixed Frequency Block (Lower); 2.3 GHz Band Generic Frequency Blocks; 2.3 GHz Band Fixed Frequency Block (Upper); 2.6 GHz Band FDD Blocks; 2.6 GHz Band TDD Fixed Frequency Block (Lower); 2.6 GHz Band TDD Generic Frequency Blocks; and 2.6 GHz Band TDD Fixed Frequency Block (Upper).
Spectrum Usage Fee (SUFs)	Annual Fees which a Winning Bidder must pay in respect of spectrum rights of use assigned in the Award Process. For a MBSA2 Liberalised Use Licence, the total annual SUF is the sum of the SUFs associated with each Lot included in the Licence.
Statement of Authorised Apparatus	Part 2 of Schedule 2 and 3 of the MBSA2 Licence Regulations.
Sub-1 GHz Competition Cap	No Bidder may bid for/acquire spectrum rights of use in the Award Process that would result in it holding total spectrum rights of use for more than 70 MHz (2 × 35 MHz) of spectrum across the 700 MHz Duplex, 800 MHz and 900 MHz Bands at any time during either of the two Time Slices.
Supplementary Bid	A Bid submitted in the Supplementary Bids Round for a Package of Lots for a Bid Amount specified by the Bidder. The specified Bid Amount will be subject to a minimum (floor) and, in some cases, a maximum (cap), as set out in the Activity Rules for the Auction.
Supplementary Bids Round	A single Round of bidding during which each Bidder can submit multiple Bids, each for a Package of Lots for a Bid Amount specified by the Bidder. The specified Bid Amount for each Supplementary Bid submitted in this Round will be subject to a minimum (floor) and, in some

	cases, a maximum (cap), as set out in the Activity Rules for the Auction.
SUTP	Single User Throughput. The downlink bit rate that can be successfully delivered to a single active user per cell at a particular depth and consistency of coverage. This is the downlink bit rate or download speed that a user could experience when not contending with other users for service in that cell, so that the cell delivers the maximum possible data rate to a single user consistent with the signal quality experienced by that user.
TDD Inter-Licencee Synchronisation Procedure	As set out in Section 3 of Schedule 1 of the MBSA2 Licence Regulations.
Temporary ECS Licence	Means a licence of the type set out in Schedule 1 to the S.I. No. 122 of 2020.
Time Slice	<p>Lots in the 2.3 GHz Band and 2.6 GHz Band are being made available in two “time slices”, viz:</p> <ol style="list-style-type: none"> 1. Time Slice 1: From [1 December 2020] (or such other date as may be specified by ComReg in, or in accordance with, the Information Memorandum) to [11 March 2027] (or such other date as may be specified by ComReg in, or in accordance with, the Information Memorandum); and 2. Time Slice 2: From [12 March 2027] (or such other date as may be specified by ComReg in, or in accordance with, the Information Memorandum) to [30 November 2040] (or such other date as may be specified by ComReg in, or in accordance with, the Information Memorandum); are made available in two distinct time periods. <p>Lots in the 2.1 GHz Band are being made available in two Time Slices, viz:</p>

	<ul style="list-style-type: none"> • 2.1 GHz Band Time Slice 1: From [16 October 2022] (or such other date as may be specified by ComReg in, or in accordance with, the Information Memorandum) to [11 March 2027] (or such other date as may be specified by ComReg in, or in accordance with, the Information Memorandum); and • 2.1 GHz Band Time Slice 2: From [12 March 2027] (or such other date as may be specified by ComReg in, or in accordance with, the Information Memorandum) to [30 November 2040] (or such other date as may be specified by ComReg in, or in accordance with, the Information Memorandum).
Time Slice 1	<p>For Lots in the 2.3 GHz Band and 2.6 GHz Band, it is the time period from 1 December 2020 to 11 March 2027 (as may be amended by ComReg).</p> <p>For Lots in the 2.1 GHz Band, it is the time period from 16 October 2022 to 11 March 2027 (as may be amended by ComReg).</p>
Time Slice 2	<p>For Lots in the 2.3 GHz Band and 2.6 GHz Band, it is the time period from 12 March 2027 to 30 November 2040 (as may be amended by ComReg).</p> <p>For Lots in the 2.1 GHz Band it is the time period from 12 March 2027 to 30 November 2040 (as may be amended by ComReg).</p>
Time Slice Bandwidth Variation ('TBV')	The absolute value of the difference in the number of frequency-generic Lots assigned to an Assignment Bidder in that band across the two Time Slices.
Time Slice Variation ('TSV')	The number of the highest frequency block assigned to that winner in either Time Slice plus one, less the number of the lowest frequency block assigned to that winner in either Time Slice minus the maximum number

	of frequency blocks allocated to that winner across either Time Slice.
Total Time Slice Variation ('TTSV')	The sum of the Time Slice Variations of all winners of frequency-generic Lots in that band. Unassigned Lots are not considered when evaluating the TTSV.
Transfer Regulations	Means the Wireless Telegraphy (Transfer of Spectrum Rights of Use) Regulations 2014 (S.I. No. 34 of 2014).
Transfer	Has the meaning set out in the Transfer Regulations.
Transferee	Has the meaning set out in the Transfer Regulations.
Transition	The process of completing all Transition Activities.
Transition Activities	Adjustments as maybe required by Existing Licensees and Winning Bidders to their existing networks in order to comply with the outcome of the Award Process and align their use of spectrum with the rights of use that they obtain, if any.
Transition Plan	A plan which outlines interim milestones for Transition Activities for Existing 2.1 GHz Licensees and/or Existing 2.3 GHz Licences.
Transition Plan Proposals	Proposals formulated by Winning Bidders, Existing 2.1 GHz Licensees, and/or Existing 2.3 GHz Licences who have agreed to abide by the Transition Rules.
Transition Scenario A	Refers to the scenario where an Existing 2.1 GHz Band Licensee or a Winning Bidder of Lots in Time Slice 1 wins an equal or greater amount of new spectrum rights in the same band in Time Slice 2 but these spectrum rights are in a different frequency location.

Transition Scenario B	Refers to the scenario where an Existing 2.1 GHz Band Licensee or a Winning Bidder of Lots in Time Slice 1 wins a reduced amount of new spectrum rights in the same band in Time Slice 2.
Transition Scenario C	Refers to the scenario where an Existing 2.1 GHz Band Licensee or a Winning Bidder of Lots in Time Slice 1 wins no new spectrum rights in the same band in Time Slice 2.
Transition Rules	Rules regarding Transition, as set out in Section 3.8 of this document.
USO	Universal Service Obligation.
Valid Bid	A Bid submitted within the Auction or by way of the Application Form that is in accordance with the Auction Rules. A Valid Bid represents a binding commitment to buy the specified Package of Lots at any price not exceeding the specified Bid Amount and pay the appropriate SUFs over the duration of the Licence.
VAT	Value Added Tax.
VoIP	Voice over Internet Protocol.
VoLTE	Voice over LTE.
Winning Bid	A Bid in respect of which a Winning Bidder is assigned at least one Lot in the Winning Combination of Bids.
Winning Bidder	A Bidder that wins at least one Lot in the Award Process.
Winning Combination of Bids	Is a Feasible Combination of Bids that has the greatest value across all Feasible Combinations of Bids, considering all the Bids submitted in the Auction

	(including Initial Bids, standard and Relaxed Primary Bids, Chain Bids and Supplementary Bids.
Winning Combination of Assignment Bids	The combination of valid Assignment Bids submitted during the Assignment Round that has the highest total value of Assignment Bid amounts, and is compatible with one of the Candidate Frequency Plans.
Winner Determination	The process of selecting the Winning Bids on the basis of optimisation.
Working Day	Working Day means a day which is not a Saturday or Sunday or a public holiday.
Zero Bid	<p>A Bid for no Lots with an Associated Bid Amount of zero. Entry of a Zero Bid in the Primary Bid Rounds does not prevent the entry of Supplementary Bids.</p> <p>A Zero Bid will be submitted automatically in the case that a Bidder fails to submit a Bid within the Round Schedule of a Round, or within 30 minutes of the scheduled end time of a Round where the Bidder had at least one Extension right at the beginning of the Round.</p>
Zero Package	A Final Primary Package that consists of no Lots in any Lot Category for which the Bid Amount is zero.

Annex: 2 Draft MBSA2 Licensing Regulations and Draft 2.1 GHz Early Liberalisation and Interim Licensing Regulations

Draft MBSA2 Licensing Regulations

This annex contains a draft of the proposed MBSA2 licensing regulations. These regulations will provide for the issuing of all licences arising from the proposed Award Process except those relating to early liberalisation and interim licensing in the 2.1 GHz Band which are provided for separately by the draft regulations in Annex 2.

Any final version of these regulations, which would be made by ComReg under section 6 of the Wireless Telegraphy Act 1926 is expressly subject to the consent of the Minister for Communications, Climate Action and Environment under section 37 of the Communications Regulation Act 2002.

ComReg will take into account comments from interested parties when finalising these proposed regulations. ComReg may also make such editorial changes to the text of any final regulations as it considers necessary and without further consultation, where such changes would not affect the substance of the regulations.

S.I. No. XX of 2020**WIRELESS TELEGRAPHY (LIBERALISED USE AND RELATED LICENCES IN THE 700 MHZ DUPLEX, 2.1 GHZ, 2.3 GHZ AND 2.6 GHZ BANDS) REGULATIONS 2020**

Notice of the making of this Statutory Instrument was published in “Iris Oifigiúil” of [XX] 2020.

The Commission for Communications Regulation, in exercise of the powers conferred on it by section 6(1) of the Wireless Telegraphy Act, 1926 (No. 45 of 1926) as substituted by section 182 of the Broadcasting Act 2009 (No. 18 of 2009), and with the consent of the Minister for Communications, Climate Action and Environment in accordance with section 37 of the Communications Regulation Act 2002 (No. 20 of 2002), hereby makes the following Regulations:

Citation

1. These Regulations may be cited as the Wireless Telegraphy (Liberalised Use and Related Licences in the 700 MHz Duplex, 2.1 GHz, 2.3 GHz and 2.6 GHz Bands) Regulations 2020.

Interpretation

2. (1) In these Regulations:

“2.1 GHz Band” means radio frequency spectrum in the range 1920 to 1980 MHz paired with radio frequency spectrum in the range 2110 to 2170 MHz;

“2.1 GHz Band Block” means a 5 MHz paired block of radio frequency spectrum in the 2.1 GHz Band;

“2.3 GHz Band” means radio frequency spectrum in the range 2300 to 2400 MHz;

“2.3 GHz Band Fixed Frequency Block (Lower)” means the 30 MHz unpaired block of radio frequency spectrum in the range 2300 to 2330 MHz;

“2.3 GHz Band Fixed Frequency Block (Upper)” means the 10 MHz unpaired block of radio frequency spectrum in the range 2390 to 2400 MHz;

“2.3 GHz Band Generic Frequency Block” means a 5 MHz unpaired block of radio frequency spectrum in the range 2330 to 2390 MHz;

“2.3 GHz Band Blocks” means the 2.3 GHz Band Fixed Frequency Block (Lower), 2.3 GHz Band Fixed Frequency Block (Upper) and 2.3 GHz Band Generic Frequency Blocks;

“2.6 GHz Band” means radio frequency spectrum in the range 2500 to 2690 MHz;

“2.6 GHz Band FDD Generic Frequency Block” means a 5 MHz block of radio frequency spectrum in the range 2500 to 2570 MHz paired with a 5 MHz block of radio frequency spectrum in the range 2620 to 2690 MHz;

“2.6 GHz Band TDD Fixed Frequency Block (Lower)” means the 5 MHz unpaired block of radio frequency spectrum in the range 2570 to 2575 MHz;

“2.6 GHz Band TDD Fixed Frequency Block (Upper)” means a 5 MHz unpaired block of radio frequency spectrum in the range 2615 to 2620 MHz;

“2.6 GHz Band TDD Generic Frequency Block” means a 5 MHz unpaired block of radio frequency spectrum in the range 2575 to 2615 MHz;

“2.6 GHz Band Blocks” means the 2.6 GHz Band FDD Generic Frequency Block, 2.6 GHz Band TDD Fixed Frequency Block (Lower), 2.6 GHz Band TDD Fixed Frequency Block (Upper) and 2.6 GHz Band TDD Generic Frequency Blocks;

“2.6 GHz Band TDD Blocks” means the 2.6 GHz Band TDD Fixed Frequency Block (Lower), 2.6 GHz Band TDD Fixed Frequency Block (Upper) and 2.6 GHz Band TDD Generic Frequency Blocks;

“700 MHz Duplex” means radio frequency spectrum in the range 703 to 733 MHz paired with radio frequency spectrum in the range 758 to 788 MHz;

“700 MHz Duplex Block” means a 5 MHz paired block of radio frequency spectrum in the 700 MHz Duplex;

“Act of 1926” means the Wireless Telegraphy Act 1926 (No. 45 of 1926);

“Act of 1972” means the Wireless Telegraphy Act, 1972 (No. 5 of 1972);

“Act of 2002” means the Communications Regulation Act 2002 (No. 20 of 2002);

“Apparatus” in relation to Licences means apparatus for wireless telegraphy as defined in section 2 of the Act of 1926 for terrestrial systems capable of providing Electronic Communications Services in one or more of the 700 MHz Duplex, 2.1 GHz Band, 2.3 GHz Band and 2.6 GHz Band;

“Authorisation Regulations” means the European Communities (Electronic Communications Networks and Services) (Authorisation) Regulations 2011 (S.I. No. 335 of 2011);

“Award” or “MBSA2” means the competitive award procedure used by the Commission for the purpose of granting individual rights of use for radio frequencies to the Liberalised Spectrum, as detailed in the Information Memorandum;

“Award Rules” means the rules and procedures relating to the Award as set out in the Information Memorandum and its annexes;

“Bidder” has the meaning set out in the Information Memorandum;

“Commission” means the Commission for Communications Regulation established under the Act of 2002;

“CPI” means the Consumer Price Index as published from time to time by the CSO;

“CPI Adjustment” means a negative or positive adjustment to a Spectrum Usage Fee, calculated using the CPI according to the methodology set out in the Information Memorandum;

“CSO” means the Central Statistics Office of Ireland or its successor;

“Decision of 2008” means European Commission Decision (2008/477/EC) of 13 June 2008 on the harmonisation of the 2500-2690 MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community;

“Decision of 2012” means European Commission Implementing Decision (2012/688/EU) of 5 November 2012 on the harmonisation of the frequency bands 1920-1980 MHz and 2110-2170 MHz for terrestrial systems capable of providing electronic communications services in the Union;

“Decision of 2014” means Electronic Communications Committee Decision (14)02 entitled "Harmonised technical and regulatory conditions for the use of the band 2300-2400 MHz for Mobile/Fixed Communications Networks (MFCN)";

“Decision of 2016” means European Commission Implementing Decision (EU) 2016/687 of 28 April 2016 on the harmonisation of the 694-790 MHz frequency band for terrestrial systems capable of providing wireless broadband electronic communications services and for flexible national use in the Union;

“Electronic Communications Network” and “Electronic Communications Service” have the meanings assigned to them in the Framework Regulations;

“Equivalent Isotropically Radiated Power” (EIRP) means the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna;

“Existing 2.3 GHz Band Licence” means a licence granted under the Wireless Telegraphy (Radio Link Licence) Regulations, 2009 (S.I. No 370 of 2009) by which rights of use for radio frequencies are assigned within the range 2307 – 2327 MHz;

“Existing 2.3 GHz Band Licensee” means a holder of an Existing 2.3 GHz Band Licence;

“FDD” means Frequency Division Duplex;

“Framework Regulations” means the European Communities (Electronic Communications Networks and Services) (Framework) Regulations 2011 (S.I. No. 333 of 2011);

“General Authorisation” means an authorisation for an undertaking to provide an Electronic Communications Network or Electronic Communications Service under and in accordance with Regulation 4 of the Authorisation Regulations;

“Harmful Interference” has the meaning set out in the Framework Regulations;

“Information Memorandum” means the document published by the Commission on [date] and bearing the Commission Document number 20/[XX] and which outlines in detail the processes and procedures the Commission will follow in running the Award, as may be updated from time to time;

“Lease” means the assignment by a Licensee (“the Lessor”) of some or all of a right of use for radio frequencies granted under a MBSA2 Liberalised Use Licence for a period less than the remaining duration of the right of use to another party (“the Lessee”), after which the right of use for radio frequencies reverts to the Lessor;

“Liberalised Spectrum” consists of:

- the 700 MHz Duplex Blocks;
- the 2.1 GHz Band Blocks;
- the 2.3 GHz Band Fixed Frequency Block (Lower);
- the 2.3 GHz Band Fixed Frequency Block (Upper);
- the 2.3 GHz Band Generic Frequency Blocks;
- the 2.6 GHz Band FDD Generic Frequency Blocks;
- the 2.6 GHz Band TDD Fixed Frequency Block (Lower);
- the 2.6 GHz Band TDD Fixed Frequency Block (Upper); and
- the 2.6 GHz Band TDD Generic Frequency Blocks.

“Licence” means a non-exclusive licence granted under section 5 of the Act of 1926 in accordance with and subject to the matters prescribed in these Regulations to keep and have possession of Apparatus in a specified place in the State, being one of:

- (a) a MBSA2 Liberalised Use Licence;
- (b) a MBSA2 Spectrum Lease Licence;
- (c) a MBSA2 Preparatory Licence; or

(d) a MBSA2 2.3 GHz Band Transition Licence.

“Licence Commencement Date” means the date, as specified in the Licence, upon which the Licence comes into effect;

“Licensee” means the holder of a Licence;

“MBSA2 2.3 GHz Band Transition Licence” means a Licence in the form set out in Schedule 4 to keep and have possession of apparatus for wireless telegraphy for the provision of Point to Multi-Point Radio Links in the 2.3 GHz Band, in accordance with and subject to the terms and conditions set out therein;

“MBSA2 2.3 GHz Band Transition Licence Price A” has the meaning set out in the Information Memorandum;

“MBSA2 2.3 GHz Band Transition Licence Price B” has the meaning set out in the Information Memorandum;

“MBSA2 Liberalised Use Licence” means a Licence in the form set out in Schedule 1 to keep and have possession of Apparatus, in accordance with and subject to the terms and conditions set out therein;

“MBSA2 Preparatory Licence” means a Licence in the form set out in Schedule 3 to keep and have possession of Apparatus, in accordance with and subject to the terms and conditions set out therein;

“MBSA2 Spectrum Lease Licence” means a Licence in the form set out in Schedule 2 to keep and have possession of Apparatus, in accordance with and subject to the terms and conditions set out therein;

“Non-exclusive”, in relation to a Licence, means that the Commission is not precluded from authorising the keeping and having possession by persons other than the Licensee, on a Non-Interference and Non-Protected Basis, of apparatus for wireless telegraphy for the radio frequency spectrum specified in the Licence;

“Non-Interference and Non-Protected Basis” means that the use of apparatus for wireless telegraphy is subject to no Harmful Interference being caused to any Radiocommunication Service, and that no claim may be made for the protection of apparatus for wireless telegraphy used on this basis against Harmful Interference originating from Radiocommunication Services;

“Point to Multi-Point Radio Link” means a Radio Link between two specified fixed points;

“Radio Equipment Regulations” means the European Union (Radio Equipment) Regulations 2017 (S.I. No. 248 of 2017);

“Radio Link” means a link by means of apparatus for wireless telegraphy;

“Radiocommunication Service” means a service as defined in the Radio Regulations of the International Telecommunication Union involving the transmission, emission or reception of radio waves for specific telecommunication purposes;

“Spectrum Access Fee” or “SAF” has the meaning set out in the Information Memorandum;

“Spectrum Usage Fee” or “SUF” means the relevant fee as detailed in Schedule 5;

“TDD” means Time Division Duplex;

“Time Slice 1” means, in relation to 2.3 GHz Band Blocks and 2.6 GHz Band Blocks, the period commencing on [1 December 2020] and ending on 11 March 2027 or on such other date or dates as may be specified by the Commission, and, in relation to 2.1 GHz Band Blocks, means the period commencing 16 October 2022 and ending on 11 March 2027 or on such other date or dates as may be specified by the Commission;

“Time Slice 2” means, in relation to 2.1 GHz Band Blocks, 2.3 GHz Band Blocks and 2.6 GHz Band Blocks, the period commencing on 12 March 2027 and ending on [30 November 2040], or on such other date or dates as may be specified by the Commission under Regulation 5 of these Regulations;

“Transfer” has the meaning set out in the Transfer Regulations;

“Transferee” has the meaning set out in the Transfer Regulations;

“Transfer Regulations” means the Wireless Telegraphy (Transfer of Spectrum Rights of Use) Regulations 2014 (S.I. No. 34 of 2014);

and

“Winning Bidder” has the meaning set out in the Information Memorandum.

(2) A word or expression that is used in these Regulations and that is also used in the Act of 1926 has, unless the context otherwise requires, the same meaning in these Regulations that it has in that Act.

(3) A word or expression that is used in these Regulations and that is also used in the Act of 2002 has, unless the context otherwise requires, the same meaning in these Regulations that it has in that Act.

(4) A word or expression that is used in these Regulations and that is also used in the Framework Regulations or in the Authorisation Regulations has, unless the context otherwise requires, the same meaning in these Regulations that it has in those Regulations.

Licences to which these Regulations apply

3. (1) These Regulations apply to:

- (a) MBSA2 Liberalised Use Licences;
- (b) MBSA2 Spectrum Lease Licences;
- (c) MBSA2 Preparatory Licences; and
- (d) MBSA2 2.3 GHz Band Transition Licences.

Application for the Grant and Form of Licences

4. (1) Application for the grant of a MBSA2 Liberalised Use Licence or MBSA2 Preparatory Licence on foot of the Award shall be made by a Winning Bidder to the Commission in writing and in such form as may be determined by the Commission from time to time.

(2) The Commission may grant a MBSA2 Liberalised Use Licence or MBSA2 Preparatory Licence on foot of the Award following payment by the applicant of the relevant fees prescribed in Regulation 8.

(3) The Commission may grant a MBSA2 Liberalised Use Licence to a Transferee in accordance with the Transfer Regulations.

(4) Application for the grant of a MBSA2 Spectrum Lease Licence shall be made by a Lessee to the Commission in writing and in such form as may be determined by the Commission from time to time. The Commission may grant a MBSA2 Spectrum Lease Licence to a Lessee following the approval of the relevant Lease by the Commission in accordance with sub-paragraphs (r) and (s) of Regulation 6.

(5) Application for the grant of a MBSA2 2.3 GHz Band Transition Licence shall be made by an Existing 2.3 GHz Band Licensee to the Commission in writing and in such form as may be determined by the Commission from time to time. The Commission may grant a MBSA2 2.3 GHz Band Transition Licence upon receipt of an application submitted in accordance with these Regulations following payment by the applicant of the relevant fees prescribed in Regulation 8.

(6) A person who applies for the grant of a Licence shall furnish to the Commission such information as the Commission may reasonably require for the purposes of its functions under these Regulations, the Framework Regulations or the Authorisation Regulations, and if the person, without reasonable cause, fails to comply with this paragraph, the Commission may refuse to grant the Licence concerned to the person.

(7) A MBSA2 Liberalised Use Licence to which these Regulations apply shall be in the form specified in Schedule 1, with such variation, if any, whether by addition, deletion or alteration as the Commission may determine from time to time or in any particular case in accordance with the Authorisation Regulations.

(8) A MBSA2 Spectrum Lease Licence to which these Regulations apply shall be in the form specified in Schedule 2, with such variation, if any, whether by addition, deletion or alteration as the Commission may determine from time to time or in any particular case in accordance with the Authorisation Regulations.

(9) A MBSA2 Preparatory Licence to which these Regulations apply shall be in the form specified in Schedule 3, with such variation, if any, whether by addition, deletion or alteration as the Commission may determine from time to time or in any particular case in accordance with the Authorisation Regulations.

(10) A MBSA2 2.3 GHz Band Transition Licence to which these Regulations apply shall be in the form specified in Schedule 4, with such variation, if any, whether by addition, deletion or alteration as the Commission may determine from time to time or in any particular case in accordance with the Authorisation Regulations.

Duration of Licences

5. (1) The commencement date of a MBSA2 Liberalised Use Licence shall be specified in the Licence and, in respect of:

- (a) 700 MHz Duplex Blocks shall be [1 December 2020] or such other date as may be specified by the Commission;
- (b) 2.1 GHz Band Blocks in Time Slice 1 shall be 16 October 2022 or such other date as may be specified by the Commission;
- (c) 2.3 GHz Band Blocks and 2.6 GHz Band Blocks in Time Slice 1 shall be [1 December 2020] or such other date as may be specified by the Commission;
- (d) 2.1 GHz Band Blocks, 2.3 GHz Band Blocks and 2.6 GHz Band Blocks in Time Slice 2 shall be 11 March 2027 or such other date as may be specified by the Commission.

(2) A MBSA2 Liberalised Use Licence, unless it has been withdrawn or had its duration reduced under Regulation 7, shall in any event expire:

- (a) in the case of 700 MHz Duplex Blocks on [30 November 2040];
- (b) in the case of 2.1 GHz Band Blocks, 2.3 GHz Band Blocks and 2.6 GHz Band Blocks in Time Slice 1 on 11 March 2027, or such other date or dates as may be specified by the Commission; and
- (c) in the case of 2.1 GHz Band Blocks, 2.3 GHz Band Blocks and 2.6 GHz Band Blocks in Time Slice 2 on [30 November 2040].

(2) The commencement date and expiry date of a MBSA2 Spectrum Lease Licence shall be set by the Commission and specified in the MBSA2 Spectrum Lease Licence. A MBSA2 Spectrum Lease Licence to which these Regulations apply shall in any event expire on or before [30 November 2040].

(3) The commencement date and expiry date of a MBSA2 Preparatory Licence shall be set by the Commission and specified in the MBSA2 Preparatory Licence.

(4) The commencement date and expiry date of a MBSA2 2.3 GHz Band Transition Licence shall be set by the Commission and specified in the MBSA2 2.3 GHz Band Transition Licence.

Conditions of Licences

6. (1) Any Licensee that is granted a Licence under these Regulations and to which these Regulations apply shall:

- (a) ensure that it complies with the conditions in its Licence and with these Regulations;
- (b) ensure that any Apparatus in the 700 MHz Duplex complies with the Decision of 2016, any Apparatus in the 2.1 GHz Band complies with the Decision of 2012, any Apparatus in the 2.3 GHz Band, except those held under a MBSA2 2.3 GHz Band Transition Licence, complies with the Decision of 2014, and that any Apparatus in the 2.6 GHz Band complies with the Decision of 2008;
- (c) ensure that all Apparatus installed, maintained, possessed or kept under the Licence is capable of operating within the radio frequency spectrum specified in the Licence;
- (d) ensure that all Apparatus worked or used under the Licence is worked or used only in the radio frequency spectrum specified in the Licence;
- (e) comply with any rules to prevent spectrum hoarding as may be laid down by the Commission under the Framework Regulations;
- (f) ensure that it makes payment of all applicable Licence fees set out in and in accordance with Regulation 8;
- (g) ensure that in advance of the Licence Commencement Date and on or before the anniversary of same for each calendar year in which the Licence concerned is in force, it submits up to date information to the Commission in respect of Parts 1, 2 and 3 of its MBSA2 Liberalised Use Licence, Parts 1, 2 and 3 of its MBSA2 Spectrum Lease Licence, and/or Parts 2 and 3 of its MBSA2 2.3 GHz Band Transition Licence, as the case may be;

- (h) furnish such information in connection with the Licence as may be requested by the Commission from time to time;
- (i) ensure that all Apparatus, or any part thereof, is installed, maintained, and where a Licence other than a MBSA2 Preparatory Licence is held, worked and used, so as not to cause Harmful Interference;
- (j) ensure that all Apparatus, or any part thereof, complies with the Radio Equipment Regulations;
- (k) comply with any special conditions imposed under section 8 of the Act of 1972;
- (l) (i) notify the Commission in writing, not less than 6 months prior to the proposed cessation of use of any terrestrial system listed in Part 2 of the MBSA2 Liberalised Use Licence or MBSA2 Spectrum Lease Licence as the case may be; and
 - (ii) use all reasonable endeavours to ensure that any adverse effects on users caused by the cessation of use of a terrestrial system are minimised;
- (m) upon becoming aware of any event likely to materially affect its ability to comply with these Regulations, or any conditions set out or referred to in any Licence, notify the Commission of that fact in writing no later than 5 Working Days upon becoming aware;
- (n) comply with all obligations under relevant international agreements relating to the use of Apparatus or the frequencies to which they are assigned under a Licence;
- (o) notify the Commission of its intention to Transfer any rights of use for radio frequencies attaching to a Licence;
- (p) only Transfer the rights of use for radio frequencies attaching to a Licence in accordance with the Transfer Regulations;
- (q) notify the Commission of its intention to Lease any rights of use for radio frequencies attaching to a Licence;
- (r) subject to paragraph (s), only Lease the rights of use for radio frequencies attaching to a Licence in accordance with such procedures as may be specified by the Commission from time to time under Regulation 19 of the Framework Regulations;
- (s) where the Commission has not yet put in place procedures referred to in paragraph (r) of this Regulation, not, without the prior consent of the Com-

mission, which shall not be unreasonably withheld, Lease any such rights of use attaching to a Licence; and

- (t) ensure that if the address of the Licensee or its Transferee or Lessee changes, the Licensee, Transferee or Lessee shall, as soon as possible, but in any event within 28 days, notify the Commission in writing of the change.

Enforcement, Amendment, Withdrawal and Suspension

7. (1) Enforcement by the Commission of compliance by a Licensee with conditions attached to its Licence shall be in accordance with the Authorisation Regulations.

(2) The Commission may amend any Licence from time to time in accordance with the Authorisation Regulations.

(3) A Licence may be suspended or withdrawn by the Commission in accordance with the Authorisation Regulations.

(4) A Licence may be suspended or withdrawn by the Commission if, after the grant of a Licence pursuant to these Regulations, it emerges that the Licensee has breached the Award Rules.

Licence Fees

8. (1) The fee for a MBSA2 Liberalised Use Licence granted on foot of the Award is the sum of the Spectrum Access Fee and the Spectrum Usage Fees over the duration of the Licence, less any adjustments or refunds applicable to the Licensee as identified in the Information Memorandum.

(2) Where the commencement date of a MBSA2 Liberalised Use Licence is delayed due to circumstances identified in the Information Memorandum, a Licensee shall be entitled to an adjustment of the licence fees payable or a refund of licence fees already paid, as provided for in the Information Memorandum.

(3) The SAF specified in paragraph 1 of this Regulation shall be paid to the Commission on a date specified by the Commission in accordance with the Information Memorandum.

(4) The annual SUF before CPI Adjustment for each block of Liberalised Spectrum is detailed in Schedule 5.

(5) The annual SUF for a MBSA2 Liberalised Use Licence is the sum of the annual SUFs before CPI Adjustment associated with each block of Liberalised Spectrum identified in the Licence and the CPI Adjustment for each block of Liberalised Spectrum identified in the Licence.

(6) In the case of a SUF for a period of less than one year, the SUF shall be the relevant sum as detailed in paragraph 5 adjusted on a *pro rata* daily basis for such period.

(7) The SUF specified in this Regulation, less any adjustments or refunds applicable to the Licensee, shall be paid to the Commission prior to the grant of a MBSA2 Liberalised Use Licence or prior to [1 December] of each respective calendar year during the term of the MBSA2 Liberalised Use Licence, as the case may be.

(8) If a MBSA2 Liberalised Use Licence is suspended or withdrawn, the Licensee shall not be entitled to be repaid any part of the SAF or SUF paid by the Licensee under this Regulation, but shall still be liable to pay any sums, including interest, that are outstanding.

(9) If the amount of radio frequency spectrum specified in a MBSA2 Liberalised Use Licence is reduced, the Licensee may be entitled to a refund of the relevant SUF already paid in the relevant year and to a reduction on future SUF's, on a *pro rata* basis having regard to the nature of the amendment. The Licensee shall not be entitled to any refund of its SAF.

(10) If the duration of a MBSA2 Liberalised Use Licence is reduced at the request of the Licensee, the Licensee may be entitled to a refund of SUF's already paid in the relevant year, on a *pro rata* basis having regard to the reduced duration. The Licensee shall not be entitled to any refund of its SAF.

(11) The fee for a MBSA2 Spectrum Lease Licence shall be specified by the Commission in accordance with such procedures as may be specified by the Commission from time to time under Regulation 19 of the Framework Regulations.

(12) The fee for a MBSA2 Preparatory Licence is €100.

(13) The annual fee for a MBSA2 2.3 GHz Band Transition Licence is detailed in Schedule 6.

(14) In the case of an annual fee for a MBSA2 2.3 GHz Band Transition Licence for a period of less than one year, the annual fee shall be the relevant sum as detailed in Schedule 6 adjusted on a *pro rata* daily basis for such period.

(15) The SUF's for a MBSA2 Liberalised Use Licence granted on foot of a Transfer are the SUF's specified in paragraphs 5 and 6 of this Regulation.

(16) Any payment to be paid by a Licensee under this Regulation shall be made by way of banker's draft or such other means and on such other terms, if any, as the Commission may decide. Where the date of payment falls on a day other than a Working Day, payment shall be made on or before the last Working Day before the date on which payment would otherwise have fallen due.

(17) Failure by a Licensee to pay part or all of a fee required under this Regulation on or before the date it falls due shall constitute non-compliance by the Licensee

concerned with these Regulations and the Commission, in respect of such non-payment of a fee, may take enforcement action in accordance with Regulation 7 and may take steps to recover the amount due in accordance with paragraphs 18 and 19 of this Regulation.

(18) Where a fee or part of a fee is not paid in time, the Licensee concerned shall pay to the Commission interest on the fee or part thereof that was or is outstanding. Interest shall accrue from the date when such fee or part thereof fell due until the date of payment of such fee or part thereof and shall be calculated at the same rate payable in respect of late payments in commercial transactions pursuant to the European Communities (Late Payment in Commercial Transactions) Regulations 2012, as amended (S.I. No. 580 of 2012).

(19) Any fee payable and owed by a Licensee under this Regulation may be recovered by the Commission from the Licensee as a simple contract debt in any court of competent jurisdiction.

Licensee to satisfy all legal requirements

9. (1) Licences granted pursuant to these Regulations do not grant to the Licensee any right, interest or entitlement other than to keep, have possession of, install, and maintain, and for Licences other than a MBSA2 Preparatory Licence, to work and use Apparatus, and for a MBSA2 2.3 GHz Band Transition Licence Apparatus for the provision of Point to Multi-Point Radio Links in the 2.3 GHz Band only, at a specified location or locations in the State.

SCHEDULE 1**WIRELESS TELEGRAPHY ACT, 1926****WIRELESS TELEGRAPHY (LIBERALISED USE AND RELATED LICENCES IN THE 700 MHZ DUPLEX, 2.1 GHZ, 2.3 GHZ AND 2.6 GHZ BANDS) REGULATIONS 2020****MBSA2 Liberalised Use Licence for terrestrial systems capable of providing Electronic Communications Services**

Licence under section 5 of the Act of 1926 to keep and have possession of apparatus for wireless telegraphy for terrestrial systems capable of providing Electronic Communications Services.

The Commission for Communications Regulation, in exercise of the powers conferred on it by section 5 of the Act of 1926 hereby grants the following licence to **[LICENSEE NAME]** of **[LICENSEE ADDRESS]** ("the Licensee").

The Licensee is hereby authorised to keep and have possession of apparatus for wireless telegraphy for terrestrial systems capable of providing Electronic Communications Services as specified in Part 2 of this Licence, subject to such apparatus being installed, maintained, worked and used in accordance with the terms, conditions and restrictions set out in the Wireless Telegraphy (Liberalised Use and Related Licences in the 700 MHz Duplex, 2.1 GHz, 2.3 GHz and 2.6 GHz Bands) Regulations 2020 (S.I. No. of 2020) ("the Regulations"), including but not limited to, the following:

- (1) The Licensee shall ensure that it complies with all of the conditions contained within the Regulations and within Parts 1 to 4 of this Licence; and
- (2) The Licensee shall ensure that it makes payment of all fees as detailed in the Regulations.

For the purpose of this Licence, the definitions set out in the Wireless Telegraphy (Liberalised Use and Related Licences in the 700 MHz Duplex, 2.1 GHz, 2.3 GHz and 2.6 GHz Bands) Regulations 2020 apply.

This Licence shall come in to effect on **DD/MM/YYYY** (the "Licence Commencement Date") and, subject to revocation, suspension or withdrawal, expires on **DD/MM/YYYY**.

Signed: _____

For and on behalf of the Commission for Communications Regulation

Date of Issue: _____

Part 1

Commencement and expiry dates of Liberalised Spectrum

Authorised Band	Name of Spectrum Block	Frequency Assigned to Spectrum Block	Commencement Date per Spectrum Block	Expiry Date per Spectrum Block
700 MHz Duplex, 2.1 GHz, 2.3 GHz, 2.6 GHz as appropriate	[One or more Blocks of Liberalised Spectrum]	From ——— MHz to ——— MHz	DD Month YYYY	DD Month YYYY

Part 2

The Apparatus to which this Licence applies

Authorised Band	Equipment Index Reference	Terrestrial System	Equipment Description	Manufacturer	Model
700 MHz Duplex, 2.1 GHz, 2.3 GHz, 2.6 GHz as appropriate					

Part 3

Apparatus Location and Details

Authorised Band	Site Identity	Eastings	Northings	Equipment Index Reference	Maximum EIRP
700 MHz Duplex, 2.1 GHz, 2.3 GHz, 2.6 GHz as appropriate					

Part 4

Licence Conditions

Section 1: General

1. Provision of Maps and Data

For the purposes of complying with rollout obligations (see Section 5) and quality of service obligations (see Section 6) compliance assessments, the Licensee shall, on request, provide to the Commission the following:

- (1) Maps showing rollout as required under Section 5;
- (2) An up-to-date list of the locations of Base Stations including the Rollout Base Stations covered by the Licence; and
- (3) An adequate number of Terminal Stations, Subscriber Identity Modules (SIM) cards or equivalents for testing as applicable.

2. Harmful Interference

- (1) In the event of Harmful Interference, the affected Licensees shall exchange information with a view to resolving the Harmful Interference by mutual consent. Where resolution cannot be agreed between the affected Licensees, ComReg may mediate in accordance with its statutory functions, objectives and duties.

Section 2: Technical Conditions

1. Definitions

The following additional definitions shall apply to this section:

“Aeronautical Primary Radars” means Apparatus (including “Star2000” and “TA10” models) providing primary aircraft detection used in airport surveillance networks;

“Base Station” means Apparatus connected to a backhaul network, which provides a Radiocommunication Service to Terminal Stations using the Liberalised Spectrum;

“Block Edge Mask” or “BEM” is an emission mask that is defined as a function of frequency in relation to a ‘block edge’, the latter being the frequency boundary of a spectrum block for which rights of use are assigned to a Licensee. The BEM consists of several elements which are defined for certain measurement bandwidths.

“dBm” means decibels of power referenced to one milliwatt;

“Downlink” means transmissions from a Base Station to a Terminal Station;

“Indoor Small Cell” means a Base Station with an EIRP of less than or equal to 24 dBm per 20 MHz carrier that is located indoors either within a residential or non-residential property;

“Inter-Licensee Synchronisation Procedure” means the synchronisation procedure set out in Section 3 of this Licence;

“Power Flux Density limit” or pfd limit (dBW/m²) means the interference threshold at radar receiver input (measured in dBW) minus the radar antenna gain (measured in dBi) plus $10 \log (4\pi / \lambda^2)$, where λ is the wavelength in metres;

“RurTel” means the point-to-multipoint system used to provide fixed telephony services in areas of counties Galway and Donegal;

“TD-LTE” means the TDD variant of LTE (Long Term Evolution) technology;

“Terminal Station” means mobile user equipment and fixed customer premise equipment which communicate with a Base Station using the Liberalised Spectrum; and

“Uplink” means transmissions from a Terminal Station to a Base Station.

2. Technical Conditions

(1) 700 MHz Duplex

- (a) Only terrestrial systems compatible with the Decision of 2016 (as amended) can be worked and used in the 700 MHz Duplex.
- (b) The FDD mode of operation shall be used in the 700 MHz Duplex. The duplex spacing shall be 55 MHz with Terminal Station transmission (FDD uplink) located in the lower frequency band 703-733 MHz and Base Station transmission (FDD downlink) located in the upper frequency band 758-788 MHz.
- (c) The Licensee shall comply with planning arrangements agreed in all Memoranda of Understanding (‘MoU’)¹ between the Commission and its neighbouring national regulatory authorities responsible for communications matters, in particular the Office of Communications (‘Ofcom’) in the UK, or its successor, in relation to the 700 MHz Duplex.

Base Stations

¹ [Memorandum of Understanding](#) on frequency coordination between Ireland and the United Kingdom concerning the spectrum coordination of Land Mobile Radio Communication Networks in the frequency range 703 MHz to 2690 MHz, available at www.comreg.ie

- (d) Within a 700 MHz Duplex Block assigned to the Licensee, the in-block power from a Base Station must not exceed a maximum mean EIRP of 64 dBm/5 MHz per antenna.
- (e) Outside of the 700 MHz Duplex Block(s) assigned to the Licensee, the Licensee shall comply with the out-of-block BEM as specified in Section B "*Technical conditions for base stations for terrestrial systems capable of providing electronic communications services within the 738-788 MHz frequency band*" of the Annex of the Decision of 2016.

Terminal Stations

- (f) The maximum mean in-block power limit of 23 dBm for Terminal Stations shall apply².
- (g) The technical conditions set out in Section C. "*Technical conditions for terminal stations for electronic communications services within the 703-733 MHz frequency band*" of the Annex to the Decision of 2016 shall apply to out-of-block Terminal Stations.
- (h) Where a Licensee is assigned more than two 700 MHz Duplex Blocks and if this assignment is deployed starting at 703 MHz, the Licensee shall ensure that the terminal station bandwidth is no greater than 10 MHz in order to meet the conditions as set out in Table 12 of the Annex to the Decision of 2016 to provide protection to the frequency range 470 - 694 MHz.

(2) The 2.1 GHz Band

- (a) Only terrestrial systems compatible with the Decision of 2012 (as amended) can be worked and used in the 2.1 GHz Band.
- (b) The duplex mode of operation shall be FDD. The duplex spacing shall be 190 MHz with terminal station transmission (FDD uplink) located in the lower part of the band starting at 1920 MHz and finishing at 1980 MHz and base station transmission (FDD downlink) located in the upper part of the band starting at 2110 MHz and finishing at 2170 MHz.

² This power limit is specified as EIRP for terminal stations designed to be fixed or installed and as total radiated power (TRP) for terminal stations designed to be mobile or nomadic. This value is subject to a tolerance of up to + 2 dB, to take account of operation under extreme environmental conditions and production spread.

- (c) The Licensee shall comply with planning arrangements agreed in all MoU³ between the Commission and its neighbouring national regulatory authorities responsible for communications matters, in particular Ofcom in the UK, or its successor, in relation to the 2.1 GHz Band.

Base Stations

- (d) Within a 2.1 GHz Band Block assigned to the Licensee, the in-block radiated power from a Base Station transmitter in the downlink direction must not exceed an in-block EIRP power of 64 dBm/5 MHz per antenna.
- (e) Outside of the 2.1 GHz Band Block(s) assigned to the Licensee, the Licensee shall comply with the out-of-block BEM as specified in Section B. “*Technical conditions for FDD base stations*” of the Annex to the Decision of 2012.

Terminal Stations

- (f) The maximum mean in-block power limit over frequencies of FDD uplink of 24 dBm⁴ per 5 MHz for Terminal Stations shall apply⁵.

(3) The 2.3 GHz Band

- (a) Only terrestrial systems compatible with the Decision of 2014 (as amended) can be worked and used in the 2.3 GHz Band.
- (b) The Time Division Duplex (TDD) mode of operation shall be used in the 2.3 GHz Band.
- (c) The Licensee shall comply with the Inter-Licensee Synchronisation Procedure set out in Section 3 of this Licence.

³ [Memorandum of Understanding](#) on frequency coordination between Ireland and the United Kingdom concerning the spectrum coordination of Land Mobile Radio Communication Networks in the frequency range 703 MHz to 2690 MHz, available at www.comreg.ie

⁴ For the determination of out of band emissions of terminals in CEPT Report 39 the maximum conducted transmit power of 23 dBm has been used as a reference.

⁵ This power limit is specified as EIRP for terminal stations designed to be fixed or installed and as TRP for terminal stations designed to be mobile or nomadic. EIRP and TRP are equivalent for isotropic antennas. It is recognised that this value may be subject to a tolerance defined in the harmonised standards to take account of operation under extreme environmental conditions and production spread.

- (d) The Licensee shall comply with planning arrangements agreed in all MoU⁶ between the Commission and its neighbouring national regulatory authorities responsible for communications matters, in particular Ofcom in the UK, or its successor, in relation to the 2.3 GHz Band.
- (e) If the Licence includes the 2.3 GHz Band Fixed Frequency Block (Lower), the Licensee shall coordinate with the operator of the RurTel system to ensure coexistence with the RurTel system currently operating in the frequency range 2307-2327 MHz⁷.

Base Stations

- (f) Within the 2.3 GHz Band Fixed Frequency Block (Lower), if assigned to the Licensee, and any 2.3 GHz Band Generic Frequency Blocks assigned to the Licensee, the in-block radiated power from a Base Station must not exceed 68 dBm/5 MHz EIRP per antenna.
- (g) Within the 2.3 GHz Band Fixed Frequency Block (Upper), if assigned to the Licensee, the in-block radiated power from a Base Station must not exceed 45 dBm/5 MHz EIRP.
- (h) Outside of the 2.3 GHz Band Fixed Frequency Block (Lower), 2.3 GHz Band Generic Frequency Block(s) and 2.3 GHz Band Fixed Frequency Block (Upper) assigned to the Licensee, the Licensee shall comply with the out-of-block BEM requirements as specified in Section A2.1 “*Technical Conditions for MFCN Base Stations*” of Annex 2 to the Decision of 2014.

Terminal Stations

- (i) The maximum mean in-block power limit of 25 dBm⁸ for Terminal Stations shall apply.

(4) The 2.6 GHz Band

⁶ [Memorandum of Understanding](#) on frequency coordination between Ireland and the United Kingdom in the frequency bands 2300 -2400 MHz to be applied in the area including the Republic of Ireland and the United Kingdom and the Isle of Man, available at www.comreg.ie

⁷ Coordination areas in the regions of Galway and Donegal are detailed in Plum Report, Document 19/124c.

⁸ This power limit is specified as EIRP for terminal stations designed to be fixed or installed and as total radiated power (TRP) for terminal stations designed to be mobile or nomadic. A tolerance of up to + 2 dB has been included in this limit, to reflect operation under extreme environmental conditions and production spread.

- a) Only terrestrial systems compatible with the Decision of 2008 (as amended) can be worked and used in the 2.6 GHz Band.
- b) Within the 2.6 GHz Band FDD Generic Frequency Blocks, the duplex mode of operation is FDD, where the duplex spacing shall be 120 MHz with terminal station transmission (uplink) located in the lower part of the band starting at 2500 MHz (extending to 2570 MHz) and base station transmission (downlink) located in the upper part of the band starting at 2620 MHz.
- c) Within the 2570-2620 MHz frequency range of the 2.6 GHz Band, the duplex mode of operation is TDD.
- d) Licensees assigned 2.6 GHz Band TDD Blocks shall comply with the Inter-Licensee Synchronisation Procedure set out in Section 3 of this Licence.
- e) The Licensee shall comply with planning arrangements agreed in all MoU⁹ between the Commission and its neighbouring national regulatory authorities responsible for communications matters, in particular Ofcom in the UK, or its successor, in relation to the 2.6 GHz Band.

Base Stations

- f) Within any 2.6 GHz Band FDD Generic Frequency Blocks and any 2.6 GHz Band TDD Generic Frequency Blocks assigned to the Licensee, the in-block radiated power from a Base Station transmitter in the downlink direction must not exceed a mean in-block power of 61 dBm/5 MHz per antenna.
- g) Within the 2.6 GHz Band TDD Fixed Frequency Block (Lower) and the 2.6 GHz Band TDD Fixed Frequency Block (Upper), if either are assigned to a Licensee, the in-block radiated power from a Base Station transmitter in the downlink direction must not exceed a mean in-block power of 25 dBm/5 MHz per antenna.
- h) Outside of any 2.6 GHz Band FDD Generic Frequency Blocks and any 2.6 GHz Band TDD Generic Frequency Blocks assigned to the Licensee, the Licensee shall comply with the unrestricted out-of-block EIRP BEM as specified in Section B: "Unrestricted BEM for Base Stations" of the Annex of the Decision of 2008.

⁹ [Memorandum of Understanding](#) on frequency coordination between Ireland and the United Kingdom concerning the spectrum coordination of Land Mobile Radio Communication Networks in the frequency range 703 MHz to 2690 MHz, available at www.comreg.ie

- i) Outside of the 2.6 GHz Band TDD Fixed Frequency Block (Lower) and the 2.6 GHz Band TDD Fixed Frequency Block (Upper) assigned to the Licensee, the Licensee shall comply with the restricted EIRP BEM as specified in Section C: “Restricted BEM for Base Stations”, of the Annex of the Decision of 2008.
- j) Licensees with the 2.6 GHz TDD Fixed Frequency Block (Lower) and/or the 2.6 GHz TDD Band Fixed Frequency Block (Upper) acknowledge and accept that usage of these blocks may be subject to a greater risk of interference from adjacent blocks.
- k) For all 2.6 GHz Band Blocks and in cases where antennas are placed indoors, alternative parameters in line with Section D, “Restricted BEM for Base Stations with Restrictions on Antenna Placement” of the Annex of the Decision of 2008 shall be implemented.
- l) A Licensee assigned any 2.6 GHz Band Blocks must ensure protection of all Aeronautical Primary Radars as follows:
 - i. Observe a coordination zone of one kilometre radius around the Aeronautical Primary Radar to provide additional protection from MFCN base station emissions at the Aeronautical Primary Radar receiver;
 - ii. in relation to Star2000 Aeronautical Primary Radars, the Licensee shall:
 - A. comply with an out-of-band Power Flux Density limit (pfd) limit given¹⁰ by $-140 \text{ dBW/m}^2/\text{MHz} + (10 \times \text{Log}_{10} (B_{\text{op}}/120))$, where B_{op} is the quantum of downlink (i.e. FDD downlink and TDD) spectrum in MHz assigned to the Licensee in the 2.6 GHz Band, to address the impact of MFCN spurious emissions at the radar antenna receiver location; and
 - B. until notified by the Commission in writing that filters are installed at the Aeronautical Primary Radar, comply with an in-band pfd limit, given¹¹ by $-78 \text{ dBW/m}^2 + (10 \times \text{Log}_{10} (B_{\text{op}}/120))$, where B_{op} is the quantum of downlink (i.e. FDD downlink and TDD) spectrum in MHz assigned to the Licensee in the 2.6 GHz

¹⁰ Where $-140 \text{ dBW/m}^2/\text{MHz}$ is the absolute limit required to protect the Star2000 Aeronautical Primary Radar installations from emissions by all operators for out-of-band (i.e. $>2700 \text{ MHz}$) power.

¹¹ Where -78 dBW/m^2 is the absolute limit required to protect the Star2000 Aeronautical Primary Radar installation from emissions by all operators for in-band (i.e. $2570 - 2690 \text{ MHz}$) power.

Band, to address the impact of blocking and intermodulation effects at the Aeronautical Primary Radar receiver.

- iii. in relation to the TA10 Aeronautical Primary Radar, the Licensee shall, until otherwise notified by the Commission in writing:
 - A. comply with an out-of-band pfd limit given¹² by $-151 \text{ dBW/m}^2/\text{MHz} + (10 \times \text{Log}_{10} (B_{\text{op}}/120))$, where B_{op} is the quantum of downlink (i.e. FDD downlink and TDD) spectrum in MHz assigned to the Licensee in the 2.6 GHz Band, to address the impact of MFCN spurious emissions at the Aeronautical Primary Radar antenna receiver location; and
 - B. comply with an in-band pfd limit given¹³ by $-88 \text{ dBW/m}^2 + (10 \times \text{Log}_{10} (B_{\text{op}}/120))$, where B_{op} is the quantum of downlink (i.e. FDD downlink and TDD) spectrum in MHz assigned to the Licensee in the 2.6 GHz Band, to address the impact of blocking and intermodulation effects at the Aeronautical Primary Radar antenna receiver.
- iv. In relation to other models of Aeronautical Primary Radars other than the Star2000 and TA10, the Licensee shall comply with conditions as may be determined by ComReg.

Terminal Stations

- m) The maximum mean in-block power (including Automatic Transmitter Power Control range) of 31 dBm/5 MHz TRP, and 35 dBm/5 MHz EIRP, shall apply to Terminal Stations¹⁴.

Section 3: Inter-Licensee Synchronisation Procedure

This Section 3 applies only to Licensees assigned 2.3 GHz Band Blocks and/or 2.6 GHz Band TDD Blocks.

¹² Where $-151 \text{ dBW/m}^2/\text{MHz}$ is the absolute limit required to protect the TA10 Aeronautical Primary Radar installation from emissions by all operators for out-of-band (i.e. $>2700 \text{ MHz}$) power.

¹³ Where -88 dBW/m^2 is the absolute limit required to protect the TA10 Aeronautical Primary Radar installation from emissions by all operators for in-band (i.e. $2570 - 2690 \text{ MHz}$) power.

¹⁴ EIRP should be used for fixed or installed terminal stations and the TRP should be used for the mobile or nomadic terminal stations. TRP is a measure of how much power the antenna actually radiates. The TRP is defined as the integral of the power transmitted in different directions over the entire radiation sphere.

1. Definitions

The following additional definitions shall apply in this section:

“Default Frame Structure” means the frame structure as detailed in Figure 1 below;

“Other Frame Structure” means a frame structure other than the Default Frame Structure;

“Restricted BEM” means, for Licensees utilising the Other Frame Structure (or failing to synchronise with adjacent channel networks for any other reason):

- a) for 2.6 GHz Band TDD Blocks, the Annex of the Decision of 2008, “*C. Restricted BEM for Base Stations*” and “*B. Unrestricted BEM for Base Stations*” applies¹⁵; and
- b) for 2.3 GHz Band Blocks, section “*A2.1.1 In-block requirements for MFCN base stations*” and Table 2 and Table 4 (relating to unsynchronised TDD blocks) of Annex 2 to the Decision of 2014 apply;

“Unrestricted BEM” means, for Licensees utilising the Default Frame Structure on their network (and having a common reference phase clock with adjacent channel operators¹⁶):

- a) for 2.6 GHz Band TDD Blocks, the Annex of the Decision of 2008, “*B. Unrestricted BEM for Base Stations*” applies; and
- b) for 2.3 GHz Band Blocks, Table 2 and Table 4 of Annex 2 of the Decision of 2014 relating to synchronised TDD blocks apply.

2. Introduction

(1) Licensees assigned 2.3 GHz Band Blocks and/or 2.6 GHz Band TDD Blocks shall be bound by the inter-Licensee synchronisation procedure set out in this Section 3.

¹⁵ It is important to note that, in order to meet the restricted mask, operators would likely have to adopt guard bands within their assignment.

¹⁶ Each operator needs to ensure the start of frame is aligned with adjacent channel operators above and below its assignment

- (2) Licensees shall co-operate in such a way that one network deployment within the Liberalised Spectrum does not cause Harmful Interference to another Licensee within the Liberalised Spectrum.
- (3) This procedure sets out the circumstances in which Licensees may use the Unrestricted BEM and the Restricted BEM, so as to minimise the risk of Harmful Interference to other Licensees.

3. Conditions for using the Unrestricted BEM

- (1) Default Frame Structure - The technical conditions for Unrestricted BEM shall apply where a Licensee's Base Station complies with the Default Frame Structure outlined below:
- (a) Transmissions from a Licensee's Base Station(s) shall have a frame structure as shown in Table 1. Indicated timeslots (or subframes) must not be allocated to anything other than Downlink (D) and Uplink (U) transmissions. 'S' denotes a special subframe. TD-LTE frame configuration 2 (Downlink: Uplink, 3:1) with special subframe configuration 6 or equivalent frame structures whose transmit and receive periods are aligned with this configuration are permitted;
- (b) Timeslots shall have a duration of 1 millisecond; and
- (c) Licensees shall ensure that frames start at a common reference time (+/- 1.5 μ s) so that all Licensees' frames are aligned and transmissions synchronised.

Table 1: Default Frame Structure

DL/UL ratio	Timeslot or Subframe number									
	0	1	2	3	4	5	6	7	8	9
3:1	D	S	U	D	D	D	S	U	D	D

4. Conditions for using the Restricted BEM

- (1) Other Frame Structure — the technical conditions for Restricted BEM shall apply where a Licensee's Base Station complies with the Other Frame Structure as outlined below:
- (a) All frame configurations that are not compatible with TD-LTE frame configuration 2 (3:1) with special sub-frame configuration 6 or equivalent

frame structure whose transmit and receive periods are aligned with this configuration are permitted;

- (b) Licensees shall co-operate to minimise Harmful Interference caused by sub-frame overlaps if different technologies are used; and
- (c) Licensees using the Restricted BEM shall not cause Harmful Interference to those Licensees' networks that use the Default Frame Structure (or equivalent). Achieving this may include applying internal guard bands and/or reduced in block power levels in blocks adjacent to those Licensees' networks that use the Default Frame Structure (or equivalent).

5. Indoor Small Cells

- (1) Indoor Small Cells with an EIRP not exceeding 24 dBm for indoor domestic and other indoor locations are exempted from synchronisation restrictions. The Permissive BEM set out in this Section applies to such Indoor Small Cells on the condition that they do not cause Harmful Interference to any other Licensees.

Section 4: Coverage Requirements

1. Definitions

The following additional definition shall apply in this section:

“Existing MNO” means a Licensee that on 1 January 2020 was a holder of one or more of the following licences:

- a licence under the Wireless Telegraphy (Liberalised Use and Preparatory Licences in the 800 MHz, 900 MHz and 1800 MHz bands) Regulations 2012 (S.I. No. 251 of 2012); and/or
- a licence under the Wireless Telegraphy (Third Generation and GSM Mobile Telephony Licence) (Amendment) Regulations, 2002 (S.I. No. 345 of 2002), as amended;

“New Entrant” means a Licensee that is not an Existing MNO; and

“RSRP” means Reference Signal Received Power which is defined as the linear average of the reference signal power (in Watts) within a number of specific resource elements across a specified bandwidth within an LTE downlink signal.

LTE specific equipment is required to decode the LTE downlink signal to make this measurement.

2. Minimum Coverage Requirement

(1) A Licensee that is an Existing MNO and is assigned one or more 700 MHz Duplex Blocks under this Licence shall achieve and maintain:

- the minimum outdoor coverage levels as set out in Table 2 below; and
- the minimum outdoor coverage levels at specific locations as set out in Table 3 below.

Table 2: Outdoor coverage obligations for an Existing MNO

Quantum of spectrum assigned to the Licensee in the 700 MHz Duplex under this Licence	Outdoor Coverage Service (Single User Throughput Cell Edge)	Coverage dimension	Coverage level to be met in ¹⁷ :		
			3 Years	5 Years	7 Years
At least 2 x 10 MHz	30 Mbit/s	Population	85%	92%	95%
	30 Mbit/s	Motorways	75%	85%	90%
	30 Mbit/s	Primary Roads	60%	75%	80%
	3 Mbit/s	Population	99%	99%	99%
	3 Mbit/s	Geographic area	90%	91%	92%
Only 2 x 5 MHz	20 Mbit/s	Population	85%	92%	95%
	20 Mbit/s	Motorways	75%	85%	90%
	20 Mbit/s	Primary Roads	60%	75%	80%
	3 Mbit/s	Population	99%	99%	99%
	3 Mbit/s	Geographic area	90%	91%	92%

¹⁷ From the commencement date of the 700 MHz Duplex Block(s).

Table 3: Outdoor coverage obligations at specific locations for an Existing MNO

Coverage	Location	Obligation
<p>Outdoors:</p> <p><u>Case 1</u></p> <p>Where the Licensee is assigned at least 2 x 10 MHz in the 700 MHz Duplex Band under this Licence:</p> <p>30 Mbit/s (Single User Throughput Cell Edge)</p> <p><u>Case 2</u></p> <p>Where the Licensee is assigned only 2 x 5 MHz in the 700 MHz Duplex Band under this Licence:</p> <p>20 Mbit/s (Single User Throughput Cell Edge)</p>	<p>Specific locations as particularised in the Information Memorandum which include</p> <ul style="list-style-type: none"> • Business and technology Parks: Located at and adjacent to the Industrial Development Authorities (IDA) 31 business and technology Parks and 9 Strategic Sites; • Hospitals: the Health Service Executive (HSE) identifies a list of the 48 public and 17 private hospitals; • Higher Education Campuses: The Higher Education Authority (HEA) identifies a list of 8 Universities, 11 Institutes of Technology and 5 other colleges; • Air and Sea Ports: the Department of Transport Tourism and Sport (DTTAS) identifies a list of the 7 main airports and the Irish Maritime Development Office (IMDO) identify a list of the 7 passenger sea ports; • Train and bus stations: the National Transport Authority (NTA) identifies the busiest 144 train stations and Bus Éireann identifies a list of the main 16 bus stations; and • Top visitor attraction information points: Fáilte Ireland identifies a list of the top 21 fee charging and 21 free entry visitor attractions. 	<p>For each category</p> <p>70 % in 3 years</p> <p>90 % in 5 years</p> <p>100 % in 7 years</p>

(2) A Licensee that is a New Entrant and is assigned one or more 700 MHz Duplex Blocks under this Licence shall achieve and maintain the minimum outdoor coverage levels as set out in Table 4 below.

Table 4: Outdoor Coverage Obligations for New Entrants

Quantum of spectrum assigned to the Licensee under this Licence	Outdoor Coverage Service (Single User Throughput Cell Edge)	Coverage dimension	Coverage level to be met in ¹⁸ :		
			4 Years	6 Years	10 years
At least 2 x 10 MHz in the 700 MHz Duplex and 2 x 20 MHz ¹⁹ across any of the 2.1 GHz, 2.3 GHz or 2.6 GHz Bands	30 Mbit/s	Population	75%	80%	90%
Only 2 x 10 MHz or 2 x 5 MHz in the 700 MHz Duplex Band	20 Mbit/s	Population	75%	80%	90%

(3) If the Licensee provides a mobile voice and/or text service using rights of use in any of the 700 MHz Duplex, 2.1 GHz, 2.3 GHz or 2.6 GHz Bands under this Licence, the Licensee shall:

- use (i.e. deploy and maintain) Native Wi-Fi technology on its network in respect of rights of use to the Liberalised Spectrum within 2 years of the Licence commencement date; and
- shall make available Native Wi-Fi voice and/or text services (as appropriate to the type of mobile service/s provided by the Licensee) to all end users on its network (including the end users of third party customers²⁰), where those end users:
 - have established for themselves a suitable Wi-Fi connection; and
 - have a Native Wi-Fi / Wi-Fi calling-enabled mobile device.

3. Measuring and Monitoring Outdoor Coverage Compliance

¹⁸ From the commencement date of the 700 MHz Duplex Block(s)

¹⁹ Or equivalent: i.e. 40 MHz of TDD spectrum.

²⁰ E.g. MVNOs

(1) For the purpose of determining compliance with the above outdoor coverage obligations, the Commission will measure and monitor the outdoor coverage obligations based on the following principles:

- the Commission's network planning tools, supported by field measurements or other tests as appropriate will be the key component in assessing compliance with the coverage obligations;
- all rights of use available to the Licensee can be used to contribute to meeting the coverage obligations;
- while acknowledging that newer technologies will be rolled out over time, LTE technology is expected to continue to be used by operators in delivering data to consumers for some time and in this regard the Commission will use a RSRP metric for determining the coverage levels;
- the obligations are set to incentivise Licensees to rollout new sites as appropriate, upgrade sites with additional spectrum and make use of improvements in technology such as new standards including carrier aggregation and carrier sharing or extension techniques;
- depending how the above techniques are deployed on a network, this will yield varying benefits in terms of increasing the range of a cell for a given throughput;
- where carrier aggregation is deployed using carriers with similar propagation characteristics the additional bandwidth and resultant throughput gains will be available, to a large extent, for the whole of the cell range;
- where frequency bands with different propagation characteristics are carrier aggregated, the throughput enhancements will be considered over the range of the highest of the frequency bands;
- a RSRP base level of -95 dBm will be used as a proxy for a 30 Mbit/s SUTP²¹ level for a 10 MHz downlink carrier. Where capacity increasing techniques are used such as carrier aggregation and or deploying additional bandwidth, a lower RSRP value can be used;
 - where two or three band carrier aggregation is deployed across bands with similar propagation characteristics (e.g. 700 MHz Duplex Band,

²¹ ComReg notes that for the purpose of assessing compliance with the obligation where an Existing MNO was to obtain 2 x 5 MHz in the 700 MHz Duplex Band (i.e. where the obligation is to provide 20Mbit/s SUTP), ComReg will deploy the same methodology for the 30 Mbit/s case, (i.e. assume a 2 x 10 MHz carrier is deployed).

800 MHz Band and 900 MHz Band carriers) an RSRP level of -100 dBm and -105 dBm will apply respectively;

- a RSRP base level of -110 dBm will be used as a proxy for a 3 Mbit/s SUTP level for a 10 MHz downlink carrier. Where capacity increasing techniques are used such as carrier aggregation and or deploying additional bandwidth, a lower RSRP value can be used;
 - where two or three band carrier aggregation is deployed across bands with similar propagation characteristics (e.g. 700 MHz Duplex Band, 800 MHz Band and 900 MHz Band carriers) an RSRP level of -112 dBm and -114 dBm will apply respectively;
- noting that there may be many different potential combinations of spectrum and deployment techniques that could be used by a New Entrant, the Commission will apply the same principles as identified above in determining the appropriate approach to measuring and monitoring the coverage obligations; and
- as new technologies or coverage enhancing techniques are rolled out, the Commission will consider proposals from licensees as to how this could influence meeting the coverage obligations.

4. Reporting of Compliance

- (1) Where the Licensee holds rights of use in the 700 MHz Duplex under this Licence, the Licensee shall measure outdoor coverage every twelve months.
- (2) Where the Licensee provides a mobile voice and/or text service using rights of use in any of the 700 MHz, 2.1 GHz, 2.3 GHz or 2.6 GHz Bands under this Licence, the Licensee shall measure Native Wi-Fi availability on its network in those bands every twelve months.
- (3) Where the Licensee is subject to the outdoor coverage and/or Native Wi-Fi obligations set out in this section, the Licensee shall submit to the Commission an annual compliance report on outdoor coverage and/or Native Wi-Fi ("Coverage Compliance Report") within 30 days of each anniversary of the commencement of the Licence. The Commission reserves the right to publish any information provided by the Licensee, subject to the provisions of the Commission's guidelines on the treatment of confidential information.
- (4) The information required for this annual compliance report shall be agreed with the Commission in advance and the compliance report shall have sufficient detail

and granularity to allow the Commission to verify the contents of the Licensee's annual compliance report.

- (5) The Licensee shall identify in the Coverage Compliance Report whether it has either (a) met the relevant outdoor coverage obligations and indoor Native WiFi coverage obligations specified in its Licence, or (b) failed to meet the said obligations. The Licensee shall identify the outdoor coverage levels obtained at the time of the annual compliance report. Where the Licensee has failed to meet the relevant coverage obligation, the Licensee shall provide detailed reasons and supporting information for same.
- (6) The Commission shall have the right to publish details of these reports.
- (7) The Commission reserves the right to survey the outdoor coverage level claimed by a Licensee or inspect any Apparatus installed by a Licensee at any time to ensure that the system is configured and operating in accordance with its Licence conditions. The Licensee shall facilitate any inspections by the Commission within such time as may be specified by the Commission.

Section 5: Rollout Conditions

1. Definitions

The following additional definitions shall apply in this section:

“Existing MNO” means a licensee that on 1 January 2020 was a holder of one or more of the following licences:

- a licence under the Wireless Telegraphy (Liberalised Use and Preparatory Licences in the 800 MHz, 900 MHz and 1800 MHz bands) Regulations 2012 (S.I. No. 251 of 2012); and/or
- a licence under the Wireless Telegraphy (Third Generation and GSM Mobile Telephony Licence) Regulations 2002 (S.I. No. 345 of 2002);

“Existing Operator (other than an Existing MNO)” means a licensee that on 1 January 2020 was a holder of a 3.6 GHz Band Liberalised Use Licence for terrestrial systems capable of providing Electronic Communications Services under the Wireless Telegraphy (3.6 GHz Band Licences) Regulations 2016 (S.I. No. 532 of 2016) and is not an Existing MNO;

“Network-Controlled Wireless Telegraphy Apparatus” means apparatus which has backhaul capability²² over a network connection under the control of the Licensee. For the avoidance of doubt, “plug-and-play” type apparatus, such as femto cells, Terminal Stations and repeaters, are not Network-Controlled Wireless Telegraphy Apparatus;

“New Entrant (Mobile)” means a Licensee that is not an Existing MNO and which provides mobile Electronic Communications Services under this Licence;

“New Entrant (Other)” means a Licensee that is neither an Existing MNO nor an Existing Operator and which provides Electronic Communications Services other than mobile Electronic Communications Services under this Licence; and

“Rollout Base Station” means a Network Controlled Wireless Telegraphy Apparatus in any of the 2.1 GHz Band, 2.3 GHz Band, and / or 2.6 GHz Band, with a minimum spectrum efficiency capability of 4 bits/Hz.

2. Base Station minimum rollout requirements

- (1) A Licensee that is an Existing MNO or an Existing Operator (other than an Existing MNO) and is assigned rights of use to spectrum in one or more of the 2.1 GHz, 2.3 GHz or 2.6 GHz Bands under this Licence shall achieve within 4 years of the earliest commencement date of Spectrum Blocks in these bands and maintain thereafter the applicable Rollout Base Station obligation detailed in Table 5 below.

Table 5. Existing Operator Rollout Base Station Obligation

Band	2.1 GHz	2.3 GHz	2.6 GHz	2.6 GHz TDD
Existing MNO	1,200	525	525	525
Existing Operator (other than an Existing MNO)	290	290	290	290

- (2) A Licensee that is a New Entrant (Mobile) or a New Entrant (Other) and is assigned rights of use to spectrum in one or more of the 2.1 GHz, 2.3 GHz or 2.6 GHz Bands under this Licence shall achieve within 5 years of the Licence Commencement Date and maintain thereafter the applicable Rollout Base Station obligation detailed in Table 6 below.

²² If any of the 2.1 GHz, 2.3 GHz, or 2.6 GHz Bands is used for the provision of backhaul connectivity, even if such Apparatus comprises of multiple hops to the network, this counts as a single Rollout Base Station, provided such backhaul connectivity carries data originating from or destined for multiple customer premises. The connection to individual customer premises equipment is excluded.

Table 6: New Entrant Rollout Base Station Obligation

Band	2.1 GHz	2.3 GHz	2.6 GHz	2.6 GHz TDD
New Entrant (Mobile)	290	290	290	290
New Entrant (Other)	80	80	80	80

- (3) Rollout Base stations worked and used pursuant to a spectrum leasing arrangement count towards the base station rollout obligation of the Lessor's Licence.
- (4) Where a Licensee shares a Rollout Base Station with another Licensee, such Rollout Base Stations can count towards the Rollout Base Station obligation of each Licensee, provided that at least one licensed Spectrum Block of each Licensee is worked and used by the Rollout Base Station.

3. Reporting of Compliance

- (1) The Licensee shall submit to the Commission an annual compliance report on rollout within 30 days of each anniversary of the commencement of the Licence.
- (2) In the annual compliance report the Licensee shall notify the Commission whether or not it has met the applicable Base Station rollout obligation. Where the Licensee has failed to meet the relevant rollout obligation, the Licensee shall provide detailed reasons and supporting information for same.
- (3) The information required for this annual compliance report shall be agreed with the Commission in advance and the compliance report shall have sufficient detail and granularity to allow the Commission to verify the contents of the Licensee's annual compliance report.
- (4) The Commission shall have the right to publish details of these reports.
- (5) The Commission reserves the right to inspect any Rollout Base Station and any associated infrastructure installed by a Licensee at any time to ensure that the system is configured and operating in accordance with its Licence conditions and

the Licensee shall facilitate any such inspections by the Commission within such time as may be specified by the Commission.

Section 6: Quality of Service (QoS) Obligations

1. Definitions

The following additional definitions shall apply in this section:

“Liberalised Spectrum” means the Spectrum Blocks set out in Part 1 of the Licence;

“Maximum Permissible Blocking Rates” means the maximum percentage of total Voice Call attempts which are unsuccessful during the Time Consistent Busy Hour;

“Maximum Permissible Dropped Call Rates” means the maximum percentage of total originating calls which are prematurely released by the Network within 3 minutes of the Voice Call being made;

“Network” means any terrestrial system which uses the Liberalised Spectrum;

“Network Unavailability” means the average number of minutes per six month period for which services on the Network are not available due to a disturbance, failure or scheduled unavailability to a Network;

“Time Consistent Busy Hour” means the period of one-hour starting at the same time each day for which the average traffic of the network concerned is greatest over the days under consideration. The time consistent busy hour shall be determined from an analysis of traffic data obtained from the service and be subject to the Commission’s approval; and

“Voice Call” means all relevant non-VOIP (Voice over Internet Protocol) and managed VOIP call services²³ which are considered by the Commission to be substitutable with traditional voice call services as may be updated and notified to Licensees from time to time.

²³ This includes traditional voice call services carried over circuit-switched connections and ‘managed’ packet-switched voice call services (e.g. using VOIP or similar protocols) which can be provided over different technologies (e.g. VoLTE, Native Wi-Fi, etc.).

2. The Minimum “Availability of the Network” Standard

(1) “Availability of the Network” shall be measured in terms of Network Unavailability and reported on an annual basis.

(2) The Licensee shall ensure that Network Unavailability is less than 35 minutes (based on the weighting factors set out in Table 7 below) per six month period.

Table 7: Weighting Factors for Network Unavailability tracking all periods of network unavailability

Network Unavailability, Weighting Factors (divide duration of each network event by weighting factor)			
	Monday to Friday	Saturday	Sunday
For periods between 07:00 and 24:00 hours	1	2	4
For periods between 00:00 and 07:00 hours	4	8	16

(3) The “Availability of the Network” shall be calculated by combining the Network Unavailability measurements of the relevant services provided to the Licensee’s end users and provided to end users of third parties²⁴.

(4) The Licensee shall maintain a network log on a per Base Station basis in a manner that can demonstrate to the satisfaction of the Commission that such a network log is an adequate means of assessing whether the Licensee is complying with its “Availability of the Network” licence obligations.

(5) The network log, or as may be appropriate part thereof, shall be made available to the Commission upon request by the Commission.

(6) The Licensee shall calculate the Network Unavailability for any period specified by the Commission from the information recorded in the network log, and shall, upon request and within such time as may be specified by the Commission, provide the Commission with the results of that calculation.

3. The Minimum Voice Call Standard

(1) Where the Licensee and/or any third party by means of a contractual or other arrangement with the Licensee provides a Voice Call service on a terrestrial system using the Liberalised Spectrum, the Licensee shall comply with the minimum Voice Call standard set out in Table 8 below.

²⁴ For example, MVNOs or other wholesale services.

Table 8: Minimum Voice Call Standards for each 6 month period for annual reporting

	Average	Worst Case
Maximum Permissible Blocking Rates (maximum percentage of total Voice Call attempts which are unsuccessful during the Time Consistent Busy Hour ²⁵)	2%	4%
Maximum Permissible Dropped Call Rates (maximum percentage of total originating calls which are prematurely released by the Network within 3 minutes of the Voice Call being made.)	2%	4%
Transmission quality: The Licensee shall ensure that: <ul style="list-style-type: none"> • the speech transmission quality of Voice Calls is as good as or better than the speech quality associated with the relevant ETSI Standard and Technical Specifications; and • appropriate echo treatment equipment is used and that such equipment is properly configured. 		

- (2) Where a Voice Call service is provided by the Licensee and any third party via contractual or other arrangements with the Licensee, the minimum Voice Call standard shall be calculated by combining the Voice Call measurements of the Licensee with that of the third party.

4. The “VoLTE Availability” Obligation

- (1) Where the Licensee has deployed LTE technology in any of the bands in which it holds rights of use under this Licence and also offers a mobile voice service to consumers using those bands, the Licensee shall:
- (a) enable VoLTE technology on its network and on its Base Stations which use those bands;
 - (b) make a VoLTE service available to its end users (including MVNO end users) that have a VoLTE-enabled handset; and

²⁵ “Time Consistent Busy Hour” means the period of one-hour starting at the same time each day for which the average traffic of the network concerned is greatest over the days under consideration. The time consistent busy hour shall be determined from an analysis of traffic data obtained from the service and be subject to the Commission’s approval.

The ‘Time Consistent Busy Hour’ is determined from the Licensee’s voice traffic. It is the one - hour period during which there is the highest level of traffic. The blocked call rates are measured for the same one-hour period during each review period (i.e. 6 months). The one- hour period is determined by the Licensee and is subject to the Commission’s approval.

- (c) deploy and maintain VoLTE across 50% of its LTE Base Stations which use those bands within 1 year and across 100% of such base stations within 2 years.

5. Reporting on Compliance

- (1) The Licensee shall maintain a log in respect of the performance of its Network against the Minimum Voice Call Standards in Table 8, according to measuring standards as agreed with the Commission and in such a manner that can demonstrate to the satisfaction of the Commission that its network log is an adequate means of assessing whether the Licensee is complying with these standards.
- (2) The Licensee shall measure and submit to the Commission, within 30 days of each anniversary of the commencement of the Licence, an annual compliance report on (a) the performance of its Network against the Minimum Voice Call Standards in Table 8 and (b) the VoLTE Availability Obligation set out above.
- (3) In the annual compliance report the Licensee shall notify the Commission whether or not it has met the Minimum Voice Call Standards in Table 8 or the VoLTE Availability Obligation set out above. Where the Licensee has failed to meet any of these standards or obligations, the Licensee shall provide adequate reasons and supporting information for same.
- (4) The annual compliance report shall have sufficient detail and granularity to allow the Commission to verify the Licensee's measurements.
- (5) Failure by the Licensee to submit the annual compliance report to the Commission within the specified time period shall be deemed to be non-compliance by the Licensee with both these reporting obligations and the Voice Call standards.
- (6) The Licensee shall, upon request by the Commission²⁶, carry out drive test measurements against the Maximum Permissible Blocking Rates and Maximum Permissible Dropped Call Rates standards and submit these results to the Commission. These drive test measurements are to be carried out at the Licensee's own expense and to a standard as agreed with the Commission.
- (7) Failure by the Licensee to carry out and submit the drive tests measurements to the standard agreed with the Commission shall be deemed to be non-

²⁶ The Commission does not envisage drive test measurements being required on a frequent basis, but notes that such measurements may be appropriate in circumstances where:

- a Licensee is submitting a compliance report on QoS for the first time; and/or
- the Commission's own verification checks, drive test measurements or other information suggests that there may be discrepancies in the compliance report on QoS or the Licensee may not be meeting its QoS obligations.

compliance by the Licensee with both these reporting obligations and the Maximum Permissible Blocking Rates and Maximum Permissible Dropped Call Rates standards.

DRAFT

SCHEDULE 2

WIRELESS TELEGRAPHY ACT, 1926

WIRELESS TELEGRAPHY (LIBERALISED USE AND RELATED LICENCES IN THE 700 MHZ DUPLEX, 2.1 GHZ, 2.3 GHZ AND 2.6 GHZ BANDS) REGULATIONS 2020

MBSA2 Spectrum Lease Licence for terrestrial systems capable of providing Electronic Communications Services

Licence under section 5 of the Act of 1926 to keep and have possession of apparatus for wireless telegraphy for terrestrial systems capable of providing Electronic Communications Services.

The Commission for Communications Regulation, in exercise of the powers conferred on it by section 5 of the Act of 1926 hereby grants the following licence to **[LICENSEE NAME]** of **[LICENSEE ADDRESS]** (“the Licensee”).

The Licensee is hereby authorised to keep and have possession of apparatus for wireless telegraphy for terrestrial systems capable of providing Electronic Communications Services as specified in Part 2 of this Licence, subject to such apparatus being installed, maintained, worked and used in accordance with the terms, conditions and restrictions set out in the Wireless Telegraphy (Liberalised Use and Related Licences in the 700 MHz Duplex, 2.1 GHz, 2.3 GHz and 2.6 GHz Bands) Regulations 2020 (S.I. No. of 2020) (“the Regulations”), including but not limited to, the following:

- (1) The Licensee shall ensure that it complies with all of the conditions contained within the Regulations and within Parts 1 to 4 of this Licence; and
- (2) The Licensee shall ensure that it makes payment of all fees as detailed in the Regulations.

For the purpose of this Licence, the definitions set out in the Wireless Telegraphy (Liberalised Use and Related Licences in the 700 MHz Duplex, 2.1 GHz, 2.3 GHz and 2.6 GHz Bands) Regulations 2020 apply.

This Licence shall come in to effect on **DD/MM/YYYY** (the “Licence Commencement Date”) and, subject to revocation, suspension or withdrawal, expires on **DD/MM/YYYY**.

Signed: _____

For and on behalf of the Commission for Communications Regulation

Date of Issue: _____

Part 1

Commencement and expiry dates per Spectrum Block of Liberalised Spectrum

Lessor MBSA2 Liberalised Use Licence Number	Authorised Band	Name of Spectrum Block	Frequency Assigned to Spectrum Block	Commencement Date per Spectrum Block	Expiry Date per Spectrum Block
		<i>[One or more Blocks of Liberalised Spectrum]</i>	From ____ MHz to ____ MHz	DD Month YYYY	DD Month YYYY

Part 2

The Apparatus to which this Licence applies

Authorised Band	Equipment Index Reference	Terrestrial System	Equipment Description	Manufacturer	Model
700 MHz Duplex, 2.1 GHz, 2.3 GHz, 2.6 GHz as appropriate					

Part 3

Apparatus Location and Details

Authorised Band	Site Identity	Eastings	Northings	Equipment Index Reference	Maximum EIRP
700 MHz Duplex, 2.1 GHz, 2.3 GHz, 2.6 GHz as appropriate					

Part 4
Licence Conditions

The Licence Conditions will be specified by the Commission in accordance with such procedures as may be specified by the Commission from time to time under Regulation 19 of the Framework Regulations.

DRAFT

SCHEDULE 3

WIRELESS TELEGRAPHY ACT, 1926

WIRELESS TELEGRAPHY (LIBERALISED USE AND RELATED LICENCES IN THE 700 MHZ DUPLEX, 2.1 GHZ, 2.3 GHZ AND 2.6 GHZ BANDS) REGULATIONS 2020

MBSA2 Preparatory Licence for terrestrial systems capable of providing Electronic Communications Services

Licence under section 5 of the Act of 1926 to keep and have possession of apparatus for wireless telegraphy for terrestrial systems capable of providing Electronic Communications Services.

The Commission for Communications Regulation, in exercise of the powers conferred on it by section 5 of the Act of 1926 hereby grants the following licence to **[LICENSEE NAME]** of **[LICENSEE ADDRESS]** (“the Licensee”).

The Licensee is hereby authorised to keep and have possession of apparatus for wireless telegraphy for terrestrial systems capable of providing Electronic Communications Services as specified in Part 2 of this Licence, subject to such apparatus being installed and maintained in accordance with the terms, conditions and restrictions set out in the Wireless Telegraphy (Liberalised Use and Related Licences in the 700 MHz Duplex, 2.1 GHz, 2.3 GHz and 2.6 GHz Bands) Regulations 2020 (S.I. No. of 2020) (“the Regulations”), including but not limited to, the following:

- (1) The Licensee shall ensure that it complies with all of the conditions contained within the Regulations and within Parts 1 to 2 of this Licence; and
- (2) The Licensee shall ensure that it makes payment of all fees as detailed in the Regulations.

For the purpose of this Licence, the definitions set out in the Wireless Telegraphy (Liberalised Use and Related Licences in the 700 MHz Duplex, 2.1 GHz, 2.3 GHz and 2.6 GHz Bands) Regulations 2020 apply.

This Licence shall come in to effect on **DD/MM/YYYY** (the “Licence Commencement Date”) and, subject to revocation, suspension or withdrawal, expires on **DD/MM/YYYY**.

Signed: _____

For and on behalf of the Commission for Communications Regulation

Date of Issue: _____

Part 1
Licence Conditions

(1) The Licensee may keep, have possession of, install and maintain the Apparatus detailed in Part 2 of this Licence.

(2) The Licensee shall not work or use the Apparatus detailed in Part 2 of this Licence.

Part 2
The Apparatus to which this Licence applies

To Include:

Authorised Band	Commencement Date	Expiry Date	Manufacturer	Model
	DD Month YYYY	DD Month YYYY		

SCHEDULE 4

WIRELESS TELEGRAPHY ACT, 1926

WIRELESS TELEGRAPHY (LIBERALISED USE AND RELATED LICENCES IN THE 700 MHZ DUPLEX, 2.1 GHZ, 2.3 GHZ AND 2.6 GHZ BANDS) REGULATIONS 2020

MBSA2 2.3 GHz Band Transition Licence for apparatus for wireless telegraphy for the provision of Point to Multi-Point Radio Links

Licence under section 5 of the Act of 1926 to keep and have possession of apparatus for wireless telegraphy for the provision of Point to Multi-Point Radio Link Radio Links.

The Commission for Communications Regulation, in exercise of the powers conferred on it by section 5 of the Act of 1926 hereby grants the following licence to **[LICENSEE NAME]** of **[LICENSEE ADDRESS]** (“the Licensee”).

The Licensee is hereby authorised to keep and have possession of apparatus for wireless telegraphy for the provision of Point to Multi-Point Radio Link Radio Links as specified in Part X of this Licence, subject to such apparatus being installed, maintained, worked and used in accordance with the terms, conditions and restrictions set out in the Wireless Telegraphy (Liberalised Use and Related Licences in the 700 MHz Duplex, 2.1 GHz, 2.3 GHz and 2.6 GHz Bands) Regulations 2020 (S.I. No. of 2020) (“the Regulations”), including but not limited to, the following:

- (1) The Licensee shall ensure that it complies with all of the conditions contained within the Regulations and within Parts 1 to 2 of this Licence; and
- (2) The Licensee shall ensure that it makes payment of all fees as detailed in the Regulations.

For the purpose of this Licence, the definitions set out in the Wireless Telegraphy (Liberalised Use and Related Licences in the 700 MHz Duplex, 2.1 GHz, 2.3 GHz and 2.6 GHz Bands) Regulations 2020 apply.

This Licence shall come in to effect on **DD/MM/YYYY** (the “Licence Commencement Date”) and, subject to revocation, suspension or withdrawal, expires on **DD/MM/YYYY**.

Signed: _____

For and on behalf of the Commission for Communications Regulation

Date of Issue: _____

Part 1

Commencement and Expiry dates per Point to Multi-Point Radio Link

Existing Point to Multi-Point Licence No.	Transmit Station location (Eastings, Northings)	Frequency Assigned	Commencement Date	Expiry Date
		From ____ MHz to ____ MHz And From ____ MHz to ____ MHz	DD MonthYYYY	DD MonthYYYY

Part 2

Location(s) and technical conditions of Apparatus

Existing Point to Multi-Point Licence No.	Transmit Station location (Eastings, Northings)	Max EIRP (dBW)	Make	Model

SCHEDULE 5

Annual SUF before CPI Adjustment for each block of Liberalised Spectrum

The CPI Adjustment for a SUF is calculated using 1 December 2020 (or such other date as may be specified by ComReg) as the base date for the CPI (i.e. CPI = 100). ComReg will use the most current CPI data available to it at that time. For example, for 1 December, ComReg envisages that the most up to date CPI data available is likely to be from October of that year.

Table 9: Annual SUF before CPI adjustment per Lot of 700 MHz Duplex

Spectrum Block	Annual SUF before CPI Adjustment (€)
700 MHz Duplex Block	1,168,778

Table 10: Annual SUF before CPI adjustment per Lot

Lot Category	Annual SUF before CPI Adjustment (€) for Time Slice 1	Annual SUF before CPI Adjustment (€) for Time Slice 2
2.1 GHz Band Block	615,147	615,147
2.3 GHz Band Fixed Frequency Block (Lower)	274,082	274,082
2.3 GHz Band Fixed Frequency Block (Upper)	123,029	123,029
2.3 GHz Band Generic Frequency Block	61,515	61,515
2.6 GHz Band FDD Generic Frequency Block	123,029	123,029
2.6 GHz Band TDD Fixed Frequency Block (Lower)	61,515	61,515
2.6 GHz Band TDD Fixed Frequency Block (Upper)	61,515	61,515
2.6 GHz Band TDD Generic Frequency Block	61,515	61,515

SCHEDULE 6

Annual Fee for a MBSA2 2.3 GHz Band Transition Licence

The Annual Fee for a MBSA2 2.3 GHz Band Transition Licence is based on the higher of the following:

- A. MBSA2 2.3 GHz Band Transition Licence Price A; or
- B. MBSA2 2.3 GHz Band Transition Licence Price B.

GIVEN under the official seal of the Commission for Communications Regulation,

[DATE] 2020

[NAME of COMMISSIONER]

For and on behalf of the Commission for Communications Regulation

The Minister for Communications, Climate Action and Environment, in accordance with Section 37 of the Communications Regulation Act, 2002, consents to the making of the foregoing Regulations.

GIVEN under the Official Seal of the Minister for Communications, Climate Action and Environment,

[DATE] 2020

[NAME OF MINISTER]

Minister for Communications, Climate Action and Environment.

Explanatory Note

(This note is not part of the Instrument and does not purport to be a legal interpretation.)

These Regulations prescribe matters in relation to licences for apparatus for wireless telegraphy for terrestrial systems capable of providing Electronic Communications Services in the 700 MHz Duplex, the 2.1 GHz, the 2.3 GHz and the 2.6 GHz Bands.

DRAFT

Draft 2.1 GHz Early Liberalisation and Interim Licensing Regulations

This annex contains a draft of the proposed regulations to implement ComReg's award proposals in relation to:

- the liberalisation of existing rights of use in the 2.1 GHz Band (in particular, Regulation 4); and
- the proposed grant of interim 2.1 GHz Band rights of use to Three (in particular Regulations 5 to 10).

Any final version of these regulations, which would be made by ComReg under section 6 of the Wireless Telegraphy Act 1926, is expressly subject to the consent of the Minister for Communications, Climate Action and Environment under section 37 of the Communications Regulation Act 2002, as amended.

ComReg will take into account comments from interested parties when finalising the proposed Regulations. ComReg may also make such editorial changes to the text of any final regulations as it considers necessary and without further consultation, where such changes would not affect the substance of the regulations.

S.I. No. XX of 2020**WIRELESS TELEGRAPHY (THIRD GENERATION AND GSM LICENCE
(AMENDMENT) AND INTERIM LICENSING) REGULATIONS 2020**

Notice of the making of this Statutory Instrument was published in “Iris Oifigiúil” of [XX] 2020.

The Commission for Communications Regulation, in exercise of the powers conferred on it by section 6(1) of the Wireless Telegraphy Act, 1926 (No. 45 of 1926) as substituted by section 182 of the Broadcasting Act 2009 (No. 18 of 2009), and with the consent of the Minister for Communications, Climate Action and Environment in accordance with section 37 of the Communications Regulation Act 2002 (No. 20 of 2002), hereby makes the following Regulations:

Citation

1. These Regulations may be cited as the Wireless Telegraphy (Third Generation and GSM Licence (Amendment) and Interim Licensing) Regulations 2020.

Interpretation

2. (1) In these Regulations:

“2.1 GHz Band” means radio frequency spectrum in the range 1920 to 1980 MHz paired with radio frequency spectrum in the range 2110 MHz to 2170 MHz;

“Act of 1926” means the Wireless Telegraphy Act 1926 (No. 45 of 1926);

“Act of 1972” means the Wireless Telegraphy Act, 1972 (No. 5 of 1972);

“Act of 2002” means the Communications Regulation Act 2002 (No. 20 of 2002);

“Authorisation Regulations” means the European Communities (Electronic Communications Networks and Services) (Authorisation) Regulations 2011 (S.I. No. 335 of 2011);

“Award” means the competitive award procedure used by the Commission for the purpose of granting individual rights of use for radio frequencies in the 700 MHz Duplex, 2.1 GHz, 2.3 GHz and 2.6 GHz Bands, as detailed in the Information Memorandum;

“Commission” means the Commission for Communications Regulation established under the Act of 2002;

“Decision of 1999” means Decision No. 128/1999/EC of the European Parliament and of the Council of 14 December 1999 on the co-ordinated introduction of a third generation mobile and wireless communications system in the Community;

“Decision of 2012” means European Commission Implementing Decision (2012/688/EU) of 5 November 2012 on the harmonisation of the frequency bands 1920-1980 MHz and 2110-2170 MHz for terrestrial systems capable of providing electronic communications services in the Union;

“ERC Decision of 1999” means ERC Decision ERC/DEC/(99)25 of 29 November 1999 on the harmonised utilisation of spectrum for terrestrial Universal Mobile Telecommunications System (UMTS) operating within the bands 1900 - 1980 MHz, 2100 - 2025 MHz and 2110 - 2170 MHz;

“Equivalent Isotropically Radiated Power” (EIRP) means the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna;

“Electronic Communications Network” and “Electronic Communications Service” have the meanings assigned to them in the Framework Regulations;

“EURIBOR” means the rate at which euro interbank term deposits are offered within the European Monetary Union zone by one prime bank to another and, in relation to any payment, a reference to the prevailing EURIBOR means the rate prevailing at close of business on the date on which payment falls due;

“Existing Licence” means a licence issued under the Principal Regulations;

“Existing A Licence” means a licence issued under the Principal Regulations and which is due to expire on 24 July 2022;

“Existing B Licence” means a licence issued under the Principal Regulations and which is due to expire on 1 October 2022;

“Existing Licensee” means a person holding one, or more, Existing Licences;

“Framework Regulations” means the European Communities (Electronic Communications Networks and Services) (Framework) Regulations 2011 (S.I. No. 333 of 2011);

“Harmful Interference” has the meaning set out in the Framework Regulations;

“ICNIRP” means the International Commission on Non-Ionising Radiation Protection;

“Information Memorandum” means the document published by the Commission on [date] and bearing the Commission Document number 20/[XX] and which outlines in detail the processes and procedures the Commission will follow in running the Award, as may be updated from time to time;

“Licence” means a non-exclusive licence granted under section 5 of the Act of 1926 in accordance with and subject to the matters prescribed in these Regulations to keep and have possession of Liberalised Apparatus or Third Generation Apparatus, as the case may be, in a specified place in the State, being one of:

- (a) a Third Generation 2.1 GHz Band Interim A Licence;
- (b) a Third Generation 2.1 GHz Band Interim B Licence;
- (c) a Liberalised 2.1 GHz Band Interim A Licence; or
- (d) a Liberalised 2.1 GHz Band Interim B Licence.

“Licence Commencement Date” means the date, as specified in the Licence, upon which the Licence comes into effect;

“Liberalisation” or “Liberalise” in relation to an Existing Licence means such amendments as required to be made by the Commission to an Existing Licence to enable the Existing Licensee to keep, have possession of, install, maintain, work and use Liberalised Apparatus;

“Liberalisation Fee” has the meaning set out in the Information Memorandum;

“Liberalised Apparatus” means apparatus for wireless telegraphy as defined in section 2 of the Act of 1926 for terrestrial systems capable of providing Electronic Communications Services in the 2.1 GHz Band and which comply with the Decision of 2012;

“Liberalised 2.1 GHz Band Interim Licence” means a Liberalised 2.1 GHz Band Interim A Licence or a Liberalised 2.1 GHz Band Interim B Licence;

“Non-exclusive”, in relation to a Licence, means that the Commission is not precluded from authorising the keeping and having possession by persons other than the Licensee, on a Non-Interference and Non-Protected Basis, of apparatus for wireless telegraphy for the radio frequency spectrum specified in the Licence;

“Non-Interference and Non-Protected Basis” means that the use of apparatus for wireless telegraphy is subject to no Harmful Interference being caused to any Radiocommunication Service, and that no claim may be made for the protection of apparatus for wireless telegraphy used on this basis against Harmful Interference originating from Radiocommunication Services;

“Principal Regulations” means the Wireless Telegraphy (Third Generation and GSM Licence) Regulations, 2002 (S.I. No. 345 of 2002) as amended by the Wireless Telegraphy (Third Generation and GSM Licence) (Amendment) Regulations, 2003 (S.I. No. 340 of 2003);

“Radiocommunication Service” means a service as defined in the Radio Regulations of the International Telecommunication Union involving the transmission, emission or reception of radio waves for specific telecommunication purposes;

“Third Generation mobile telephony service” means a mobile and wireless communications system based on a standard within the IMT-2000 system capable of supporting innovative multimedia services beyond the capability of second generation systems such as GSM, and capable of supporting the characteristics referred to in Annex 1 of the Decision of 1999;

“Third Generation Apparatus” means apparatus for wireless telegraphy which is licensed to operate in the 2.1 GHz Band for the purpose of providing a Third Generation mobile telephony service and, in relation to a Third Generation 2.1 GHz Band Interim Licence, means apparatus to which the Third Generation 2.1 GHz Band Interim Licence relates;

“Third Generation 2.1 GHz Band Interim Licence” means a Third Generation 2.1 GHz Band Interim A Licence or a Third Generation 2.1 GHz Band Interim B Licence; and

“Undertaking” means Three Ireland (Hutchison) Limited, a company with a registered office at 28/29 Sir John Rogerson’s Quay, Dublin 2.

(2) A word or expression that is used in these Regulations and that is also used in the Act of 1926 has, unless the context otherwise requires, the same meaning in these Regulations that it has in that Act.

(3) A word or expression that is used in these Regulations and that is also used in the Act of 2002 has, unless the context otherwise requires, the same meaning in these Regulations that it has in that Act.

(4) A word or expression that is used in these Regulations and that is also used in the Framework Regulations or in the Authorisation Regulations has, unless the context otherwise requires, the same meaning in these Regulations that it has in those Regulations.

Licences to which these Regulations apply

3. (1) These Regulations apply to:

- (a) Existing Licences;
- (b) a Third Generation 2.1 GHz Band Interim A Licence;
- (c) a Third Generation 2.1 GHz Band Interim B Licence;
- (d) a Liberalised 2.1 GHz Band Interim A Licence; and
- (e) a Liberalised 2.1 GHz Band Interim B Licence.

Amendment of Principal Regulations

4. (1) The Principal Regulations are amended by inserting the following after Regulation 12:

“Application by Existing Licensee for Liberalisation of Existing Licence and Liberalisation Fee

13. (1) Application by an Existing Licensee for the Liberalisation of its Existing Licence(s) shall be made by an Existing Licensee to the Commission in writing and in such form as may be determined by the Commission from time to time.

(2) The Commission may Liberalise an Existing Licence which expires on or before 15 October 2022 in accordance with the Authorisation Regulations and no additional Liberalisation Fee shall apply. The Existing Licensee shall continue to be liable for all other applicable fees relating to the Existing Licence specified in these Regulations.

(3) The Commission may, before the outcome of the Award, Liberalise an Existing Licence which expires after 15 October 2022 upon receipt of a written binding commitment by the Existing Licensee to pay the Liberalisation Fee, and such binding commitment shall be in such form as may be determined by the Commission from time to time. If, in light of the outcome of the Award, a Liberalisation Fee is determined by the Commission to apply to the Liberalisation of such Existing Licence, the Commission shall issue an invoice to the relevant Existing Licensee setting out the Liberalisation Fee and the relevant Existing Licensee shall pay the Liberalisation Fee within the time period specified in the invoice. The Existing Licensee shall continue to be liable for all other applicable fees relating to the Existing Licence specified in these Regulations.

(4) Where payment of the Liberalisation Fee is not made within the time period specified in the invoice, then the Existing Licensee shall pay to the Commission interest on the Liberalisation Fee or part thereof that was or is outstanding. Interest shall accrue from the date when such fee or part thereof fell due until payment of such fee or part thereof and shall be calculated at the same rate payable in respect of late payments in commercial transactions pursuant to the European Communities (Late Payment in Commercial Transactions) Regulations 2012, (S.I. No. 580 of 2012).

(5) Without prejudice to the Commission’s other statutory powers, an amount payable by an Existing Licensee in respect of the Liberalisation Fee, including interest where applicable, may be recovered by the Commission from the Existing Licensee as a simple contract debt in any court of competent jurisdiction.

(6) The Commission may, after the outcome of the Award, Liberalise an Existing Licence which expires after 15 October 2022 following payment of the Liberalisation Fee if applicable. The Existing Licensee shall continue to be liable for all other applicable fees relating to the Existing Licence specified in these Regulations.

(7) For the purpose of this Regulation 13, the definitions set out in Regulation 2(1) of the Wireless Telegraphy (Third Generation and GSM Licence (Amendment) and Interim Licensing) Regulations 2020 apply.”

Interim Licences in the 2.1 GHz Band

Application for the Grant and Form of Licences

5. (1) Application for the grant of a Third Generation 2.1 GHz Band Interim A Licence, a Third Generation 2.1 GHz Band Interim B Licence, a Liberalised 2.1 GHz Band Interim A Licence or a Liberalised 2.1 GHz Band Interim B Licence, as the case may be, shall be made by the Undertaking to the Commission in writing and in such form as may be determined by the Commission from time to time.

(2) If, at the time of application, the Existing A Licence held by the Undertaking has not been Liberalised by the Commission in accordance with Regulation 13 of the Principal Regulations, the Commission may grant a Third Generation 2.1 GHz Band Interim A Licence following payment by the Undertaking of the relevant fees prescribed in Regulation 9.

(3) If, at the time of application, the Existing B Licence held by the Undertaking has not been Liberalised by the Commission in accordance with Regulation 13 of the Principal Regulations, the Commission may grant a Third Generation 2.1 GHz Band Interim B Licence following payment by the Undertaking of the relevant fees prescribed in Regulation 9.

(4) If, at the time of application, the Existing A Licence held by the Undertaking has been Liberalised by the Commission in accordance with Regulation 13 of the Principal Regulations, the Commission may grant a Liberalised 2.1 GHz Band Interim A Licence following payment by the Undertaking of the relevant fees prescribed in Regulation 9.

(5) If, at the time of application, the Existing B Licence held by the Undertaking has been Liberalised by the Commission in accordance with Regulation 13 of the Principal Regulations, the Commission may grant a Liberalised 2.1 GHz Band Interim B Licence following payment by the Undertaking of the relevant fees prescribed in Regulation 9.

(6) A person who applies for the grant of a Licence shall furnish to the Commission such information as the Commission may reasonably require for the purposes of its functions under these Regulations, the Act of 1926, the Act of 2002, the Framework Regulations or the Authorisation Regulations, and if the person, without reasonable cause, fails to comply with this paragraph, the Commission may refuse to grant the Licence concerned to the person.

(7) A Third Generation 2.1 GHz Band Interim A Licence or a Third Generation 2.1 GHz Band Interim B Licence to which these Regulations apply shall be in the form specified in Schedule 1, with such variation, if any, whether by addition, deletion or alteration as the Commission may determine from time to time or in any particular case in accordance with the Authorisation Regulations.

(8) A Liberalised 2.1 GHz Band Interim A Licence or a Liberalised 2.1 GHz Band Interim B Licence to which these Regulations apply shall be in the form specified in Schedule 2, with such variation, if any, whether by addition, deletion or alteration as the Commission may determine from time to time or in any particular case in accordance with the Authorisation Regulations.

Duration of Licences

6. (1) The commencement date of a Third Generation 2.1 GHz Band Interim A Licence or a Liberalised 2.1 GHz Band Interim A Licence shall be 25 July 2022 or such other date as may be specified by the Commission. Unless it has been withdrawn, or had its duration reduced under Regulation 8, a Third Generation 2.1 GHz Band Interim A Licence or a Liberalised 2.1 GHz Band Interim A Licence to which these Regulations apply shall in any event expire on 15 October 2022.

(2) The commencement date of a Third Generation 2.1 GHz Band Interim B Licence or a Liberalised 2.1 GHz Band Interim B Licence shall be 2 October 2022 or such other date as may be specified by the Commission. Unless it has been withdrawn, or had its duration reduced under Regulation 8, a Third Generation 2.1 GHz Band Interim B Licence or a Liberalised 2.1 GHz Band Interim B Licence to which these Regulations apply shall in any event expire on 15 October 2022.

Conditions of Licences

7. (1) Any Licensee that is granted a Licence under these Regulations and to which these Regulations apply shall:

- (a) ensure that it complies with the geographical and technical conditions contained within Parts 1 to 3 of the Licence;
- (b) ensure that it complies with all those commitments contained within Part 4 of the Licence having been made in the course of a comparative evaluation selection procedure for the Existing A Licence or Existing B Licence as the case may be;
- (c) ensure that it does not, without the consent of the Commission (which shall not be unreasonably withheld) assign the Licence or otherwise seek to transfer any of the rights of use conferred by it or obligations imposed under the Licence;

(d) that if the address of the Licensee changes, the Licensee shall, as soon as possible, notify the Commission in writing of the change; and

(e) comply with any special conditions imposed under section 8 of the Act of 1972.

Enforcement, Amendment, Withdrawal and Suspension

8. (1) Enforcement by the Commission of compliance by a Licensee with conditions attached to its Licence shall be in accordance with the Authorisation Regulations.

(2) The Commission may amend any Licence from time to time in accordance with the Authorisation Regulations.

(3) A Licence may be suspended or withdrawn by the Commission in accordance with the Authorisation Regulations.

Licence Fees

9. (1) Subject to paragraph (4) of this Regulation, the following fees are prescribed in relation to a Third Generation 2.1 GHz Band Interim A Licence, a Third Generation 2.1 GHz Band Interim B Licence, a Liberalised 2.1 GHz Band Interim A Licence and a Liberalised 2.1 GHz Band Interim B Licence.

(2) The fee for a Third Generation 2.1 GHz Band Interim A Licence or a Liberalised 2.1 GHz Band Interim A Licence is €714,349.88 per 2 x 5 MHz block.

(3) The fee for a Third Generation 2.1 GHz Band Interim B Licence or a Liberalised 2.1 GHz Band Interim B Licence is €120,492.75 per 2 x 5 MHz block.

(4) The fees specified in paragraphs (2) and (3) of this Regulation shall be paid to the Commission, on a date specified by the Commission, by way of banker's draft or such other means and on such other terms, if any, as the Commission may decide. Where the date of payment falls on a day other than a working day, payment shall be made on or before the last working day before the date on which payment would otherwise have fallen due.

(5) An amount payable by a person in respect of a fee under these Regulations may be recovered by the Commission from the person as a simple contract debt in any court of competent jurisdiction.

(6) If a Licence is suspended or revoked, the Licensee shall not be entitled to be repaid any part of the fee paid by the Licensee under these Regulations but shall still be liable to pay any sums (including interest) outstanding.

(7) Where payment is not made in due time, interest shall accrue from the due date until the date on which payment is effected at the prevailing EURIBOR plus five percentage points.

Licensee to satisfy all legal requirements

10. (1) Licences granted pursuant to these Regulations do not grant to the Licensee any right, interest or entitlement other than to keep, have possession of, install, maintain, work and use Third Generation Apparatus or Liberalised Apparatus, as the case may be, at a specified location or locations in the State.

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SCHEDULE 1

WIRELESS TELEGRAPHY ACT, 1926

WIRELESS TELEGRAPHY (THIRD GENERATION AND GSM LICENCE (AMENDMENT) AND INTERIM LICENSING) REGULATIONS 2020

Third Generation 2.1 GHz Band Interim Licence

Licence under section 5 of the Act of 1926 to keep and have possession of apparatus for wireless telegraphy for terrestrial systems capable of providing Electronic Communications Services.

The Commission for Communications Regulation, in exercise of the powers conferred on it by section 5 of the Act of 1926, hereby grants the following licence to **[LICENSEE NAME]** of **[LICENSEE ADDRESS]** (“the Licensee”).

The Licensee is hereby authorised to keep and have possession of apparatus for wireless telegraphy for terrestrial systems capable of providing Electronic Communications Services as specified in Part 2 of this Licence, subject to such apparatus being installed, maintained, worked and used in accordance with the terms, conditions and restrictions set out in the Wireless Telegraphy (Third Generation and GSM Licence (Amendment) and Interim Licensing) Regulations 2020 (S.I. No. of 2020) (“the Regulations”), including but not limited to, the following:

- (1) The Licensee shall ensure that it complies with all of the conditions contained within the Regulations, and within Parts 1 to 3 of this Licence; and
- (2) The Licensee shall ensure that it complies with all the commitments contained within Part 4 of the Licence being made in the course of a comparative evaluation selection procedure forming part of the Existing Licence to which this Third Generation 2.1 GHz Band Interim Licence relates.

For the purpose of this Licence, the definitions set out in the Wireless Telegraphy (Third Generation and GSM Licence (Amendment) and Interim Licensing) Regulations 2020 apply.

This Licence shall come in to effect on **DD/MM/YYYY** (the “Licence Commencement Date”) and, subject to revocation, suspension or withdrawal, expires on **15 October 2022**.

Signed: _____

For and on behalf of the Commission for Communications Regulation

Date of Issue: _____

Part 1

Places at which the Licensee is authorised by this Licence to keep and have possession of Third Generation Apparatus

No.	Site I.D.	Easting	Northing

Part 2

The Third Generation Apparatus for wireless telegraphy to which this Licence applies

No.	Manufacturer	Component	Equipment No.

Part 3

Radio frequency bands in which the Third Generation Apparatus is authorised by this Licence to be used

The following frequency bands may be used for FDD mode operation:

Mobile Transmit	Paired with Base Station Transmit

Use of the frequency bands shall be in compliance with the ERC Decision of 1999.

Part 4

Commitments made in the course of a comparative evaluation selection procedure forming part of the Existing Licence to which this Third Generation 2.1 GHz Band Interim Licence relates

SCHEDULE 2

WIRELESS TELEGRAPHY ACT, 1926

WIRELESS TELEGRAPHY (THIRD GENERATION AND GSM LICENCE (AMENDMENT) AND INTERIM LICENSING) REGULATIONS 2020

Liberalised 2.1 GHz Band Interim Licence

Licence under section 5 of the Act of 1926 to keep and have possession of apparatus for wireless telegraphy for terrestrial systems capable of providing Electronic Communications Services.

The Commission for Communications Regulation, in exercise of the powers conferred on it by section 5 of the Act of 1926, hereby grants the following licence to **[LICENSEE NAME]** of **[LICENSEE ADDRESS]** (“the Licensee”).

The Licensee is hereby authorised to keep and have possession of apparatus for wireless telegraphy for terrestrial systems capable of providing Electronic Communications Services as specified in Part 2 of this Licence, subject to such apparatus being installed, maintained, worked and used in accordance with the terms, conditions and restrictions set out in the Wireless Telegraphy (Third Generation and GSM Licence (Amendment) and Interim Licensing) Regulations 2020 (S.I. No. of 2020) (“the Regulations”), including but not limited to, the following:

- (1) The Licensee shall ensure that it complies with all of the conditions contained within the Regulations, and within Parts 1 to 3 of this Licence; and
- (2) The Licensee shall ensure that it complies with all the commitments contained within Part 4 of the Licence being made in the course of a comparative evaluation selection procedure forming part of the Existing Licence to which this Liberalised 2.1 GHz Band Interim Licence relates.

For the purpose of this Licence, the definitions set out in the Wireless Telegraphy (Third Generation and GSM Licence (Amendment) and Interim Licensing) Regulations 2020 apply.

This Licence shall come in to effect on **DD/MM/YYYY** (the “Licence Commencement Date”) and, subject to revocation, suspension or withdrawal, expires on **15 October 2022**.

Signed: _____

For and on behalf of the Commission for Communications Regulation

Date of Issue: _____

Part 1

Places at which the Licensee is authorised by this Licence to keep and have possession of Liberalised Apparatus

No.	Site I.D.	Easting	Northing

Part 2

The Liberalised Apparatus for wireless telegraphy to which this Licence applies

No.	Manufacturer	Component	Equipment No.

Part 3

Radio frequency bands in which the Liberalised Apparatus is authorised by this Licence to be used

The following frequency bands may be used for FDD mode operation:

Mobile Transmit	Paired with Base Station Transmit

Use of the frequency bands shall be in compliance with the Decision of 2012.

Part 4

Commitments made in the course of a comparative evaluation selection procedure forming part of the Existing Licence to which this Liberalised 2.1 GHz Band Interim Licence relates

GIVEN under the official seal of the Commission for Communications Regulation,

[DATE] 2020

[NAME of COMMISSIONER]

For and on behalf of the Commission for Communications Regulation

The Minister for Communications, Climate Action and Environment, in accordance with Section 37 of the Communications Regulation Act, 2002, consents to the making of the foregoing Regulations.

GIVEN under the Official Seal of the Minister for Communications, Climate Action and Environment,

[DATE] 2020

[NAME OF MINISTER]

Minister for Communications, Climate Action and Environment.

Explanatory Note

(This note is not part of the Instrument and does not purport to be a legal interpretation.) These Regulations prescribe matters in relation to licences for apparatus for wireless telegraphy for terrestrial systems capable of providing Electronic Communications Services in the 2.1 GHz Band.

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Annex: 3 Application Form¹⁵⁵

Applicants must complete Parts 1, 2 and 3 of this Application Form. Any additional documentation required to be supplied by the Applicant as part of its Application is to be appended to this Application Form.

Part 1: Administrative Information

For an Application to be complete, the administrative information listed in Table A3.1 below must be provided.

Appropriate evidence of the authorisation of Authorised Agent(s), as per paragraph 3.41 of the IM, must also be attached hereto.

Note that the Applicant name provided will be that to whom licences will be awarded where relevant. Contact details for Authorised Agents are those that will be used by ComReg for circulating Bidder Materials for the Award Process and for contacting the Bidder during the Award Process if necessary.

Table A3.1: Administrative information

Information required	Information provided
Name of Applicant*	Name:
Complete postal address of registered office or, if it does not have a registered office, the principal place where it carries on business and, if different, address to which all communications will be sent regarding the Award Process	Address 1:
	Address 2 (if different):

¹⁵⁵ A writeable PDF format of this form will be made available on the ComReg website.

Telephone number for Applicant	Telephone:
Bank details of Applicant (for the purpose of returning part or all of the Applicant's Deposit where applicable)	Name of bank and address of relevant branch: Account Number: Sort Code: BIC Code: IBAN No:
Name of Applicant's Authorised Agent 1** (Block capitals)	Name:
Position of Applicant's Authorised Agent 1	Position:
Telephone numbers and e-mail address of Applicant's Authorised Agent 1	Telephone (fixed): Telephone (mobile): Email:
Specimen signature of Applicant's Authorised Agent 1 Witnessed By:	Signature 1: Name: Position:

	Signature:
Name of Applicant's Authorised Agent 2*** (Block capitals)	Name:
Position of Applicant's Authorised Agent 2	Position:
Telephone numbers and e- mail address of Applicant's Authorised Agent 2	Telephone (fixed): Telephone (mobile): Email:
Specimen signature of Applicant's Authorised Agent 2 Witnessed By:	Signature: Name: Position: Signature:

* Note: In the case of Applicants that are bodies corporate, attach a certified copy of Certificate of Registration along with the constitution of the company or equivalent together with a certified translation thereof into English or Irish, where the original is not in English or Irish. The Company Secretary or authorised signatory is required to certify the copy.

** Note: Authorised Agents must be authorised to bind the Bidder and to take all decisions or communicate all decisions connected with the Auction on the Bidder's behalf including, but not limited to, the authority to submit Bids in respect of any of the Lots available in the Award Process and to commit to payment of the necessary amount if the Bidder is granted a Licence as a result of the outcome of the Award Process. The same applies with respect to Authorised Agent 2 where one is appointed (see Note below).

*** Note: Applicants can authorise another person (i.e. Authorised Agent 2) to act as an alternative Authorised Agent in case of unavailability of the primary Authorised Agent (i.e. Authorised Agent 1). In case of any duplication of documentation submitted (this would not include documentation requested by ComReg, or where an Applicant is replacing its Application in accordance with paragraph 3.118 of this IM) on behalf of the Bidder by different Authorised Agents, the documentation submitted by the first Authorised Agent would be considered as final and binding.

Part 2: Applicant Declaration

The terms “Award Rules”, “Associated Bidders”, “Applicant”, “Bidding Group”, “Connected Person”, “Confidential Information” and “Insider” for the purposes of this declaration shall be construed as defined in the Information Memorandum.

We, the undersigned, being Authorised Agents of [_____]
(the “**Applicant**”) hereby undertake, warrant and declare, and to the extent that anything contemplated hereunder remains to be done, covenant, both on our own behalf and on behalf of the Applicant, having made all reasonable inquiries that:

1. The Applicant is entitled to submit the Application and participate in the Award Process, and the Applicant has obtained all necessary declarations of consent, permissions and approvals.
2. The Applicant has ensured and will ensure that all information and all declarations contained in the Application and appendices attached thereto are correct and accurate.
3. The Applicant has and will ensure that, until public announcement by ComReg on the outcome of the Award Process, the Applicant discloses Confidential Information only to the extent it is necessary and then, save as expressly permitted by the Information Memorandum, only to other parties within the Applicant's own Bidding Group or to persons who, prior to such disclosure, are Insiders in relation to the same Applicant and that the Applicant shall take all reasonable measures with a view to ensuring that the person who receives such Confidential Information treats it as confidential at all times until public announcement by ComReg on the outcome of the Award Process.
4. The Applicant has ensured and will ensure that the Applicant, the Applicant's employees, board of directors (where Applicant is a body corporate) and persons connected with the Applicant or Insiders refrain from disclosing Confidential Information to parties other than as specified in paragraph 3 above and from exchanging Confidential Information with other parties regarding the Applicant's strategy for obtaining and use of the Licence or Licences until public announcement by ComReg on the outcome of the Award Process.
5. Save as expressly permitted by the Information Memorandum, the Applicant will ensure that the Applicant and any Connected Persons and any Insiders - shall refrain from entering into agreements or negotiations with a view to entering into agreements with other Interested Parties or their Connected Persons in relation to matters concerning the Award Process, including without

prejudice to the generality of the foregoing, agreements relating to spectrum, network or infrastructure sharing, from the time at which this Application is submitted until the public announcement on the outcome of the Award Process by ComReg.

6. The Applicant has ensured and will ensure that the Applicant - and, to the best knowledge of the Applicant, any Connected Persons and any Insiders - neither prior to the submission of the Application, nor after the submission thereof and until the public announcement on the outcome of the Award Process by ComReg, shall enter into agreements or establish any understanding with a provider of equipment or software which:
 - regulates such provider's possibility of supplying equipment or software to another Applicant or their Connected Persons concerning the planning, establishment or operation of a network using the frequencies dealt with in this Award Process, or
 - regulates the prices or other terms and conditions that a provider of equipment or software may offer another Applicant or their Connected Persons in connection with the planning, establishment or operation of a network using the frequencies dealt with in this Award Process.

The Applicant has ensured that agreements already entered into or understandings already established, as mentioned in this paragraph 6, have been terminated, and to the best knowledge of the Applicant, any Connected Persons and any Insider have ensured that any such agreements or understandings have been terminated.

7. The Applicant has ensured and will ensure that the Applicant - and, to the best knowledge of the Applicant, any Connected Persons and any Insider - does not enter into agreements or establish any understanding with a third party, either prior to or during the Award Process, for the access to or the use of the Applicant's network or networks using the frequencies dealt with in this Award Process, if the agreement or the understanding directs such third party not to participate or limits such third party's ability to participate in the Award Process.
8. The Applicant has ensured that agreements already entered into or understandings already established, as mentioned in paragraph 7, have been terminated, including to the best knowledge of the Applicant, any Connected Persons and any Insider have ensured such agreements or understandings have been terminated.
9. The Applicant has ensured and will ensure that the Applicant – and, to the best knowledge of the Applicant, any Connected Persons and any Insiders – both

prior to and after the submission of an Application and until the public announcement on the outcome of the Award Process by ComReg, refrains from any action that could have an adverse effect on the Award Process.

10. The Applicant shall comply with the Award Rules as contained in the Information Memorandum as well as the provisions of Chapter 5 of the Information Memorandum at all times and shall procure that its personnel, Insiders and Connected Persons, to the extent appropriate, shall also comply with the Award Rules and the provisions of Chapter 5 of the Information Memorandum from the date of publication of the Information Memorandum until the commencement of the Licences.
11. The Applicant has ensured and will ensure that, prior to the submission of its Application, it has taken all reasonable measures with a view to identifying its Connected Persons and Associated Bidders.
12. The Applicant will ensure that, in accordance with Section 3.3 of the Information Memorandum, after submitting its Application all material changes to its ownership structure are notified to ComReg.
13. Save as disclosed in an appendix attached to this Declaration, the Applicant (i) is not, or, in case the Applicant is a partnership, a joint venture or equivalent, each of the relevant partners or participants is not and is not expected to be subject to an insolvency process including, without prejudice to the generality of the foregoing, liquidation, examinership, receivership, bankruptcy, winding-up proceedings or equivalent proceedings in other jurisdictions and (ii) is capable of paying its debts as they fall due.
14. Save as disclosed in an appendix attached to this Declaration, the Applicant is not, or, in case the Applicant is a partnership, a joint venture or equivalent, each of the relevant partners or participants is not and is not expected to be involved in any disputes which may in any material and adverse way affect the Applicant's possibility of complying with the terms of any Licence, if the Applicant is awarded such Licence.
15. The Applicant agrees that any disclosure made under paragraph 13 and/or paragraph 14 above must contain sufficiently clear and detailed information to allow ComReg to assess the Applicant's capacity to participate in the Award Process, to comply with the Award Rules and the provisions of Chapter 5 of the Information Memorandum and to comply with the terms of any Licence. The Applicant agrees that ComReg's decision further to any assessment in this respect shall be final and that ComReg reserves the right to, where necessary and proportionate, seek further information or clarification from an

Applicant, to specify the level of detail required and the timescales within which it must be provided. The Applicant agrees that any failure to cooperate fully with this disclosure requirement may result in an Applicant's Application being deemed invalid or in subsequent disqualification of the Applicant from the Award Process.

- 16. The Applicant agrees that, even if they are unsuccessful in becoming a Bidder or withdraw their Application, they remain bound by the Award Rules and the provisions of Chapter 5 of the Information Memorandum, including those on confidentiality and Bidder behaviour, until a public announcement on the outcome of the Award Process is made by ComReg.
- 17. The Applicant agrees to take part and be bound by any Transition Plan that may be defined by ComReg with regard to the Award Spectrum.
- 18. The Applicant agrees that this Declaration is without prejudice to its legal obligations more generally, including those relating to any duty of confidence and its obligations under competition law.

Applicant Name: _____

For and on behalf of the Applicant (**Authorised Agent 1**):

Name in block capitals: _____

Date (DD/MM/YYYY):

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Where the Applicant has authorised a second person to act as Authorised Agent:-

Applicant Name: _____

For and on behalf of the Applicant (**Authorised Agent 2**):

Name in block capitals: _____

Date (DD/MM/YYYY):

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If the Applicant is a partnership, a joint venture or equivalent, the Declaration must also be signed by the relevant partners or participants:

As partner/participant:

(Signature)

Name in block capitals: _____

Date (DD/MM/YYYY):

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Part 3: Initial Bid Form

The submission of this Initial Bid Form as part of a complete Application represents a binding offer to pay the SAF and annual SUFs linked to each of the Lots specified herein in exchange for a Licence for those Lots. The Initial Bid Form, including Lots in all Lot Categories, Reserve Prices and associated Eligibility Points are presented in Tables A3.3 and A3.4 below. Note that for an Initial Bid Form to be valid, it must:

- adhere to the Award Rules on Competition Caps; and
- be accompanied by a Deposit of an amount no lower than the sum of the Reserve Prices of Lots requested by the Applicant in Tables A3.3 and A3.4 below.

All Deposits are to be paid into ComReg's Nominated Bank Account by the deadline of *[a date and time will be specified in the final Information Memorandum]*. The details of ComReg's Nominated Bank Account are as follows:

[Bank details will be provided in the final Information Memorandum]

If making a bank transfer/EFT, please ensure that:

- Reference is "MBSA2 Award"; and
- Your Bank quotes your ComReg account number (if an existing ComReg account holder) in making the transfer to ComReg.

Table A3.2. Summary Information

Information Required	Information Provided
Applicant Name:	
Total no. Lots applied for:	
Total amount of Deposit:	

Table A3.3: Frequency specific A-Lots available in the Award Process

Lot Category	Frequency range	Licence duration	Time Slice	Lots available	Lot size	Reserve Price per Lot (€)	Annual SUF per Lot (€)	Eligibility Points/ Lot	Number of Lots applied for per Lot Category
A2.3L/1	2 300 - 2 330 MHz	01/12/2020 to 11/03/2027	1	1	30 MHz	963,000	274,082	6	
A2.3L/2	2 300 - 2 330 MHz	12/03/2027 to 30/11/2040	2	1	30 MHz	1,090,000	274,082	6	
A2.3U/1	2 390 - 2 400 MHz	01/12/2020 to 11/03/2027	1	1	10 MHz	432,000	123,029	2	
A2.3U/2	2 390 - 2 400 MHz	12/03/2027 to 30/11/2040	2	1	10 MHz	489,000	123,029	2	
A2.6TL/1	2 570 - 2 575MHz unpaired	01/12/2020 to 11/03/2027	1	1	5 MHz	216,000	61,515	1	
A2.6TL/2	2 570 - 2 575MHz unpaired	12/03/2027 to 30/11/2040	2	1	5 MHz	245,000	61,515	1	
A2.6TU/1	2 615 - 2 620 MHz unpaired	01/12/2020 to 11/03/2027	1	1	5 MHz	216,000	61,515	1	

¹⁵⁶ As detailed in subsection 2.3.3 of the Information Memorandum, the commencement and expiry dates of Lots in Time Slice 1 may be adjusted by ComReg.

A2.6TU/2	2 615 - 2 620 MHz unpaired	12/03/2027 to 30/11/2040	2	1	5 MHz	245,000	61,515	1	
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Table A3.4: Frequency generic B-Lots available in the Award Process

Lot Category	Frequency range	Licence duration ¹⁵⁷	Time Slice	Number of Lots	Lot size	Reserve Price per Lot (€)	Annual SUF per Lot (€)	Eligibility Points/Lot	Number of Lots applied for per Lot Category
B700	703-733 MHz paired with 758- 788 MHz	01/12/2020 to 30/11/2040	1 & 2	6	2 × 5 MHz	8,755,000	1,168,778	4	
B2.1/1	1 920 – 1 980 MHz paired with 2 110 – 2 170 MHz ¹⁵⁸	16/10/2022 to 11/03/2027	1	9	2 × 5 MHz	1,416,000	615,147	2	
B2.1/2	1 920 – 1 980 MHz paired with 2 110 – 2 170 MHz	12/03/2027 to 30/11/2040	2	12	2 × 5 MHz	2,447,000	615,147	2	
B2.3/1	2 330 – 2 390 MHz	01/12/2020 to 11/03/2027	1	12	5 MHz	216,000	61,515	1	
B2.3/2	2 330 – 2 390 MHz	12/03/2027 to 30/11/2040	2	12	5 MHz	245,000	61,515	1	

¹⁵⁷ Note that, as discussed in subsection 2.3.3, the commencement and expiry dates of Lots in Time Slice 1 may be adjusted by ComReg.

¹⁵⁸ This does not include the three lots currently assigned to Eir.

Lot Category	Frequency range	Licence duration ¹⁵⁷	Time Slice	Number of Lots	Lot size	Reserve Price per Lot (€)	Annual SUF per Lot (€)	Eligibility Points/Lot	Number of Lots applied for per Lot Category
B2.6F/1	2 500 – 2 570 MHz paired with 2 620 – 2 690 MHz	01/12/2020 to 11/03/2027	1	14	2 × 5 MHz	432,000	123,029	2	
B2.6F/2	2 500 – 2 570 MHz paired with 2 620 – 2 690 MHz	12/03/2027 to 30/11/2035	2	14	2 × 5 MHz	489,000	123,029	2	
B2.6T/1	2 575 – 2 615 MHz	01/12/2020 to 11/03/2027	1	8	5 MHz	216,000	61,515	1	
B2.6T/2	2 575 – 2615 MHz	12/03/2027 to 30/11/2035	2	8	5 MHz	245,000	61,515	1	

Applicant Name: _____

(Signature of Authorised Agent)

Name in block capitals: _____

Date (DD/MM/YYYY):

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Application Checklist

Tick the boxes to ensure that all the required information is included in your Application. A complete Application must consist of the following:

Part 1: Original Administrative Information - All sections of Table A3.1 completed and signed.

- Appropriate evidence for authorisation of Authorised Agents as specified in paragraph 3.41 of the Information Memorandum
- An Ownership Structure Document and accompanying document in accordance with paragraphs 3.46 and 3.47 of the Information Memorandum

Part 2: Original Applicant Declaration signed

Part 3: Original Initial Bid Form completed and signed

Note that, for an Application to be considered complete, five identical paper copies of the above documents should also be provided with the Application. The original version of the Application Form should be identified as such. See below for further details.

Application Procedure

In order to participate as a Bidder in the Award Process, an Interested Party must submit the following original documents in paper format:

- a completed and signed Application Form;
- an Ownership Structure Document along with appropriate certification in relation to same in accordance with paragraphs 3.46 and 3.47 of the IM; and
- appropriate evidence in respect of Authorised Agents in accordance with paragraph 3.41 of the IM.

An Interested Party must also submit five identical paper copies of each of the above documents. The original documents should be identified as such.

The container(s) in which the above paper documentation are submitted must not in any way disclose the identity of the Interested Party.

ComReg will only accept Applications submitted between **09.00 hours and 17.30 hours** (Irish time) on any of the following five Working Days:

[five dates will be specified in the final Information Memorandum]

Interested Parties must make appointments with ComReg to submit their Applications. To make an appointment, an Interested Party must contact **Mr Joseph Coughlan or Mr. Patrick Bolton** by telephone between **10:00 to 13:00 and 14:00 to 16.00 hours (Irish time)** on Working Days between *[dates will be specified in the final Information Memorandum]* inclusive.

The number for telephoning Mr. Coughlan or Mr. Bolton is: *[number will be specified in final IM]*. ComReg will record all phone calls made or received during the Award Process in order to manage technical issues and risks arising, and to ensure the integrity and administrative efficiency of the Award Process. These recordings, which shall be stored securely, shall be retained and used only for these purposes and shall be deleted once they are no longer required by ComReg for these purposes. In the event of a dispute arising ComReg may seek to rely on the contents of these recordings.

All submitted Applications will be date and time stamped upon being received by ComReg.

Once an Application is received by ComReg, the Interested Party is deemed to be an Applicant.

Each Applicant will be given a receipt acknowledging the submission of its Application.

An Application can be replaced at any time up to 16.00 hours (Irish time) on the Application Date, *[date will be specified in the final Information Memorandum]*. In the event that an Applicant submits more than one Application prior to 16.00 hours on the Application Date, only the latest Application received from that Applicant will be taken into consideration.

On the submission of a second or subsequent Application prior to the Application Date, the Applicant must return the receipt for the prior Application to ComReg. This receipt will be endorsed to indicate that the earlier Application has been superseded and will not be evaluated. However, any superseded Applications will not be returned until after the Qualification Stage of the Award Process.

No Applications will be opened by ComReg before *[a date will be specified in the final Information Memorandum]* (the Application Date). All Applications will be opened at the same time and place and in the presence of an independent auditor.

The deadline for receipt of all Deposits, in cleared funds, will be **23:59 hours (Irish time)** on *[a date will be specified in the final Information Memorandum]* (The Application Date).

Annex: 4 Rollout and Coverage – Specific Locations

Business and Technology Parks

A 4.1 The IDA provides a list of 31 Business and Technology Parks and 9 Strategic Sites, absent other official sources, these locations are used to identify the locations of business and technology parks. The obligation thus includes adjacent business and technology parks to those of the IDA.

A 4.2 Table A4.1 below contains a list of the IDA Business and Technology Parks and strategic sites, however the coverage obligation also applies to adjacent business and technology parks as detailed in the Specific Location Boundary Files, where large green areas of no development have been removed.

Table A4.1: IDA Business and Technology Parks

Business and Technology Parks	Location	Business and Technology Parks	Location
IDA Business and Technology Park			
1. Dublin/East - College Park Dublin	College Park, Dublin	17. South East - Clonmel Business & Technology Park	Ballingarrane, Clonmel, Tipperary
2. Dublin/East - Grange Castle Business Park	Grange Castle, Dublin	18. South East - Dungarvan Business & Technology Park	Lisfennel, Dungarvan, Waterford
3. Mid East - Arklow Business & Technology Park	Ballynattin, Arklow, Wicklow	19. South East - Kilkenny Business & Technology Park	Loughboy, Kilkenny
4. Mid East - Navan Business & Technology Park	Athlumney, Navan, Meath	20. South East - Waterford Business & Technology Park, Butlerstown	Butlerstown, Waterford
5. Mid West - National Technology Park (NTP), Limerick	Plassey, Limerick	21. South East - Wexford Business & Technology Park	Sinnottstown, Wexford
6. Midlands - Athlone Business & Technology Park	Dublin Road, Athlone, Westmeath	22. South West - Carrigtwohill Business & Technology Park	Carrigtwohill, Cork
7. Midlands - Mullingar Business & Technology Park	Ardmore, Mullingar, Westmeath	23. South West - Cork Business & Technology Park	Model Farm Road, Cork
8. Midlands - Portlaoise Business & Technology Park	Mountrath Road, Portlaoise, Laois	24. South West - Fermoy Business & Technology Park	Fermoy, Cork
9. Midlands - Tullamore Business & Technology Park	Srah, Tullamore, Offaly	25. South West - Kerry Business & Technology Park	Tralee, Kerry
10. North East - Cavan Business & Technology Park	Killygarry, Cavan	26. South West - Kilbarry Business & Technology Park	Kilbarry, Cork

Business and Technology Parks	Location	Business and Technology Parks	Location
11. North East - Drogheda Business & Technology Park	Donore Road, Drogheda, Louth	27. West - Ballinasloe Business & Technology Park	Roscommon Road, Ballinasloe, Galway
12. North East - Dundalk Business & Technology Park	Finnabair, Dundalk, Louth	28. West - Castlebar Business & Technology Park	Drumconlan, Castlebar, Mayo
13. North East - Monaghan Business & Technology Park	Knockaconny Monaghan	29. West - Galway Business & Technology Park	Parkmore, Galway
14. North West - Carrick on Shannon Business & Technology Park	Keenaghan, Carrick-on-Shannon, Leitrim	30. West - Roscommon Business & Technology Park	Gallowstown, Roscommon
15. North West - Letterkenny Business & Technology Park	Lisnennan, Letterkenny, Donegal	31. West - Tuam Business & Technology Park	Dunmore Road, Tuam, Galway
16. North West - Sligo Business & Technology Park	Finisklin, Sligo		
IDA Strategic Site			
1. Mid East - Strategic Site Greystones	Charlesland, Greystones, Wicklow	6. South West - Strategic Site Carrigtwohill	Ballyadam, Carrigtwohill, Cork
2. Mid West - Strategic Site on the National Technology Park, Limerick	Plassey, Limerick	7. South West - Strategic Site Ringaskiddy, County Cork	Ringaskiddy, Cork
3. Mid West - Strategic Site, Raheen Business Park, Limerick	Raheen Business Park, Limerick	8. West - Strategic Site Athenry	Athenry, Galway
4. North East - Strategic Site Dundalk - Dundalk Science & Technology Park	Mullagharlin, Dundalk, Louth	9. West - Strategic Site Oranmore	Oranmore, Galway
5. South East - Strategic Site, Belview, Co. Kilkenny	Belview, Waterford Port, Kilkenny/Waterford		

Source: IDA, <https://www.idaireland.com/how-we-help/property>.

Hospitals

A 4.3 Table A4.2 below contains a list of public and private hospitals obtained from the Health Service Executive. Where a hospital is located in more than one location, the coverage obligations apply to each of these locations.

Table A4.2: Public and Private Hospitals

Hospitals	Location	Hospitals	Location
Public Hospital			
1. Bantry General Hospital	Cork	25. National Maternity Hospitals, Holles Street	Dublin
2. Beaumont Hospital	Dublin	26. Nenagh Hospital: UL Hospitals	Tipperary
3. Cappagh National Orthopaedic Hospital	Dublin	27. Our Lady Of Lourdes Hospital, Drogheda	Louth
4. Cavan Monaghan Hospital	Cavan, Monaghan	28. Our Lady's Hospital, Navan	Meath
5. Children's University Hospital, Temple Street	Dublin	29. Our Lady's Children's Hospital Crumlin	Dublin
6. Connolly Hospital Blanchardstown	Dublin	30. Portiuncula Hospital, Ballinasloe	Galway
7. Coombe Women's Hospital	Dublin	31. Roscommon County Hospital	Roscommon
8. Cork University Hospital	Cork	32. Rotunda Hospital	Dublin
9. Cork University Maternity Hospital	Cork	33. Royal Victoria Eye & Ear Hospital, Dublin	Dublin
10. Croom Hospital: UL Hospitals	Limerick	34. Sligo General Hospital	Sligo
11. Ennis Hospital: UL Hospitals	Clare	35. South Infirmary-Victoria Hospital, Cork	Cork
12. Galway University Hospitals	Galway	36. South Tipperary General Hospital	Tipperary
13. Kerry General Hospital	Kerry	37. St Columcille's Hospital, Loughlinstown	Dublin
14. Letterkenny University Hospital	Donegal	38. St James's Hospital	Dublin
15. Lourdes Orthopaedic Hospital, Kilcreene	Kilkenny	39. St John's Hospital Limerick	Limerick
16. Louth County Hospital, Dundalk	Louth	40. St Luke's General Hospital Carlow / Kilkenny	Kilkenny
17. Mallow General	Cork	41. St Luke's Hospital, Rathgar (Cancer Services)	Dublin
18. Mater Misericordiae University Hospital	Dublin	42. St Michael's, Dun Laoghaire	Dublin
19. Mayo General Hospital	Mayo	43. St Vincent's University Hospital, Elm Park	Dublin
20. Mercy University Hospital, Cork	Cork	44. Tallaght Hospital	Dublin
21. Midland Regional Hospital Mullingar	Westmeath	45. University Hospital Limerick	Limerick
22. Midland Regional Hospital Portlaoise	Laois	46. University Maternity Hospital: UL Hospitals	Limerick
23. Midland Regional Hospital Tullamore	Offaly	47. University Hospital Waterford	Waterford
24. Naas General Hospital	Kildare	48. Wexford General Hospital	Wexford

Hospitals		Hospitals	
Location		Location	
Private Hospital			
1. Aut Even Hospital	Kilkenny	10. Mount Carmel Hospital	Dublin
2. Barringtons Hospital	Limerick	11. Mater Private Hospital	Dublin, Cork
3. Beacon Hospital	Dublin	12. St. Joseph's Hospital	Sligo
4. Blackrock Clinic	Dublin	13. St John of God Hospital	Dublin
5. Bon Secours Health System	Cork, Dublin, Galway, Kerry	14. St Patrick's University Hospital	Dublin
6. Clane General Hospital	Kildare	15. St Vincent's Private Hospital	Dublin
7. Galway Clinic	Galway	16. Sports Surgery Clinic	Dublin
8. Hermitage Medical Centre	Dublin	17. Whitfield Clinic	Waterford
9. Highfield Healthcare	Dublin		

Source: HSE, <https://www.hse.ie/eng/services/list/3/acutehospitals/hospitals/hospitallist.html>, <https://www.hse.ie/eng/services/list/1/schemes/cbd/acchealthcareireland/>.

Higher Education Campuses

A 4.4 TableA4.3 below contains a list of higher education institutions encompassing: universities, institutes of technology and other colleges as identified by the Higher Education Authority. Where an institution is located in more than one location, the coverage obligations apply to each of these locations.

Table A4.3: Higher Education Campuses

Higher Institution	Education Location	Higher Institution	Education Location
University			
1. Dublin City University	Dublin	5. Trinity College Dublin	Dublin
2. University College Cork	Cork	6. University College Dublin	Dublin
3. National University of Ireland, Galway	Galway	7. University of Limerick	Limerick
4. Maynooth University - Kildare	Kildare	8. TU Dublin	Dublin
Institute of Technology			
1. Athlone Institute of Technology	Westmeath	7. Institute of Technology Sligo	Sligo
2. Cork Institute of Technology	Cork	8. Institute of Technology Tralee	Kerry
3. Dun Laoghaire Institute of Art and Design	Dublin	9. Letterkenny Institute of Technology	Donegal
4. Dundalk Institute of Technology	Louth	10. Limerick Institute of Technology	Limerick
5. Galway-Mayo Institute of Technology	Galway	11. Waterford Institute of Technology	Waterford
6. Institute of Technology Carlow	Carlow		
Other College			
1. Royal College of Surgeons in Ireland	Dublin	4. National College of Art and Design	Dublin
2. Royal Irish Academy	Dublin	5. Mary Immaculate College	Limerick
3. St Angela's College	Sligo		

Source: HEA, <http://hea.ie/higher-education-institutions/?v=l>.

Ports (Air and Sea)

A 4.5 Table A4.4 below contains the list of passenger focussed transport provided by airports and seaports. The list of airports was obtained from the DTTS, and the list of passenger seaports was obtained from the IMDO. Where a port as listed below contains more than one location, the coverage obligations apply to each of these locations as detailed in the Specific Location Boundary Files.

Table A4.4 Ports (Air and Sea)

Ports	Location	Ports	Location
Airport			
1. Dublin Airport	Dublin	5. Ireland West Airport Knock	Mayo
2. Cork Airport	Cork	6. Kerry Airport	Kerry
3. Shannon Airport	Clare	7. Waterford Airport	Waterford
4. Donegal Airport	Donegal		
Passenger Seaport			
1. Bantry Bay Port Company	Cork	5. Port of Galway	Galway
2. Dublin Port Company	Dublin	6. Rosslare Europort	Wexford
3. Dun Laoghaire Port Company	Dublin	7. Port of Waterford	Waterford
4. Port of Cork	Cork		

Source: DTTS, <http://www.dttas.ie/aviation/airports>; IMDO, <http://www.dttas.ie/aviation/airports>

Principal Bus Stations

A 4.6 Table A4.5 below contains a list of Bus Éireann's 16 principal bus stations which also include information offices.

Table A4.5: Principal Bus Stations

Bus Station	Location	Bus Station	Location
1. Athlone	Southern Station Road, Athlone	9. Galway	Ceannt Station, Eyre Square, Galway
2. Ballina	Kevin Barry Street, Ballina	10. Killarney	Fairhill, Killarney
3. Cavan	Farnham Street, Cavan	11. Letterkenny	Port Road, Letterkenny
4. Cork	Parnell Place, Cork	12. Limerick	Colbert Station, Parnell Street, Limerick
5. Drogheda	Donore Road, Drogheda	13. Monaghan	North Road, Monaghan
6. Dundalk	Long Walk, Dundalk	14. Sligo	Lord Edward Street, Sligo
7. Dublin	Busáras Central Station, Store Street, Dublin	15. Tralee	Casement Station, Tralee
8. Ennis	Clonroad More, Ennis	16. Waterford	The Quay, Waterford

Source: Bus Éireann, <https://www.buseireann.ie/pdf/1473240111-Network-Map.pdf>

Train Stations

A 4.7 Table A4.6 below contains a list of 144 train stations by descending passenger numbers¹⁵⁹ as obtained from the NTA.

Table A4.6: Train Stations

Train Station	Location	Train Station	Location
1. Connolly	Dublin	73. M3 Parkway	Dublin
2. Pearse	Dublin	74. Sligo	Sligo
3. Heuston	Kildare	75. Longford	Longford
4. Tara Street	Dublin	76. Killarney	Kerry
5. Grand Canal Dock	Dublin	77. Kilcock	Kildare
6. Dun Laoghaire	Dublin	78. Dunboyne	Meath
7. Cork	Cork	79. Adamstown	Dublin
8. Bray	Dublin	80. Glounthaune	Cork
9. Lansdowne	Dublin	81. Navan Road Parkway	Dublin
10. Malahide	Dublin	82. Wicklow	Wicklow
11. Maynooth	Kildare	83. Tralee	Kerry
12. Blackrock	Dublin	84. Waterford	Waterford
13. Greystones	Dublin	85. Manulla Junction	Mayo
14. Sydney Parade	Dublin	86. Enfield	Meath
15. Coolmine	Dublin	87. Ennis	Clare
16. Balbriggan	Dublin	88. Ballinasloe	Galway
17. Howth Junction and Donaghmede	Dublin	89. Hansfield	Dublin
18. Raheny	Dublin	90. Oranmore	Galway
19. Clontarf Rd	Dublin	91. Wexford	Wexford
20. Portmarnock	Dublin	92. Castlebar	Mayo
21. Limerick Junction	Tipperary	93. Clondalkin Fonthill	Dublin
22. Galway	Galway	94. Ballybrophy	Laois
23. Dalkey	Dublin	95. Carrick-on- Shannon	Leitrim
24. Docklands	Dublin	96. Muine Bheag	Carlow
25. Glenageary	Dublin	97. Edgeworthstown	Longford
26. Booterstown	Dublin	98. Carrigtwohill	Cork
27. Sallins and Naas	Kildare	99. Arklow	Wicklow
28. Skerries	Dublin	100. Clara	Offaly
29. Drumcondra	Dublin	101. Roscommon	Roscommon
30. Clonsilla	Dublin	102. Westport	Mayo
31. Kilbarrack	Dublin	103. Gorey	Wexford
32. Howth	Dublin	104. Dromod	Leitrim
33. Mallow	Cork	105. Gormanston	Meath
34. Bayside	Dublin	106. Monasterevin	Kildare

¹⁵⁹ By number of passengers boarding and alighting on 16 November 2017 as published in NTA's 'National Heavy Rail Census Report 2017'

Train Station	Location	Train Station	Location
35. Donabate	Dublin	107. Kilcoole	Wicklow
36. Newbridge	Kildare	108. Ballymote	Sligo
37. Shankill	Dublin	109. Ballina	Mayo
38. Harmonstown	Dublin	110. Boyle	Roscommon
39. Salthill and Monkstown	Dublin	111. Charleville	Cork
40. Clongriffin	Dublin	112. Templemore	Tipperary
41. Sandycove and Glasthule	Dublin	113. Claremorris	Mayo
42. Limerick	Limerick	114. Ballyhaunis	Mayo
43. Drogheda	Louth	115. Millstreet	Cork
44. Killester	Dublin	116. Enniscorthy	Wexford
45. Sandymount	Dublin	117. Rushbrooke	Cork
46. Ashtown	Dublin	118. Castlereagh	Roscommon
47. Portlaoise	Laois	119. Collooney	Sligo
48. Leixlip Louisa Bridge	Kildare	120. Rathdrum	Dublin
49. Killiney	Dublin	121. Woodlawn	Galway
50. Sutton	Dublin	122. Thomastown	Kilkenny
51. Castleknock	Dublin	123. Sixmilebridge	Clare
52. Rush and Lusk	Dublin	124. Rathmore	Kerry
53. Kildare	Kildare	125. Banteer	Cork
54. Athlone	Westmeath	126. Nenagh	Tipperary
55. Seapoint	Dublin	127. Craughwell	Galway
56. Carlow	Carlow	128. Carrigaloe	Cork
57. Portarlinton	Laois	129. Farranfore	Kerry
58. Leixlip Confey	Kildare	130. Clonmel	Tipperary
59. Thurles	Tipperary	131. Fota	Cork
60. Tullamore	Offaly	132. Rosslare Strand	Wexford
61. Midleton	Cork	133. Foxford	Mayo
62. Mullingar	Westmeath	134. Roscrea	Tipperary
63. Littleisland	Cork	135. Attymon	Galway
64. Dundalk	Louth	136. Gort	Galway
65. Hazelhatch and Celbridge	Kildare	137. Rosslare Euro Port	Wexford
66. Broombridge	Dublin	138. Castleconnell	Limerick
67. Cobh	Cork	139. Cahir	Tipperary
68. Athenry	Galway	140. Birdhill	Tipperary
69. Kilkenny	Kilkenny	141. Carrick-on-Suir	Tipperary
70. Athy	Kildare	142. Ardahan	Galway
71. Parkwest and Cherry Orchard	Dublin	143. Cloughjordan	Tipperary
72. Laytown	Meath	144. Tipperary	Tipperary

Source: National Transport Authority, 'National Heavy Rail Census Report 2017', published July 2018, https://www.nationaltransport.ie/wp-content/uploads/2018/08/National_Heavy_Rail_2018_V8_Web.pdf

Visitor Attractions - Information Centres

A 4.8 Table A4.7 below contains a list of the top 21 visitor attractions (fee charging and free of charge) by visitor numbers in 2017, as obtained from Fáilte Ireland.

Table A4.7: Visitor Attraction – Information Centres

Visitor Attraction	Location	Visitor Attraction	Location
Fee Charging			
1. Guinness Storehouse	Dublin	12. Blarney Castle and Gardens	Cork
2. Cliffs of Moher Visitor Experience	Clare	13. Kilmainham Gaol	Dublin
3. Dublin Zoo	Dublin	14. Kilkenny Castle	Kilkenny
4. National Aquatic Centre	Dublin	15. Rock of Cashel	Tipperary
5. Book of Kells	Dublin	16. Dublin Castle	Dublin
6. Tayto Park	Meath	17. Bunratty Castle and Folk Park	Clare
7. St Patrick's Cathedral	Dublin	18. Old Jameson Distillery	Dublin
8. Kylemore Abbey & Gardens	Galway	19. Brú na Bóinne Newgrange	Meath
9. Muckcross House Gardens and Traditional Farm	Kerry	20. Christ Church Cathedral	Dublin
10. Powerscourt Gardens and Waterfall	Wicklow	21. Glenveagh Castle and Grounds	Donegal
11. Fota Wildlife Park	Cork		
Free of Charge			
1. National Gallery of Ireland	Dublin	12. National Museum of Ireland - Natural History, Merrion St	Dublin
2. Castletown House Parklands	Kildare	13. Kilkenny Castle Parklands	Kilkenny
3. Glendalough Site	Wicklow	14. Chester Beatty Library	Dublin
4. National Botanic Gardens	Dublin	15. National Museum of Ireland - Decorative Arts and History, Collins Barracks	Dublin
5. DLR Lexicon1	Dublin	16. Connemara National Park	Galway
6. Irish Museum of Modern Art	Dublin	17. The National Library of Ireland	Dublin
7. Doneraile Wildlife Park	Cork	18. Crawford Art Gallery	Cork
8. National Museum of Ireland - Archaeology, Kildare St	Dublin	19. Malin Head Viewing Point	Donegal
9. Science Gallery at Trinity College Dublin	Dublin	20. Dublin City Gallery The Hugh Lane	Dublin
10. Farmleigh	Dublin	21. Sliabh Liag Cliffs	Donegal
11. Newbridge Silverware Museum of Style Icons	Kildare		

Source: Fáilte Ireland, 'TOURISM FACTS 2017', published July 2018, http://www.failteireland.ie/FailteIreland/media/WebsiteStructure/Documents/3_Research_Insights/5_International_Tourism_Trends/Tourism-Facts-2017_2.pdf?ext=.pdf

Geographic Coordinates

A 4.9 For the purposes of assessing compliance with the Coverage obligation at specific Locations, ComReg provides the geographic coordinates and Specific

Location Boundary Files for each specific location across the 7 categories on its Multi Band Spectrum Award webpage¹⁶⁰.

A 4.10 The Geographic coordinates of the specific locations and the Specific Location Boundary files were derived using the following methodology:

- Locations for each of the categories were obtained from the authoritative sources referenced in the above tables.
- Satellite images were obtained for each specific location using Google maps.
- Areas encompassed by the outdoor coverage obligations were identified using the criteria tabled below:

Table A4.8: Criteria (Outdoor coverage at/around)

Category	Criteria (outdoor coverage at/around)
Business and Technology Parks	Buildings, the adjacent carparks and thorough fares within, as well as those adjacent to IDA Business and Technology Parks and Strategic Sites.
Hospitals	Hospital's buildings, adjacent car parks and key thoroughfares.
Higher Education Campuses	Institution's buildings (including accommodation), adjacent carparks and key thoroughfares.
Ports	Airports - areas where passengers will be waiting, embarking or disembarking, adjacent short term car parks and key passenger thoroughfares. Passenger seaports - areas where passengers will be waiting, embarking or disembarking, adjacent car parks and key passenger thorough fares.
Principal Bus Stations	Areas where passengers will be waiting, embarking or disembarking, and adjacent carparks.
Train Stations	Areas where passengers will be waiting, embarking or disembarking (platforms), and adjacent carparks
Visitor Attractions – Visitor Centres	Visitor Centre

- Coordinates for the identified areas were mapped using visuals from the satellite images and QGIS. Due to the angle from which the satellite images may have been projected, the coordinates may vary slightly from the actual coordinates (e.g. mapped boundaries produced by the coordinates may vary from the actual physical boundaries).

A 4.11 The Specific Location Boundary Files for each location included in the coverage obligations can be downloaded in .shp or shape files from <https://www.comreg.ie/industry/radio-spectrum/spectrum-awards/proposed->

¹⁶⁰ <https://www.comreg.ie/industry/radio-spectrum/spectrum-awards/proposed-multi-band-spectrum-award/>

[multi-band-spectrum-award/](#).

Annex: 5 Worked Example of Activity Rules for the Primary Bid Rounds and Caps on Supplementary Bids

A 5.1 This annex presents a worked example¹⁶¹ to illustrate the mechanics of the Main Stage, including the Primary Bid Rounds and the Supplementary Bids Round. Bidders should note that the Electronic Auction System (EAS) will automatically compute a number of calculations for assisting with bidding in the Auction (such as Bid Amounts for the Primary Bid Rounds, required Chain Bids, floors and caps on Supplementary Bids). Prior to the start of the Auction (if any) ComReg will schedule at least one mock Auction for Bidders to facilitate their understanding of practicalities of participating in the award.

A 5.2 The Supplementary Bids Round example is shown in several variations to illustrate the application of the caps on Supplementary Bids in different scenarios.

A 5.3 The first part of the example shows how a Bidder can state its demand for a Package of Lots in Primary Bid Rounds and switch to bidding for different Packages of Lots as Round Prices evolve, including:

- changing the number of Lots it bids for;
- switching between frequency bands; and
- using Relaxed Primary Bids.

A 5.4 The example then proceeds to illustrate the mechanics of the Supplementary Bids Round and the constraints that apply to Supplementary Bids.

A 5.5 Bidders will be assisted throughout the Auction by the EAS, which will automatically make certain calculations¹⁶² on behalf of the Bidder (e.g. calculating the Bid Amount and Eligibility associated with the Bidder's selected

¹⁶¹ Nothing in this example is intended to be illustrative of values that ComReg believes may be achieved in the Auction, how ComReg would determine Price Increments, in light of given levels of demand, or similar matters. The valuations, increments etc in the examples have been chosen for ease of illustration only.

¹⁶² With certain exceptions, including calculating the Bidder's surplus (as the EAS is not provided with the Bidder's valuations) or setting the level of Bids in the Supplementary Bids Round (which are at the discretion of the Bidder). As noted below, the EAS will however verify that Supplementary Bids comply with the Auction Rules.

Package of Lots during the Primary Bid Rounds, calculating any Chain Bids required when submitting a Relaxed Primary Bid, and calculating the relevant floors and caps that apply to Supplementary Bids) and will allow the Bidder to check this information before either confirming or amending its Bid decisions.

Set Up

A 5.6 The example presented in this annex is based on some simple assumptions about the Lot Categories available and about a particular Bidder's valuations for different packages.

A 5.7 For simplicity, the example assumes that the Bidder is only interested in Lots in the 700 MHz Duplex and the 2.1 GHz Band in both Time Slices.

A 5.8 In Bands where there are two Time Slices a suffix in brackets indicates which Time Slice is being referred to. Thus:

- a 2.1 GHz Band Block in Time Slice 1 is denoted as a 2.1 GHz Band (1) Lot; and
- a 2.1 GHz Band Block in Time Slice 2 is denoted as a 2.1 GHz Band (2) Lot.

A 5.9 Eligibility is calculated separately for each Time Slice. Let (x,y) denote Eligibility or Activity of a Package of Lots, where x is the Eligibility in Time Slice 1 and y is the Eligibility in Time Slice 2. Therefore:

- a 2.1 GHz Band (1) Lot has Eligibility of $(2,0)$;
- a 2.1 GHz Band (2) Lot has Eligibility of $(0,2)$; and
- a 700 MHz Duplex Lot has Eligibility of $(4,4)$.

A 5.10 Similarly, we denote the Bidder's Eligibility as a vector (x,y) , where x is the Bidder's Eligibility in Time Slice 1 and y is the Bidder's Eligibility in Time Slice 2.

A 5.11 All Lots included in this example are 2×5 MHz Lots of frequency-generic spectrum. As a result of the number of Lots included in the packages, and the Lot Categories included, there are no Bidding Restrictions in this example.

A 5.12 Suppose the Bidder is interested in the following Packages of Lots.

Table A5.1. Packages of Lots and corresponding valuations and Eligibility

Package	700 MHz Lots	2.1 GHz (1) Lots	2.1 GHz (2) Lots	Valuation (€)	Eligibility
A	3	3	6	1,300,000	(18,24)
B	2	5	8	1,291,000	(18,24)
C	2	5	3	1,125,000	(18,14)
D	2	4	4	1,121,000	(16,16)
E	1	4	4	970,000	(12,12)

A 5.13 In this example, the Bidder's Initial Bid is for Package of Lots B, so its Initial Eligibility is (18,24).

A 5.14 In this example, the Bidder will make decisions based on the 'surplus' of the Package of Lots that would be achieved were the Bidder to win the Package of Lots at the submitted Bid Amount. Surplus is calculated by subtracting the Bid Amount for a Package of Lots from the Bidder's valuation for that Package of Lots. For example, if the Bidder bids for Package of Lots A and the Bid Amount is €1,000,000, the surplus associated with the Bid is €1,300,000 – €1,000,000 = €300,000.

A 5.15 Defined in this way, the surplus represents the net return that the Bidder would expect if it won the Package of Lots and it were required to pay a Base Price exactly equal to the Bid Amount. In the price determination, Bid Amounts act as upper bounds on possible Base Prices, so the Base Price will be less than or equal to the Bid Amount. Therefore, the surplus is a lower bound on the net return that the Bidder would expect if it won the Package of Lots¹⁶³.

A 5.16 For the purposes of this example we assume that the Bidder bids according to its valuations, in the sense that:

- it will never submit a Bid for a Package of Lots with a Bid Amount that gives negative surplus, as this would entail the possibility of winning spectrum with a negative return;
- during the Primary Bid Rounds, when there are multiple Packages of Lots with positive surplus at current Round Prices, the Bidder would prefer to bid on the Package of Lots that has the highest surplus, as

¹⁶³ For simplicity, we ignore any Additional Price that the Bidder may have to pay following the Assignment Stage.

this gives the highest expected return¹⁶⁴; and

- during the Supplementary Bids Round, the Bidder submits Supplementary Bids for all Packages of Lots of interest with a Bid Amount equal to the Bidder's valuation for the corresponding Package of Lots.

Primary Bid Rounds

Initial Bid

A 5.17 During the Application Stage, Bidders must specify the number of Lots in each Lot Category they would want to acquire at Reserve Prices. The Package of Lots specified and corresponding total price is the Bidder's Initial Bid. The Reserve Price per Lot for each Lot Category used in this example are set out in the Table below. These Reserve Prices are for the purpose of illustration only, the Reserve Prices for the Award Process are detailed in Table A5.2.

Table A5.2. Reserve Prices

Lot Category	Reserve Price (€)
700 MHz Duplex	110,000
2.1 GHz Band (1)	25,000
2.1 GHz Band (2)	25,000

A 5.18 Based on these prices, the Bidder can calculate the surplus associated with each of the five Packages of Lots it is interested in. As explained in the previous section, the surplus is calculated as the Bidder's valuation for a Package of Lots minus the relevant Bid Amount for that Package of Lots (in this case, based on Reserve Prices). The surplus for each Package of Lots at Reserve Prices is shown in Table A5.3 below, with the Bidder's preferred Package¹⁶⁵ highlighted in green.

¹⁶⁴ We do not consider the possibility of ties as these do not arise in this example.

¹⁶⁵ Note that reference to a Bidder's preferred Package of Lots in this example means the Package of Lots that maximises the Bidder's surplus at given prices (e.g. Reserve Prices or prevailing Round Prices in the current Primary Bid Round). As the Primary Bid Rounds progress, the Bidder's preferred Package of Lots may change relative to the Package of Lots specified in its Initial Bid (or earlier Primary Bid Rounds), in line with changing relative prices.

Table A5.3. Bidder's preferences at Reserve Prices

Package	Eligibility	Valuation	Reserve Prices (€)	Surplus (€)
A	(18,24)	1,300,000	555,000	745,000
B	(18,24)	1,291,000	545,000	746,000
C	(18,14)	1,125,000	420,000	705,000
D	(16,16)	1,121,000	420,000	701,000
E	(12,12)	970,000	310,000	660,000

A 5.19 The Bidder would therefore want to be awarded Package B at Reserve Prices. This would be the Package of Lots it would include as its Initial Bid on the Application Form, with an associated Bid Amount of €545,000.

A 5.20 The Bidder's Initial Eligibility is therefore (18,24). That is, it has an Initial Eligibility of 18 for Time Slice 1 and 24 for Time Slice 2. This is equal to the sum of the Eligibility Points for all Lots included in Package B.

A 5.21 The Round Prices in the first Primary Bid Round are dependent on the level of Aggregate Demand for each Lot Category based on Initial Bids (i.e. the sum of the demand from all Bidders in their Initial Bids). For any Lot Category where there was excess demand (i.e. Aggregate Demand exceeded the number of Lots available) at Reserve Prices, the price per Lot would be increased for Round 1. For any Lot Category with no excess demand based on Initial Bids, the Round Price for the first Round would be equal to the Reserve Price for that Lot Category.

A 5.22 Suppose that the Initial Bids submitted resulted in excess demand for all three Lot Categories in which the Bidder is interested, so all three prices will be increased relative to the Reserve Prices for the first Primary Bid Round.

Table A5.4. Round 1 prices

Lot Category	Reserve Price (€)	Excess Demand	Round 1 Price (€)
700 MHz Duplex	110,000	Yes	120,000
2.1 GHz Band (1)	25,000	Yes	30,000
2.1 GHz Band (2)	25,000	Yes	30,000

The first Primary Bid Round

A 5.23 In the first Primary Bid Round, Bidders need to state their demand for Lots in the different Lot Categories at the Round 1 prices. The EAS will display Lot Category information and prices; Bidders simply need to select the number of Lots that they wish to bid for in each Lot Category.

A 5.24 Based on the Round 1 prices, the Bidder can calculate the surplus associated with each of the five Packages of Lots it is interested in. The surplus for each Package of Lots is shown in Table A5.5 below, with the Bidder's preferred Package of Lots at Round 1 prices highlighted in green.

Table A5.5. Bidder's preferences in Round 1

Package	Eligibility	Valuation	Package Price (€)	Surplus (€)
A	(18,24)	1,300,000	630,000	670,000
B	(18,24)	1,291,000	630,000	661,000
C	(18,14)	1,125,000	480,000	645,000
D	(16,16)	1,121,000	480,000	641,000
E	(12,12)	970,000	360,000	610,000

A 5.25 The Bidder would therefore, acting rationally, bid in the first Round for Package A as this maximises its surplus at the prevailing Round Prices. Upon entering this selection, the EAS would calculate and display the Bid Amount corresponding to this Package of Lots (€630,000) and the Eligibility of the

Package (18,24), allowing the Bidder to confirm the decision, or to change the selection if it so wished. The Activity of the Bid is equal to the Eligibility of the Initial Bid, so the Bidder maintains its Eligibility for the next Primary Bid Round.

A 5.26 From one Primary Bid Round to the next, a Bidder is free to change demand between different Lot Categories that cover different frequency bands (or between frequency-generic and frequency-specific or TDD and FDD Lots in the same frequency band) within the same Time Slice, provided that the Eligibility of the Package is no greater than the Bidder's Eligibility in either Time Slice.

A 5.27 In this example, the Bidder has opted to switch demand between Lot Categories in the first Round, bidding for Package A, rather than Package B as it did in its Initial Bid. Package A and Package B have the same Eligibility in both Time Slices, so the Activity of the Bid is equal to the Bidder's Eligibility at the start of the Round. Therefore, the Bidder maintains its Eligibility in both Time Slices for the next Primary Bid Round.

A 5.28 Once Round 1 has finished, all Bidders receive information about Aggregate Demand for all Lot Categories (i.e. the sum of the demand from all Bidders in that Primary Bid Round). The Round Price for Lot Categories with excess demand (i.e. more Aggregate Demand than Lots available) would be increased for the subsequent Round. Table A5.6 shows that, again, there is excess demand in all three Lot Categories that the Bidder is interested in, so the Round Prices will increase in each Lot Category in the next Primary Bid Round. For the avoidance of doubt, the Bid increments would be determined by the Auctioneer during the Auction and pertaining to the circumstances at the time.

Table A5.6. Round 1 results and Round 2 prices

Lot Category	Round 1 Price (€)	Excess Demand	Round 2 Price (€)
700 MHz Duplex	120,000	Yes	132,000
2.1 GHz Band (1)	30,000	Yes	35,000
2.1 GHz Band (2)	30,000	Yes	35,000

A 5.29 Following the first Primary Bid Round, the Bidder's Eligibility is 18 in Time Slice 1 and 24 in Time Slice 2.

The second Primary Bid Round

A 5.30 It may also be the case that the Bidder continues to bid for the same Package of Lots from one Round to the next, where that Package of Lots continues to have the greatest associated surplus of the Packages of Lots that the Bidder is interested in, given the new Round Prices.

A 5.31 In this example, the Bidder bids again for Package A in the second Primary Bid Round. The Activity of this Bid is equal to the Bidder's Eligibility, which it maintains for the next Primary Bid Round. The Packages of Lots and corresponding surplus for Round 2 are given in the Table below.

Table A5.7. Bidder's preferences in Round 2

Package	Eligibility	Valuation	Package Price (€)	Surplus (€)
A	(18,24)	1,300,000	711,000	589,000
B	(18,24)	1,291,000	719,000	572,000
C	(18,14)	1,125,000	544,000	581,000
D	(16,16)	1,121,000	544,000	577,000
E	(12,12)	970,000	412,000	558,000

A 5.32 In this Round, suppose there is excess demand for the 2.1 GHz Band in both Time Slices, but there is no excess demand for the 700 MHz Duplex Lots. Therefore, for the next Primary Bid Round, the price of the 700 MHz Duplex Lots remains constant, while the prices for the other Lot Categories increases.

A 5.33 Round Prices for the third Primary Bid Round are given below.

Table A5.8. Round 2 results and Round 3 prices

Lot Category	Round 2 Price (€)	Excess Demand	Round 3 Price (€)
700 MHz Duplex	132,000	No	132,000
2.1 GHz Band (1)	35,000	Yes	38,000
2.1 GHz Band (2)	35,000	Yes	40,000

A 5.34 Following the second Primary Bid Round, the Bidder's Eligibility is 18 in Time Slice 1 and 24 in Time Slice 2.

The third Primary Bid Round

Reducing Demand

A 5.35 As Round Prices increase, a Bidder may wish to reduce its demand by bidding for fewer Lots in one or more Lot Categories. If a Bidder bids for a Package with Eligibility in a Time Slice less than the Bidder's Eligibility at the start of the Round in that Time Slice, then the Bidder's Eligibility for the next Primary Bid Round in that Time Slice will be reduced. In our example, the Bidder's Eligibility at the start of Round 3 was (18,24). Its preferences in this Round are expressed in Table A5.9, showing that it bids for Package C.

Table A5.9. Bidder's preferences in Round 3

Package	Eligibility	Valuation	Package Price (€)	Surplus (€)
A	(18,24)	1,300,000	750,000	550,000
B	(18,24)	1,291,000	774,000	517,000
C	(18,14)	1,125,000	574,000	551,000
D	(16,16)	1,121,000	576,000	545,000
E	(12,12)	970,000	444,000	526,000

A 5.36 The Activity of this Bid in Time Slice 1 is equal to the Bidder's Eligibility at the

start of the Round, but in Time Slice 2 the Activity of the Bid is strictly less than the Eligibility at the start of the Round. Therefore, the Bidder's Eligibility at the start of the next Primary Bid Round will remain at 18 for Time Slice 1, but fall to 14 in Time Slice 2.

A 5.37 In this Round, there is no excess demand for the 2.1 GHz Band in Time Slice 2, but there is excess demand for the other two Lot Categories. Therefore, Round Prices are increased for the latter two categories, but not for the 2.1 GHz Band Time Slice 2 Lots. The resulting Round Prices in Round 4 are given in the table below.

Table A5.10. Round 3 results and Round 4 prices

Lot Category	Round 3 Price (€)	Excess Demand	Round 4 Price (€)
700 MHz Duplex	132,000	Yes	148,000
2.1 GHz Band (1)	38,000	Yes	45,000
2.1 GHz Band (2)	40,000	No	40,000

A 5.38 Following the third Primary Bid Round, Bidder Eligibility is 18 in Time Slice 1 and 14 in Time Slice 2.

The fourth Primary Bid Round

Relaxed Primary Bids

A 5.39 A Bidder that has reduced its Eligibility in at least one Time Slice in one or more Primary Bid Rounds and/or submitted an Initial Bid resulting in Initial Eligibility strictly below the maximum possible in at least one Time Slice may still be able, under certain conditions, to submit a Primary Bid for a Package with Eligibility greater than the Bidder's current Eligibility (in one or both Time Slices). This is known as a Relaxed Primary Bid. In some cases, making a Relaxed Primary Bid will require that the Bidder also makes additional new Bids for certain other Packages of Lots. These are known as Chain Bids.

A 5.40 The EAS will automatically inform the Bidder about whether or not a Relaxed Primary Bid is possible and about any Chain Bids that are required if the Bidder wishes to make a Relaxed Primary Bid. The calculations shown here are included to illustrate how Relaxed Primary Bids and Chain Bids work, but in

practice Bidders will not be required to perform any of these calculations themselves. Moreover, the rules for Relaxed Primary Bids are specifically designed so that Relaxed Primary Bids are always permitted when a Bidder has been bidding according to its valuations, as in this example. Therefore, Bidders that adopt this bidding approach know that they will be able to bid for their preferred Package of Lots at all times and need not worry about the detailed conditions for Relaxed Primary Bids to be allowed.

A 5.41 In this Round, the surplus maximising Package of Lots is Package D, as shown in the table below. However, note that the Bidder is not eligible to bid for Package D at the start of Round 4 as its Eligibility in Time Slice 2 (14) is less than the Eligibility of the Package in Time Slice 2 (16). In order to bid for Package D in Round 4, the Bidder must therefore submit a Relaxed Primary Bid.

Table A5.11. Bidder's preferences in Round 4

Package	Eligibility	Valuation	Package Price (€)	Surplus (€)
A	(18,24)	1,300,000	819,000	481,000
B	(18,24)	1,291,000	841,000	450,000
C	(18,14)	1,125,000	641,000	484,000
D	(16,16)	1,121,000	636,000	485,000
E	(12,12)	970,000	488,000	482,000

A 5.42 For the Bidder to be allowed to submit a Relaxed Primary Bid for Package D, it must be that doing so would be consistent with the Bidder's bidding decisions in previous Eligibility-reducing Primary Bid Rounds. The EAS will check whether the relevant criteria are met, and whether or not any Chain Bids would be required for the Relaxed Primary Bid to be valid.

A 5.43 The EAS identifies the Constraining Round for the Package of Lots subject to a Relaxed Primary Bid (Package D). In this case, this is Round 3; at the start of Round 3, the Bidder's Eligibility was (18,24), which is greater than the Eligibility of Package D (16,16) in both Time Slices. In Round 3, instead of bidding for Package D, the Bidder instead chose to submit a Bid for Package C, which is therefore the Constraining Package for Package D.

A 5.44 In Round 3, the difference in price between Package D and Package C was €576k – €574k = €2k. The decision to bid for Package C rather than Package

D at those prices indicates that the Bidder's value for Package D does not exceed its value for Package C by more than €2k i.e. the Bidder is not willing to pay more than €2k to win Package D instead of Package C.

A 5.45 There are two conditions that need to be met in order for the Bidder to be able to submit a Relaxed Primary Bid for Package D.

A 5.46 The first condition is that the difference between the price of Package D and the price of the Constraining Package (Package C) at Round 4 prices must not exceed the difference in prices for the two Packages of Lots in the Constraining Round (Round 3). In this case:

- The price difference in Round 4 is $€636k - €641k = -€5k$;
- The price difference in Round 3 was €2k;
- The first condition for the Bidder to be allowed to submit the Relaxed Primary Bid is therefore satisfied.

A 5.47 The second condition is that the difference between the price of Package D at Round 4 prices and the highest Bid Amount submitted for Package C at any point should not exceed the difference in prices for the two Packages at Round 3 prices:

- The price of Package D in Round 4 is €636k;
- The highest Bid Amount submitted for Package C so far is €574k, submitted in Round 3;
- The difference between the two amounts is $€636k - €574k = €62k$, which exceeds the €2k price difference in Round 3;
- Therefore, the second condition is not satisfied.

A 5.48 In order to satisfy the second condition, the Bidder must make a higher Bid for Package C (a Chain Bid). The Bid Amount of the Chain Bid is the smallest amount necessary to satisfy the (second) condition above i.e. the Bid Amount for the Chain Bid is calculated as the price of Package D at Round 4 prices (€636k), minus the difference in the price of the two packages at Round 3 prices (€2k). Therefore, to submit a Relaxed Primary Bid for Package D, the Bidder must also submit a Chain Bid of €634k for Package C.

A 5.49 The amount of the Chain Bid is less than the price of Package C at Round 4 prices, therefore the Bidder is permitted to submit the required Chain Bid for Package C.

A 5.50 In Round 4, the Bidder was still eligible to bid for Package C, so no further Chain Bids are required and the Bidder is allowed to submit a Relaxed Primary Bid for Package D (along with the required Chain Bid for Package C).

A 5.51 In summary, the Bidder makes the following Bids in Round 4:

- a Relaxed Primary Bid for Package D with a Bid Amount of €636k; and
- a Chain Bid for Package C with a Bid Amount of €634k.

A 5.52 Note that the Bidder is willing to submit the Chain Bid for Package C, as it is less than the Bidder's valuation for Package C.

A 5.53 As mentioned earlier, for any Bidder that bids consistently according to valuation (as in this example) it is always possible to bid for the Bidder's preferred Package in every Primary Bid Round, including through Relaxed Primary Bids. Moreover, a Bidder that bids in this way will never be required to make Chain Bids with a negative surplus. Therefore, a Bidder that adopts this approach does not need to be able to perform calculations regarding the detailed conditions related to Relaxed Primary Bids and Chain Bids.

A 5.54 Note that the Bid for Package D in Round 4 is an Eligibility-reducing Relaxed Primary Bid, as the Eligibility of the Package is strictly less than the Bidder's Eligibility at the start of the Round in Time Slice 1. Therefore, the Bidder's Eligibility going into the next Primary Bid Round falls to 16 in Time Slice 1 but remains at 14 in Time Slice 2.

A 5.55 The outcome of Round 4 in the relevant Lot Categories is given below.

Table A5.12. Round 4 results and Round 5 prices

Lot Category	Round 4 Price (€)	Excess Demand	Round 5 Price (€)
700 MHz Duplex	148,000	No	148,000
2.1 GHz Band (1)	45,000	Yes	50,000
2.1 GHz Band (2)	40,000	Yes	47,000

A 5.56 Following the fourth Primary Bid Round, the Bidder's Eligibility is 16 in Time

Slice 1 and 14 in Time Slice 2.

A 5.57 Note that the Activity Rules allow for Relaxed Primary Bids to be submitted for Packages with Eligibility that exceeds the Bidder's Initial Eligibility in one or both of the Time Slices. We do not include a specific example in this Annex, but the calculations for establishing the relevant conditions and any required Chain Bids follow the same logic described above. However, in this case the last point at which the Bidder is considered to have been eligible to submit a Bid for the Package subject to the Relaxed Primary Bid is at the Application Stage, when it chose to submit an Initial Bid for a different Package of Lots at Reserve Prices.

The fifth Primary Bid Round

A 5.58 In Round 5, the Bidder wishes to switch back to bidding for Package C, as shown in Table A5.13.

Table A5.13. Bidder's preferences in Round 5

Package	Eligibility	Valuation	Package Price (€)	Surplus (€)
A	(18,24)	1,300,000	876,000	424,000
B	(18,24)	1,291,000	922,000	369,000
C	(18,14)	1,125,000	687,000	438,000
D	(16,16)	1,121,000	684,000	437,000
E	(12,12)	970,000	536,000	434,000

A 5.59 At the start of the Round, the Bidder is not eligible to bid for Package C (as it does not have sufficient Eligibility in Time Slice 1), so the Bidder would again like to submit a Relaxed Primary Bid. In this case the Relaxed Primary Bid would not be Eligibility-reducing as the Eligibility of the Package is not strictly less than the Bidder's Eligibility in either Time Slice.

A 5.60 The Constraining Round for Package C is Round 4, when the Bidder was eligible to bid for Package C but instead submitted a Bid for Package D.

A 5.61 We first check that a Bid for Package C in this Round would be consistent with the preferences expressed in the Constraining Round for Package C (Round 4):

- At Round 4 prices, the price of Package C was €641k and the price of Package D was €636k. The difference is €5k;

- At Round 5 prices, the price of Package C is €687k and the price of Package D is €684k. The difference is €3k;
- Since €3k is less than €5k, the condition is satisfied and the Bidder is allowed to submit a Relaxed Primary Bid for Package C in Round 5, subject to the need for Chain Bids.

A 5.62 Next, it is necessary to check if a Chain Bid is required for Package D, the Constraining Package:

- The price of Package C at Round 5 prices is €687k. The highest Bid Amount submitted for Package D is currently €636k (the Bidder's Round 4 Bid). The difference between these two amounts is €51k.
- The difference in price of the two Packages in Round 4 (the Constraining Round for Package C) was €5k;
- Since €51k is greater than €5k, the Bidder needs to submit a Chain Bid for Package D in order to submit the Relaxed Primary Bid for Package C.
- The amount of the required Chain Bid for Package D is €687k - €5k = €682k (which is less than the price of Package D in Round 5).

A 5.63 Since the Bidder was not eligible to bid for Package D at the start of Round 5, we need to check whether the Chain Bid for Package D would be valid. At this point, we have a loop of constraints, as (currently) Package C is the Constraining Package for Package D and Package D is the Constraining Package for Package C. It is therefore not simply a case of checking whether a Chain Bid is required for the Constraining Package for Package D. We instead need to ensure that the Bid Amount associated with the Relaxed Primary Bid for Package C and the Chain Bid to be submitted for Package D are compatible with the preferences expressed in Round 3:

- The required Chain Bid for Package D in Round 5 is €682k. The Bid Amount to be submitted for Package C in Round 5 is €687k. The difference between these two amounts is -€5k;
- The difference in price of the two Packages in Round 3 (the Constraining Round for Package D) was €2k.
- Since -€5k is less than €2k, the Bid Amounts are consistent with the preferences expressed in Round 3.

A 5.64 Therefore, the Relaxed Primary Bid for Package C and the Chain Bid for Package D can both be submitted.

A 5.65 The Eligibility of Package C exceeds the Bidder's Eligibility at the start of the Round, while the Eligibility of the Package in Time Slice 2 is equal to the Bidder's Eligibility at the start of the Round. Therefore, the Bidder maintains its Eligibility at (16,14) going into the next Primary Bid Round.

A 5.66 The outcome of Round 5 is given in Table A5.14.

Table A5.14. Round 5 results and Round 6 prices

Lot Category	Round 5 Price (€)	Excess Demand	Round 6 Price (€)
700 MHz Duplex	148,000	Yes	155,000
2.1 GHz Band (1)	50,000	Yes	60,000
2.1 GHz Band (2)	47,000	No	47,000

A 5.67 Following the fifth Primary Bid Round, the Bidder's Eligibility is 16 in Time Slice 1 and 14 in Time Slice 2.

The Final Primary Bid Round

A 5.68 In the next Round, the Bidder submits a standard Eligibility-reducing Primary Bid for Package E, which it is eligible to bid for at the start of the Round. Its preferences for this Round are given in the table below.

Table A5.15: Bidder's preferences in Round 6

Package	Eligibility	Valuation	Package Price (€)	Surplus (€)
A	(18,24)	1,300,000	927,000	373,000
B	(18,24)	1,291,000	986,000	305,000
C	(18,14)	1,125,000	751,000	374,000
D	(16,16)	1,121,000	738,000	383,000
E	(12,12)	970,000	583,000	387,000

A 5.69 This means that, going into the next Primary Bid Round, the Bidder's Eligibility would be (12,12), as the Eligibility of Package E is strictly less than the Bidder's Eligibility at the start of the Round in both Time Slices.

A 5.70 However, we assume that there is no excess demand in any Lot Category in this Round, so it is the final Primary Bid Round.

A 5.71 Note that this was the first Round in which there was a reduction in Eligibility since an Eligibility-reducing Relaxed Primary Bid was submitted for Package D (in Round 4). When applying the rules for setting Relative Caps, we therefore know that in order to prevent a disconnection in the chain of constraints generated in the Primary Bid Rounds, a new Relative Cap must be set for Package C or Package D (and the pre-existing Relative Cap on the relevant Package replaced).

A 5.72 Using the same methodology demonstrated above (we do not go through the details here), it can be shown that a Relaxed Primary Bid would have been allowed in Round 6 for Package D, but not for Package C (since the relative prices of the Package C and Package D at Round 6 prices would not be consistent with the decision to bid for Package D in Round 4). As such, a new Relative Cap is created for Package D; Package E is now the Constraining Package for Package D, and Round 6 becomes the Constraining Round relevant for calculating the Relative Cap on the Supplementary Bid for Package D. The previous Relative Cap on Package D, created in Round 3 when the Bidder submitted an Eligibility-reducing Primary Bid for Package C, is replaced and no longer applies.

A 5.73 Table A5.16 gives a summary of all Bids submitted by the Bidder during the Primary Bid Rounds.

Table A5.16. Bids submitted in the Application Stage and Primary Bid Rounds

Round	Eligibility	Activity	Package	Type of Bid	Bid Amount (€)
0 ¹⁶⁶	-	(18,24)	B	Initial	545,000
1	(18,24)	(18,24)	A	Standard	630,000
2	(18,24)	(18,24)	A	Standard	711,000
3	(18,24)	(18,14)	C	Standard	574,000
4	(18,14)	(16,16)	D	Relaxed	636,000
			C	Chain	634,000
5	(16,14)	(18,14)	C	Relaxed	687,000
			D	Chain	682,000
6	(16,14)	(12,12)	E	Standard	583,000

A 5.74 Notice that some of the Bids submitted in the earlier Primary Bid Rounds are 'dominated' by Bids in a later Primary Bid Round. For example, the Bid for Package A in Round 1 is dominated by the Bid for Package A in Round 2, because it includes a higher Bid Amount for the same Package of Lots. Bids that are dominated in this way can never be selected as winning Bids, so it is informative to look only at the highest Bids that the Bidder has submitted for each Package of Lots.

¹⁶⁶ In this example, round 0 refers to the Application Stage in which Bidder's submit their Initial Bids at Reserve Prices.

Table A5.17. Highest Bid Amounts submitted for each Package of Lots at the end of the Primary Bid Rounds

Package	Valuation (€)	Highest Bid Amount (€)	Surplus (€)
A	1,300,000	711,000	589,000
B	1,291,000	545,000	746,000
C	1,125,000	687,000	438,000
D	1,121,000	682,000	439,000
E	970,000	583,000	387,000

A 5.75 For all Packages of Lots the Bidder has a strictly positive surplus at these Bid Amounts, meaning that the Bidder can, subject to relevant caps, make higher Bids in the Supplementary Bids Round in order to increase its chances of winning one of the Packages of Lots without the risk of exceeding valuation for a particular Package of Lots.

Supplementary Bids Round

A 5.76 After the end of the Primary Bid Rounds, there will be one Supplementary Bids Round. In the Supplementary Bids Round Bidders can (subject to relevant caps):

- increase the Bid Amount for Packages of Lots bid for during the Primary Bid Rounds; and/or
- submit Bids for additional Packages of Lots with corresponding Bid Amounts.

A 5.77 All Primary Bids (including Chain Bids) are binding; that is, they will be submitted as Supplementary Bids at the highest Bid Amount specified in either the Primary Bid Rounds or the Supplementary Bids Round. The EAS will automatically add these Packages of Lots to the Bidder's list of Supplementary Bids.

A 5.78 A Bidder is able to submit Supplementary Bids for up to 1,000 Packages of Lots, including the Package of Lots specified in the Bidder's Initial Bid and any Package of Lots the Bidder Bid for during the Primary Bid Rounds. In this example, the Bidder has already submitted Bids for 5 different Packages of Lots, so could submit Supplementary Bids for an additional 995 Packages of

Lots.

A 5.79 The Package of Lots bid for in the final Primary Bid Round, the Final Primary Package (FPP), is not subject to a cap and the Bidder could increase the Bid Amount for this Package of Lots by any amount, unless the FPP is a Zero Bid or a Relaxed Primary Bid.

A 5.80 Supplementary Bids for all other Packages of Lots are subject to caps on the Bid Amount.

A 5.81 The rules for calculating these caps are explained in Section 4.2.3. All Supplementary Bids (other than the FPP) are subject to a Final Price Cap. Additionally, all Supplementary Bids for Packages of Lots with Eligibility greater than the Bidder's Eligibility at the start of the final Primary Bid Round are subject to Relative Caps.

A 5.82 This section demonstrates the Supplementary Bid cap rules under three variations of the example Primary Bid Rounds used above:

- Case 1: the Primary Bid Rounds continue beyond Round 6 and end following a Round in which the Bidder submits a Zero Bid;
- Case 2: the Primary Bid Rounds history is exactly as set out in the example above, where the Bidder's FPP is non-zero and within its Eligibility for the final Primary Bid Round; and
- Case 3: the Primary Bid Rounds ended after Round 5, so that the Bidder's FPP is a Relaxed Primary Bid.

A 5.83 These calculations are for illustrative purposes only. Bidders do not necessarily have to perform these calculations themselves. If a Bidder attempts to submit a Bid Amount for a Package that exceeds the Supplementary Bid cap, the EAS will inform the Bidder and prevent the submission of Supplementary Bids until all Bid Amounts are valid.

A 5.84 In this example, the Bidder only has valuations for five Packages of Lots. In Case 1 and Case 2, the Bidder has already submitted Bids for all five Packages of Lots in the Primary Bid Rounds, and therefore simply needs to raise the Bid Amounts in the Supplementary Bids Round. In Case 3, the Bidder will need to raise the Bid Amounts for Packages A, B, C and D, and add a Bid for Package E to its list of Supplementary Bids (by Round 5 it had not already submitted a Bid for package E).

A 5.85 In addition, the Bidder was eligible to bid for all Packages of Lots it is interested in at the start of Round 1. Note, however, that the Supplementary Bid cap calculations for Packages larger than the Package of Lots specified in the

Bidder's Initial Bid (in terms of Eligibility Points in at least one Time Slice) work in exactly the same way as the example calculations shown in this section.

A 5.86 The set of Bids submitted to date at the end of the Primary Bid Rounds do not fully express the Bidder's valuations so, in this example, the Bidder submits Supplementary Bids equal to its valuations.

Case 1: Zero Final Primary Package

A 5.87 Suppose that the Primary Bid Rounds continue until the Round Prices are as in the table below. Up to this point, the Bidder has continued to bid for Package E, but now all Packages of Lots offer negative surplus and the Bidder submits a Zero Bid. The Primary Bid Rounds end at this point.

Table A5.18. Case 1 - Round Prices in alternative final Primary Bid Round

Lot Category	Round Prices (€)
700 MHz Duplex	200,000
2.1 GHz Band (1)	100,000
2.1 GHz Band (2)	95,000

A 5.88 The Final Primary Package for the Bidder is therefore the Zero Package (i.e. no Lots in any Lot Category). According to the Final Price Cap rules, all Supplementary Bids are therefore constrained to be at most the price of the corresponding Package of Lots in the final Primary Bid Round (i.e. there is an absolute cap on each of the Supplementary Bids that the Bidder can submit).

A 5.89 The Relative Caps for each of the five Packages of Lots in the example are determined in the following way.

A 5.90 Relative Cap for Package A:

- a) The last Round in which the Bidder was eligible to bid for Package A was Round 3, and the Constraining Round for Package A was not subsequently reset, so Round 3 is the Constraining Round;
- b) In Round 3, the Bidder submitted a Bid for Package C, so Package C is the Constraining Package;
- c) In the Constraining Round, the price of Package A was €750k and the price of Package C was €574k, with a difference of €176k;
- d) The Supplementary Bid Amount for Package A cannot exceed the

highest Bid Amount for Package C **plus** €176k.

A 5.91 Relative Cap for Package B:

- a) The last Round in which the Bidder was eligible to bid for Package B was Round 3, and the Constraining Round for Package B was not subsequently reset, so Round 3 is the Constraining Round;
- b) In Round 3, the Bidder submitted a Bid for Package C, so Package C is the Constraining Package;
- c) In the Constraining Round, the price of Package B was €774k and the price of Package C was €574k, with a difference of €200k;
- d) The Supplementary Bid Amount for Package B cannot exceed the highest Bid Amount for Package C **plus** €200k.

A 5.92 Relative Cap for Package C:

- a) The last Round in which the Bidder was eligible to Bid for Package C was Round 4, and the Constraining Round for Package C was not subsequently reset, therefore, Round 4 is the Constraining Round;
- b) In Round 4, the Bidder submitted a Bid for Package D, so Package D is the Constraining Package;
- c) In the Constraining Round, the price of Package C was €641k and the price of Package D was €636k, with a difference of €5k;
- d) The Supplementary Bid Amount for Package C cannot exceed the highest Bid Amount for Package D **plus** €5k.

A 5.93 Relative Cap for Package D:

- a) The last Round in which the Bidder was eligible to Bid for Package D was Round 3, in which the Bidder instead submitted a Bid for Package C.
- b) However, the Constraining Round for Package D was subsequently reset to be Round 6. Round 6 is therefore the Constraining Round;
- c) In Round 6, the Bidder submitted a Bid for Package E, so Package E is the Constraining Package;
- d) In the Constraining Round, the price of Package D was €738k and the price of Package E was €583k, with a difference of €155k;
- e) The Supplementary Bid Amount for Package D cannot exceed the

highest Bid Amount for Package E **plus** €155k.

A 5.94 The Bidder was eligible to bid for Package E in the final Primary Bid Round, so Package E is not subject to a Relative Cap.

A 5.95 The following table provides an overview of the caps that would apply to the Supplementary Bids that the Bidder can submit. In this table, HB(X) stands for the "highest Bid submitted for package X".

Table A5.19. Case 1 - Supplementary Bid caps

Package	Relative Cap	Final Price Cap
A	HB(C) + €176,000	€1,470,000
B	HB(C) + €200,000	€1,660,000
C	HB(D) + €5,000	€1,185,000
D	HB(E) + €155,000	€1,180,000
E	None	€980,000

A 5.96 Given these caps, which result from submitting Bids for the most preferred package in each Primary Bid Round, the Bidder can reflect its valuations in its Supplementary Bids. The table below shows the Supplementary Bid Amounts that would reflect the Bidder's valuations, alongside the resulting caps:

Table A5.20. Case 1 - Supplementary Bid Amounts and resulting caps

Package	Supplementary Bid Amount	Relative Cap	Final Price Cap
A	€1,300,000	€1,301,000	€1,470,000
B	€1,291,000	€1,325,000	€1,660,000
C	€1,125,000	€1,126,000	€1,185,000
D	€1,121,000	€1,125,000	€1,180,000
E	€970,000	None	€980,000

Case 2: Standard Primary Bid in the Final Primary Bid Round

A 5.97 Suppose now that Round 6 is the final Primary Bid Round. The Final Primary

Package is Package E.

A 5.98 All packages except the Final Primary Package are subject to a Final Price Cap relative to the Final Primary Package (Package E). The Final Price Cap limits the Bid Amount for any Package of Lots other than Package E to be no greater than:

- a) the highest Bid Amount that the Bidder submits for Package E; plus
- b) the difference between the price of the Package of Lots subject to the Final Price Cap and the price of Package E in the final Primary Bid Round.

A 5.99 The price of Package E in the final Primary Bid Round was €583k.

A 5.100 The prices of the other Packages of Lots in the final Primary Bid Round and the corresponding Final Price Caps are as follows:

- The price of Package A was €927k. Therefore, the highest Bid Amount that the Bidder submits for Package A cannot exceed its highest Bid Amount for Package E plus €344k, based on the price difference between the two Packages in the final Primary Bid Round.
- The price of Package B was €986k, so the highest Bid Amount that the Bidder submits for Package B cannot exceed its highest Bid Amount for Package E plus €403k.
- The price of Package C was €751k, so the highest Bid Amount that the Bidder submits for Package C cannot exceed its highest Bid Amount for Package E plus €168k.
- The price of Package D was €738k, so the highest Bid Amount that the Bidder submits for Package D cannot exceed its highest Bid Amount for Package E plus €155k.

A 5.101 The Relative Caps are the same as in Case 1.

A 5.102 In this example, the price of Package E was below the price of the other Packages the Bidder is interested in in the final Primary Bid Round. This is not necessarily always the case, and it is possible that the cap on some packages could be the price of some Package, minus some amount.

A 5.103 The following table provides an overview of the caps that would apply to the Supplementary Bids that the Bidder can submit. In this table, HB(X) stands for the "highest Bid submitted for Package X".

Table A5.21. Case 2 - Supplementary Bid caps

Package	Relative Cap	Final Price Cap
A	HB(C) + €176,000	HB(E) + €344,000
B	HB(C) + €200,000	HB(E) + €403,000
C	HB(D) + €5,000	HB(E) + €168,000
D	HB(E) + €155,000	HB(E) + €155,000
E	None	None

A 5.104 Notice that the Supplementary Bid Amount for Package E is not subject to any cap.

A 5.105 Given these caps, which result from submitting Bids for the most preferred package in each Primary Bid Round, the Bidder can reflect its valuations in its Supplementary Bids. The table below shows the Supplementary Bid Amounts that would reflect the Bidder's valuations and the resulting caps:

Table A5.22. Case 2 - Supplementary Bid Amounts and resulting caps

Package	Supplementary Bid Amount	Relative Cap	Final Price Cap
A	€1,300,000	€1,301,000	€1,314,000
B	€1,291,000	€1,325,000	€1,373,000
C	€1,125,000	€1,126,000	€1,138,000
D	€1,121,000	€1,125,000	€1,125,000
E	€970,000	None	None

Case 3: FPP is a Relaxed Primary Bid

A 5.106 Suppose now that the Primary Bid Rounds ended following Round 5, so the Bidder submitted a Relaxed Primary Bid for Package C in the Final Primary Bid Round.

A 5.107 All packages except the Final Primary Package (Package C) are subject to a Final Price Cap relative to the Final Primary Package. The Final Price Cap limits

the Bid Amount for any Package other than Package C to be no greater than:

- a) the highest Bid Amount that the Bidder submits for Package C; plus
- b) the difference between the price of the package subject to the Final Price Cap and the price of Package C in the final Primary Bid Round.

A 5.108 The price of Package C in the final Primary Bid Round was €687k. The final Primary Bid Round prices and Final Price Caps for the other Packages of Lots that the Bidder is interested in are as follows:

- The price of Package A was €876k, so the highest Bid Amount the Bidder submits for Package A cannot exceed its highest Bid Amount for Package C **plus** €189k;
- The price of Package B was €922k, so the highest Bid Amount the Bidder submits for Package B cannot exceed its highest Bid Amount for Package C **plus** €235k;
- The price of Package D was €684k, so the highest Bid Amount the Bidder submits for Package D cannot exceed its highest Bid Amount for Package C **minus** €3k; and
- The price of Package E was €536k, so the highest Bid Amount the Bidder submits for Package E cannot exceed its highest Bid Amount for Package C **minus** €151k.

A 5.109 The Constraining Rounds for Packages A, B and C are the same as in the previous examples, so the Relative Caps for these three Packages of Lots are as described in Case 1. Note that even though Package C is the FPP, it is still subject to a Relative Cap as the Bidder was not eligible to bid for Package C at the start of the final Primary Bid Round.

A 5.110 In this case, the Eligibility-reducing Relaxed Primary Bid for Package D in Round 4 was the last time that the Bidder reduced its Eligibility, and the resetting of the Constraining Round for Package D (which for other examples happens at the end of Round 6) does not occur. The Constraining Round for Package D is therefore Round 3, which was the last Round in which the Bidder was eligible to bid for Package D. The Relative Cap for D is calculated as follows:

- In the Constraining Round, the Bidder submitted a Bid for Package C, so Package C is the Constraining Package;
- In the Constraining Round, the price of Package D was €576k and the price of Package C was €574k, with a difference of €2k;

- The Supplementary Bid Amount for Package D cannot exceed the highest Bid Amount for Package C **plus** €2k.

A 5.111 The Bidder was still eligible to bid for Package E in the final Primary Bid Round, so Package E is not subject to a Relative Cap.

A 5.112 The following table provides an overview of the caps that would apply to the Supplementary Bids that the Bidder can submit. In this table, HB(X) stands for the "highest Bid submitted for Package X".

Table A5.23. Case 3 - Supplementary Bid caps

Package	Relative Cap	Final Price Cap
A	HB(C) + €176,000	HB(C) + €189,000
B	HB(C) + €200,000	HB(C) + €235,000
C	HB(D) + €5,000	None
D	HB(C) + €2,000	HB(C) - €3,000
E	None	HB(C) - €151,000

A 5.113 Notice that all packages are subject to at least one cap.

A 5.114 Given these caps, which result from submitting Bids for the most preferred Package of Lots in each Primary Bid Round, the Bidder can reflect its valuations in its Supplementary Bids. The table below shows the Supplementary Bid Amounts that would reflect the Bidder's valuations and the resulting caps:

Table A5.24. Case 3 - Supplementary Bid Amounts and resulting caps

Package	Supplementary Bid Amount	Relative Cap	Final Price Cap
A	€1,300,000	€1,301,000	€1,314,000
B	€1,291,000	€1,325,000	€1,360,000
C	€1,125,000	€1,126,000	None
D	€1,121,000	€1,127,000	€1,122,000
E	€970,000	None	€974,000

Annex: 6 Example of Winner and Price Determination

A 6.1 This annex provides a very simple example of the winner and price determination process¹⁶⁷.

A 6.2 There are four Bidders and two Lot Categories (A and B), with two Lots in Lot Category A and two Lots in Lot Category B. All Valid Bids at the end of the Supplementary Bids Round are shown in Table A6.1, with the optimal allocation highlighted in green. For the purposes of simplifying the example, we assume that reserve prices are zero for all Lots and that bid amounts can be any whole number.

Table A6.1 Valid bids at the end of the Supplementary Bids Round

Bidder	Lot Category A	Lot Category B	Bid Amount
Bidder 1	1	0	8
Bidder 1	1	1	10
Bidder 1	0	2	12
Bidder 2	2	0	16
Bidder 2	1	1	15
Bidder 3	1	1	15
Bidder 4	2	2	24

A 6.3 In this simple case it is easy to verify that the combination giving the highest total Bid value (the Winning Combination of Bids) is Bidder 3's Bid for (1,1) and Bidder 2's Bid for (1,1), generating a total value of 30. The notation (x,y) refers to x A Lots and y B Lots.

A 6.4 If we were to accept Bidder 1's Bid for (1,0), we could only additionally accept either Bidder 2's Bid for (1,1), producing a total value of 23, or Bidder 3's Bid for (1,1), producing a total value of 23 (and leaving one B Lot unsold).

A 6.5 If we were to accept Bidder 1's Bid for (1,1), we could also accept a Bid for (1,1)

¹⁶⁷ The example is for illustrative purposes only and, for simplicity, ignores the requirements that Bid Amounts and Base Prices will be in multiples of EUR 1,000.

from either Bidder 2 or Bidder 3, creating a total value of 25 in each case.

A 6.6 If we were to accept Bidder 1's Bid for (0,2), we could only accommodate Bidder 2's Bid for (2,0) (and vice versa), producing a total value of 28.

A 6.7 If we were to accept Bidder 4's Bid for (2,2), we could not accommodate any other Bidder, giving a total value of 24.

A 6.8 This means that accepting Bids for (1,1) from Bidder 2 and (1,1) from Bidder 3 is the unique Winning Combination of Bids.

Base Price determination

A 6.9 Taking the example provided above, we establish the Base Prices that must be paid by the Winning Bidders (Bidder 2 and Bidder 3), based on Opportunity Cost.

A 6.10 We first calculate the Winning Bidders' individual Opportunity Costs, starting with Bidder 2.

Table A6.2. Outcome when excluding Bidder 2 (difference to optimal outcome)

Bidder	Lot Category A (Difference to optimal outcome)	Lot Category B (Difference to optimal outcome)	Bid Amount (Difference to optimal outcome)
Bidder 1	1 (+1)	1 (+1)	10 (+10)
Bidder 2	0 (-1)	0 (-1)	0 (-15)
Bidder 3	1 (0)	1 (0)	15 (0)
Total	2 (0)	2 (0)	25 (-5)

A 6.11 If we eliminated Bidder 2 completely from the Auction, the Winning Combination of Bids would be to take the same Bid from Bidder 3 as in the optimal allocation, together with the Bid for (1,1) from Bidder 1 at a Bid Amount of 10, creating a total value of 25. From this, we have to subtract the amount in the winning combination that comes from the Winning Bids of Bidders other than Bidder 2, which in this case is the 15 from Bidder 3's Winning Bid. This means that the Opportunity Cost of accepting Bidder 2's Winning Bid is $25 - 15 = 10$. Equally, this can be obtained by adding the differences in Bid Amounts relative to the optimal outcome in Table A6.2 above for all Bidders except Bidder 2. This gives +10 (from Bidder 1) and 0 (from Bidder 3), giving Bidder 2's individual Opportunity Cost of 10.

A 6.12 Similarly, if we eliminated Bidder 3 from the Auction, our best option would be to accept Bidder 1's Bid for (0,2) together with Bidder 2's Bid for (2,0), creating a total value of 28. The Opportunity Cost of accepting Bidder 3's Bid is therefore given by $28 - 15 = 13$. This is shown in Table A6.3; Bidder 1 is better off by 12 and Bidder 2 is better off by 1 compared to the optimal outcome. The total individual Opportunity Cost imposed by Bidder 3 is therefore 13.

Table A6.3. Outcome when excluding Bidder 3 (difference to optimal outcome)

Bidder	Lot Category A (Difference to optimal outcome)	Lot Category B (Difference to optimal outcome)	Bid Amount (Difference to optimal outcome)
Bidder 1	0 (0)	2 (+2)	12 (+12)
Bidder 2	2 (+1)	0 (-1)	16 (+1)
Bidder 3	0 (-1)	0 (-1)	0 (-15)
Total	2 (0)	2 (0)	28 (-2)

A 6.13 We then need to calculate the joint Opportunity Cost for both Winning Bidders. If we eliminate both Winning Bidders, the best option is to give both A Lots and both B Lots to Bidder 4. This generates a total bid value of 24, so the joint Opportunity Cost is 24.

Table A6.4. Jointly excluding Bidder 2 and Bidder 3 (difference to optimal outcome)

Bidder	Lot Category A (Difference to optimal outcome)	Lot Category B (Difference to optimal outcome)	Bid Amount (Difference to optimal outcome)
Bidder 2	0 (-1)	0 (-1)	0 (-15)
Bidder 3	0 (-1)	0 (-1)	0 (-15)
Bidder 4	2 (+2)	2 (+2)	24 (+24)
Total	2 (0)	2 (0)	24 (-6)

A 6.14 This means that individual Opportunity Costs are 10 for Bidder 2 and 13 for Bidder 3 respectively, and 24 for both Bidders together. Base Prices cannot be lower than individual Opportunity Costs.

A 6.15 However, setting Base Prices at individual Opportunity Cost is not sufficient in this case, as the Bidders would not cover their joint Opportunity Cost (because $10 + 13 = 23 < 24$). That is, the Winning Bidders would be jointly paying 23 for the Lots they have been awarded, but Bidder 4 would be willing to pay more (24). Together, they therefore need to pay an additional 1 over and above the sum of their individual Opportunity Costs.

A 6.16 Any set of prices for Bidder 2 and 3 that ensures Bidder 2 pays at least 10, Bidder 3 pays at least 13, and Bidders 2 and 3 jointly pay 24 minimises the sum of Base Prices. In this case, the pricing rule¹⁶⁸ splits the additional cost above the sum of individual Opportunity Costs equally. So Bidder 2's Base Price is 10.5 and Bidder 3's Base Price is 13.5.

¹⁶⁸ Which minimises the sum of squares of differences between the Base Prices for each Winner and the individual Opportunity Cost for that Winner.

Annex: 7 Implications of the Final Price Cap

A 7.1 This annex considers the implications of the Final Price Cap for bidding strategies in the Supplementary Bids Round. The analysis presented is intended to aid Bidders' consideration of appropriate bidding strategies. However, ComReg makes no warranty or representation that any strategy suggested herein is necessary or sufficient to ensure winning spectrum.

A 7.2 Please note that this annex is not an extension of the example set out in Annex 5 and should be considered separately.

Overview

A 7.3 In the Supplementary Bids Round, the Final Price Cap constrains the possible Bids that can be submitted by each Bidder. For any Package (which we will call Package X) other than the Final Primary Package, the Supplementary Bid Amount cannot exceed the highest Bid submitted for the Final Primary Package plus the price difference between the Final Primary Package and Package X at the Round Prices in the final Primary Bid Round.

A 7.4 If the Bid submitted by a Bidder in the final Primary Bid Round was a standard Primary Bid (i.e. not a Relaxed Primary Bid) for a non-zero Package, then there is no limit on the Supplementary Bid Amount that the Bidder can submit for the Final Primary Package. Bidders should note, however, that if the Bid submitted by a Bidder in the final Primary Bid Round was a Relaxed Primary Bid, the Supplementary Bid Amount that the Bidder can submit for the Final Primary Package will be constrained by a Relative Cap.

A 7.5 We illustrate this with a simple example with only two Lot Categories, A and B, each with ten Lots. Suppose that Reserve Prices are €3,000 for A-Lots and €5,000 for B-Lots, and that the Round Prices in the final Primary Bid Round are €8,000 for A-Lots and €15,000 for B-Lots.

A 7.6 Suppose that a Bidder's Final Primary Package consists of four A-Lots and four B-Lots. If the Bidder's highest Bid for this Package is a Supplementary Bid of €100,000, then the Final Price Cap on the Package of five A-Lots and five B-Lots would be €123,000¹⁶⁹, while the Final Price Cap on the Package

¹⁶⁹ The highest Bid on the Final Primary Package, which is €100,000, plus the difference between the price of the constrained Package and the Final Primary Package at the Round Prices in the final Primary Bid Round (€115,000 - €92,000 = €23,000).

containing only four A-Lots would be €40,000¹⁷⁰.

A 7.7 Bidders can use the information disclosed about the Round Prices and the level of Aggregate Demand for each Lot Category in the final Primary Bid Round to assess their likelihood of winning with particular Bids, and in particular the Bid for the Final Primary Package. This is because from the perspective of one Bidder the Final Price Cap¹⁷¹ limits the amount that rival Bidders can bid to add Lots to their positions in the final Primary Bid Round, and thus the extent to which they can outbid that Bidder for its Final Primary Package.

A 7.8 The Final Price Cap has two implications:

- the outcome in which each Bidder is assigned its Final Primary Package can only be improved upon if it makes it possible to assign more Lots by selecting other Bids, which is only possible if the outcome in which each Bidder is assigned its Final Primary Package does not lead to assigning all Lots;
- the additional value that can be achieved by assigning more Lots is at most (and often will be less than) the Round Price of such Lots in the final Primary Bid Round less the Reserve Price, as any Bid that includes such Lots is at least subject to the Final Price Cap (and might be subject to a tighter Relative Cap).

A 7.9 Given this, there are a number of strategies available for Bidders who wish to mitigate the risk that they may not win their Final Primary Package, which take into account the possibility that the total value of an outcome in which they do not win their Final Primary Package might reflect the value of assigning Lots for which there was no Aggregate Demand in the final Primary Bid Round. We refer to these Lots as 'provisionally unassigned Lots'. Such unassigned Lots are valued at the Reserve Price when assessing outcomes for the purposes of determining winners.

A 7.10 A first possible strategy is to specify:

- a Supplementary Bid for the Final Primary Package equal to:
 - the value of that Package based on the Round Prices in the

¹⁷⁰ The highest Bid Amount on the Final Primary Package, which is €100,000, plus the difference between the price of the Package and the price of the Final Primary Package at the Round Prices in the final Primary Bid Round (€32,000 - €92,000 = -€60,000).

¹⁷¹ Constraints on Supplementary Bids arising from Relative Caps may provide additional constraints on rivals Bids, but these depend on the history of Eligibility reductions made by Bidders. The constraint arising from the Final Price Cap depends on only on the final Round Prices, which are known to all Bidders when preparing their Supplementary Bids.

final Primary Bid Round;

- plus the value of provisionally unassigned Lots at final Round Prices less their value at Reserve Prices;
- plus a further positive increment (e.g. €1000)
- Supplementary Bids for other Packages (if any) that do not exceed the value of those Packages based on the Round Prices in the final Primary Bid Round¹⁷².

A 7.11 Following the example above, suppose that Aggregate Demand in the final Primary Bid Round was such that two A Lots and one B-Lot would remain provisionally unassigned. The Round Price of provisionally unassigned Lots would be $2 \times \text{€}8,000 + \text{€}15,000 = \text{€}31,000$. The Reserve Price of these Lots is $2 \times \text{€}3,000 + \text{€}5,000 = \text{€}11,000$. The difference between the value of the Lots at final Round Prices and Reserve Prices would be $\text{€}31,000 - \text{€}11,000 = \text{€}20,000$. Therefore, if the Bidder in the example followed this first strategy it would make a Supplementary Bid of $\text{€}92,000 + \text{€}20,000 + \text{€}1000 = \text{€}113,000$ for its Final Primary Package of four A-Lots and four B-Lots, and ensure that none of its other Supplementary Bids exceed the price of the corresponding Package in the final Primary Bid Round.

A 7.12 With this strategy, the Bidder will win its Final Primary Package regardless of the Supplementary Bids made by other Bidders (provided that their Bids made in the final Primary Bid Round remain valid). For the avoidance of doubt, the Base Price for this Winning Bid would be less than or equal to the Bid Amount submitted.

A 7.13 A second possible strategy is to specify:

- a Supplementary Bid for the Final Primary Package, again equal to the value of that Package based on the Round Prices in the final Primary Bid Round, plus the value of provisionally unassigned Lots at final Round Prices less their value at Reserve Prices, plus a further positive increment (e.g. €1000); and
- Supplementary Bids for other Packages, at least one of which is at least the value of the Package based on the Round Prices in the final Primary Bid Round plus a further positive increment which is no less than the positive increment applied to the Bid for the Final Primary Package.

¹⁷² For the avoidance of doubt, such bids are not a necessary component of the outlined strategy, but if they are included then the Bid Amounts should be limited as described.

A 7.14 With this strategy, the Bidder will win either its Final Primary Package or one of the other Packages for which it submitted Bid Amounts that exceed the value of those Packages based on the Round Prices in the final Primary Bid Round (provided that their Bids made in the final Primary Bid Round remain valid). This holds regardless of the Supplementary Bids made by other Bidders due to the effect of the Final Price Cap in limiting the amount that other Bidders can bid. For the avoidance of doubt, the Base Price for this Winning Bid would be less than or equal to the Bid Amount submitted.

A 7.15 Following the example above, if the Bidder followed this second strategy it would make a Supplementary Bid of €113,000 for the Final Primary Package of four A-Lots and four B-Lots, but might then also submit Supplementary Bids above the value of the Package based on the Round Prices in the final Primary Bid Round (plus the corresponding increment) for selected Packages that it might also be willing to win. For example, suppose that the Bidder's Final Primary Package, Package X, was subject to a Relaxed Primary Bid, and its Constraining Package, Package Y, contained three A-Lots and five B-Lots. In the Constraining Round the price of Package Y was €6,000 greater than the price of Package X. If the Bidder makes a Supplementary Bid of €107,000 for Package Y, then it will also be able to submit the Supplementary Bid for Package X, assuming that the Relative Cap on Package Y is satisfied (which may require additional Supplementary Bids).

A 7.16 A Bidder whose Primary Bid in the final Primary Bid Round was neither a Relaxed Primary Bid nor the Zero Bid can always follow either of these strategies. Conversely, a Bidder who made a Relaxed Primary Bid in the final Primary Bid Round may not always be able to adopt the first strategy (depending on the Bids that the Bidder is required to make for Constraining Packages in order to be able to make the required Bid for its Final Primary Package to the level set out above); however, such a Bidder would still be able to adopt the second strategy.

A 7.17 A more formal explanation of the implications of the Final Price Cap, including a mathematical proof, is provided below.

Mathematical derivation

Notation

A 7.18 Suppose there are n Lot Categories and let L denote the set of Lot Categories.

A 7.19 Let $s = (s_1, s_2, \dots, s_n)$ denote the number of Lots available in each Lot Category, where s_i is the number of Lots available in Lot Category i .

A 7.20 We represent a Package of Lots as a vector $q = (q_1, q_2, \dots, q_n)$ where $q_i \geq 0$ is

the number of Lots in Lot Category i .

A 7.21 Let J be the set of all Bidders. For any given Bidder, we only need to consider the highest Bid that the Bidder made for any particular package.

A 7.22 Let $\beta^{j,f} = (b^{j,f}, q^{j,f})$ denote the highest Bid that Bidder j made for its Final Primary Package.

A 7.23 Let $u = (u_1, u_2, \dots, u_n)$ denote the number of provisionally unassigned Lots in the final Primary Bid Round, given by:

$$u = s - \sum_{j \in J} q^{j,f}$$

A 7.24 Let $\rho = (\rho_1, \rho_2, \dots, \rho_n)$ denote the round prices in the final Primary Bid Round and $r = (r_1, r_2, \dots, r_n)$ be the Reserve Prices.

A 7.25 The value of the feasible outcome in which the Bidder receives its Final Primary Package is then

$$v^f = \sum_{j \in J} b^{j,f} + r \cdot u = \sum_{j \in J} b^{j,f} + r \cdot \left(s - \sum_{j \in J} q^{j,f} \right)$$

where $r \cdot u$ is the total value¹⁷³ of the unassigned Lots at Reserve Prices r .

Analysis

A 7.26 We focus on one particular Bidder $\hat{j} \in J$. We consider the effect if this Bidder increases its Bid for its Final Primary Package by the value of any provisionally unassigned Lots at the end of the final Primary Bid Rounds in excess of the reserve price, plus a small increment. This means making a Supplementary Bid for the Final Primary Package of an amount

$$(A) \quad b^{\hat{j},f} = \rho \cdot q^{\hat{j},f} + (\rho - r) \cdot u + \varepsilon$$

where $\varepsilon > 0$ is some small increment. (In the subsequent analysis, this will resolve any ties.) Notice that the Bidder's bid at the end of the Primary Rounds, $\rho \cdot q^{\hat{j},f}$, is being increased by an amount $(\rho - r) \cdot u$ (plus the small increment) as final Round Prices ρ cannot be lower than Reserve Prices r .

A 7.27 We now compare the value of an outcome in which each Bidder receives its Final Primary Package with some alternative 'test' outcome and identify sufficient conditions for the optimal outcome to be that in which each Bidder is

¹⁷³ $r \cdot u$ is the scalar product $\sum_i r_i u_i$

assigned its Final Primary Package.

A 7.28 Let $\beta^{j,t} = (b^{j,t}, q^{j,t})$ be the winning Bid of Bidder j in the alternative 'test' outcome. By assumption this is a feasible outcome, so

$$(B) \quad s_i \geq \sum_{j \in J} q_i^{j,t} \quad \forall i \in L$$

A 7.29 The test outcome has a total value v^t given by

$$v^t = \sum_{j \in J} b^{j,t} + r \cdot \left(s - \sum_{j \in J} q^{j,t} \right)$$

where unassigned Lots are valued at Reserve Prices.

A 7.30 The Bid amount of Bidder \hat{j} (as defined in (A) above) is

$$\begin{aligned} b^{\hat{j},f} &= \rho \cdot q^{\hat{j},f} + (\rho - r) \cdot u + \varepsilon \\ &= \rho \cdot q^{\hat{j},f} + (\rho - r) \cdot \left(s - \sum_{j \in J} q^{j,f} \right) + \varepsilon \end{aligned}$$

and so

$$(C) \quad b^{\hat{j},f} \geq \rho \cdot q^{\hat{j},f} + (\rho - r) \cdot \left(\sum_{j \in J} q^{j,t} - \sum_{j \in J} q^{j,f} \right) + \varepsilon$$

where the inequality is obtained by substituting (B) for the supply of Lots s , as $\rho - r \geq 0$.

A 7.31 Now consider the total value of Bids by Bidder \hat{j} 's rivals in the alternative allocation. Regardless of the bidding strategies adopted by rival Bidders, all their Bids are bounded by the Final Price Cap, which requires that:

$$(D) \quad b^{j,f} \geq b^{j,t} + \rho \cdot (q^{j,f} - q^{j,t})$$

A 7.32 Adding together inequality (C) for Bidder \hat{j} and the inequalities (D) for each Bidder $j \neq \hat{j}$ gives that

$$\begin{aligned}
\sum_{j \in J} b^{j,f} &\geq \rho \cdot q^{\hat{j},f} + \sum_{j \in J \setminus \hat{j}} [b^{j,t} + \rho \cdot (q^{j,f} - q^{j,t})] + (\rho - r) \cdot \left(\sum_{j \in J} q^{j,t} - \sum_{j \in J} q^{j,f} \right) \\
&\quad + \varepsilon \\
&= \sum_{j \in J \setminus \hat{j}} b^{j,t} + \rho \cdot q^{\hat{j},t} - r \cdot \left(\sum_{j \in J} q^{j,t} - \sum_{j \in J} q^{j,f} \right) + \varepsilon
\end{aligned}$$

A 7.33 Rearranging we obtain that

$$\sum_{j \in J} b^{j,f} - r \cdot \sum_{j \in J} q^{j,f} \geq \rho \cdot q^{\hat{j},t} + \sum_{j \in J \setminus \hat{j}} b^{j,t} - r \cdot \sum_{j \in J} q^{j,t} + \varepsilon$$

which can be rewritten in terms of the values of original and test outcomes as

$$v^f \geq \rho \cdot q^{\hat{j},t} - b^{\hat{j},t} + v^t + \varepsilon$$

A 7.34 This demonstrates that provided that Bidder \hat{j} makes a Bid for its Final Primary Package according to the rule set out in (A), then an optimal outcome in which Bidder \hat{j} does not win its Final Primary Package must result in Bidder \hat{j} winning some alternative Package $q^{\hat{j},t}$ for which $b^{\hat{j},t} \geq \rho \cdot q^{\hat{j},t} + \varepsilon$. No assumption has been made about the Bids of other Bidders other than that they satisfy the Final Price Cap. This result also holds irrespective of whether Bidder \hat{j} 's Primary Bid in the final Primary Bid Round was a Relaxed Primary Bid or not.

Implications

Raising bid for Final Primary Package only

A 7.35 An implication of this result is that if Bidder \hat{j} bids for its Final Primary Package according to rule (A) and increases its Bid for no other Package to more than that Package's price in the final Round plus ε , then, provided that the Bids received in the final Primary Bid Round remain valid, the Bidder will win its Final Primary Package regardless of the Supplementary Bids made by other Bidders.

Raising bid for Final Primary Package and other Packages

A 7.36 If Bidder \hat{j} makes a Bid for its Final Primary Package according to rule (A), then it cannot win any other Package for which it has made a Primary Bid, but for which it has not made a Supplementary Bid. This is because such a Primary Bid must have been placed in a round prior to the final Primary Bid Round, at prices no greater than ρ and so this Bid cannot exceed the price of the Package in the final Primary Bids Round plus ε .

The case of a Relaxed Primary Bid for the Final Primary Package

A 7.37 In the case that a Bidder's Primary Bid in the final Primary Bid Round is not a Relaxed Primary Bid, then it is possible for the Bidder to raise its Bid for its Final Primary Package according to rule (A) and make no other Supplementary Bids. Therefore, the Bidder can ensure that it wins its Final Primary Package (provided that all the Bids submitted in the final Primary Bid Round remain valid) if it is prepared to raise its Bid by a sufficient amount.

A 7.38 However, in the case that a Bidder's Primary Bid in the final Primary Bid Round is a Relaxed Primary Bid, there will be a Package $q^{\hat{j},k}$ that is a Constraining Package setting a Relative Cap on Bidder \hat{j} 's Final Primary Package. In turn, $q^{\hat{j},k}$ may be subject to a Relative Cap with a Constraining Package $q^{\hat{j},k'}$ and so on. In this case, it is possible that in order to increase its Bid for its Final Primary Package as specified by rule (A), Bidder \hat{j} might need to increase one or more of its Bids for these Constraining Packages to a level exceeding the price of the corresponding Package in the final Primary Bid Round plus ε .

A 7.39 In such a case, Bidder \hat{j} does not have available a strategy that will ensure that it will win its Final Primary Package regardless of the Supplementary Bids submitted by other Bidders (provided that all the Bids submitted in the final Primary Bid Round remain valid). However, even in this case if Bidder \hat{j} makes no Supplementary Bids for any other Packages, then it will win either its Final Primary Package or one of these Constraining Packages for which it submitted a Supplementary Bid that exceeds the price of the corresponding Package in the final Primary Bids Round plus ε .

Cautionary remarks

A 7.40 The analysis presented in this annex holds in theory but might be affected by exceptional circumstances in practice.

A 7.41 For example, if an exceptional event were to occur after the Supplementary Bids Round, resulting in certain Bids or Bidders being excluded from consideration, this could affect the analysis above by altering the number of provisionally unassigned Lots as of the end of the Primary Bid Rounds. Though unlikely, such an event or any other unanticipated event cannot be ruled out. ComReg maintains the right to make a Deposit Call after the Supplementary Bids Round and in the case that one or more Bidders failed to meet this Deposit Call it is possible that their Bids could be excluded from the determination of Winning Bids.

A 7.42 Therefore, the analysis in this annex does not provide an absolute guarantee in relation to particular winning outcomes. ComReg makes no warranty or representation that any strategy suggested herein is necessary or sufficient to

ensure the winning of spectrum.

Annex: 8 Relationships, resolution of Bidder connections, exemptions and changes

Ownership Rules – Relationship Examples

A 8.1 This paragraph is intended to illustrate the types of relations that ComReg considers to fall within the concepts of Connected Persons and Associated Bidders, as discussed in Section 3.3.5. The following is not meant to be an exhaustive or comprehensive description of the relationships that may fall within each category.

- (a) A “**Bidding Group**” includes a Bidder and its Connected Persons.
- (b) A person is considered to be a “**Connected Person**” in relation to a Bidder where the person and/or any of its Controlling Persons and/or any of its Controlled Persons:
 - (iii) either by itself or in concert with another person or other persons controls the Bidder;
 - (iv) either by itself or in concert with another person or other persons has a direct or indirect interest of 10% or more in the Bidder;
 - (v) is a partner of the Bidder;
 - (vi) is Controlled by the Bidder alone or in concert with another Connected Person or Persons; or
 - (vii) has as a director or senior executive any individual who is a director or senior executive of the Bidder or any of its Controlled Persons.
- (c) A person (the “**Controlling Person**”) is considered to control another person (the “**Controlled Person**”) for example:
 - (i) where the Controlling Person and/or its Controlled Persons and/or its Associates, either by itself or in concert with other persons has:
 - (A) an interest in 30% or more of the share capital of the Controlled Person;
 - (B) the right to cast 30% or more of the votes of shareholders on any matter at shareholders meetings;
 - (ii) where the Controlled Person routinely or generally acts in accordance with the instructions of the Controlling Person;

- (iii) where, in the plain meaning of the words, the Controlling Person and/or its Controlled Persons controls the Controlled Person;
- (iv) where the Controlling Person is capable of exercising decisive influence on the activity of the Controlled Person by means of:
 - (A) securities, contracts or any other means, or any combination of securities, contracts or other means; and/or
 - (B) ownership of, or the right to use all or part of, the assets of the Controlled Person, and/or
 - (C) rights or contracts which enable decisive influence to be exercised with regard to the composition, voting or decisions of the organs of the “Controlled Person”; and/or
 - (D) without limitation by the foregoing, any other way,

and “**Control**” will be construed accordingly.

In addition to the above, in determining whether influence of the kind referred to above is capable of being exercised by a “Controlling Person” over a “Controlled Person”, regard shall be had to all the circumstances of the matter and not solely to the legal effect of any instrument.

- (d) A person is considered to be “**in concert**” with another person in circumstances where, for example:
 - (i) one person Controls the other person;
 - (ii) one person is Associated with the other person;
 - (iii) there is an agreement or arrangement (whether or not legally binding) between those persons as to co-ordinated or concerted behaviour or activity by those persons (or either of them); or
 - (iv) where, within the plain meaning of the expression “concerted”, the persons’ behaviour or activity is concerted.
- (e) An “**interest**” is considered to include:
 - (i) an ownership interest, legal or beneficial, actual or contingent;
 - (ii) an interest as the holder of a mortgage, charge, lien, hypothecation or other encumbrance;
 - (iii) any derivative interest such as a participation or sub-participation where the holder of the interest and/or any of its Controlled Persons directly or indirectly bears some or all of the rewards and / or some or all of the risks of the relevant entity, shares or other securities;
 - (iv) an option to acquire any of the foregoing; or
 - (v) a right to convert a right or asset (such as a debt security) into any of the foregoing.

- (f) An “**Associate**” of any entity is considered to include:
- (i) a director or company secretary or like officer of the entity and/or of its Controlled Persons;
 - (ii) a senior executive of the entity and/or of its Controlled Persons;
 - (iii) a spouse, civil partner or cohabiting partner of the foregoing;
 - (iv) any minor child of the foregoing and any child of the foregoing residing with the foregoing;
 - (v) any partner of the foregoing; or
 - (vi) any entity Controlled by any one or more of the foregoing and any partner of such entity.
- (g) “**Associated Bidders**” is considered to include Bidders who have one of the following relationships to each other:
- (i) a Connected Person in relation to one Bidder holds a direct or indirect interest of 20% or more in the other Bidder, or
 - (ii) a person who is not a Connected Person in relation to any of the Bidders concerned holds a direct or indirect interest of 20% or more in both Bidders.

Resolution of Bidder connections

A 8.2 It is possible at the Application Date that a Bidder is unaware that another party with whom it has common or overlapping Bidding Groups or with which it is an Associated Bidder is applying. If ComReg considers that one of the relations referred to above exists between Bidders, it shall notify this to the Bidders affected, indicating a deadline for Bidders to:

- (a) apply for exemption from the rules on relations between Bidders (see below);
- (b) bring the relation to an end; or
- (c) refrain from further participation in the Award Process.

A 8.3 If the Bidders affected are not granted an exemption, do not bring the relation to an end or refrain from participation in the Award Process, ComReg will exclude the Bidders affected from further participation in the Award Process. If the relation comes to light later in the Award Process, i.e. after the Auction has commenced, then ComReg may exclude the Bidder from further participation in the Award Process (see paragraph 3.103 of this Information Memorandum above in that regard) and this may result in partial or whole Deposit forfeiture for the affected Bidders. ComReg may also declare the result of the Award Process not binding, wholly or partly, on it.

A 8.4 If one of the above-mentioned relations exists between two or more Bidders, and it is not possible to bring the relation to an end within the deadline set by ComReg, and ComReg does not grant an exemption, one or more of the Bidders may withdraw from participation in the Award Process, before the deadline for doing so set by ComReg, so that it is not necessary for ComReg to exclude both Bidders from the Award Process. However, the composition of the remaining Bidder and the content of its Application must remain unchanged, subject to ComReg's discretion to approve appropriate amendments.

Exemption from ownership rules

A 8.5 ComReg may, in exceptional circumstances and at its sole discretion, grant exemption from the ownership rules described in Section 3.3.5 of this Information Memorandum. Furthermore, ComReg may attach terms to a decision granting exemption from the ownership rules.

A 8.6 In considering whether to grant an exemption and any terms to attach to an exemption, ComReg will be guided by the need to ensure the efficient use of spectrum, compliance with Section 4 of the Competition Act 2002 (as amended) and compliance with its statutory functions, objectives and duties generally.

A 8.7 ComReg will only grant an exemption from the ownership rules if it is established by the affected Bidders, without undue delay and to ComReg's satisfaction, that there will be no breach of the rules on confidentiality and Bidder behaviour and the relation will not otherwise have a negative impact on the Award Process. For the avoidance of doubt, ComReg will exercise its discretion whether or not to grant an exemption acting reasonably and in accordance with its statutory functions, objectives and duties.

Changes to ownership structures

A 8.8 After the Application Date, a Bidder and its Connected Persons must refrain from actions or omissions that establish a relation to another Bidder resulting in the Bidders falling outside permitted ownership structures. In the absence of an exemption, failure to comply with this rule may result in partial or whole Deposit forfeiture and/or exclusion from the Award Process.

A 8.9 In any event, the Bidder must notify ComReg of any changes that occur after the date its Application is submitted which impact on the ownership structures on which its Application is based.

Bidders subject to Restructuring

A 8.10 ComReg may, at its sole discretion, permit an Applicant in a restructuring process to participate in the Auction subject to additional conditions to be set by ComReg on a case by case basis on receipt of the relevant disclosures.

Annex: 9 Methodology for generating Assignment Options

A 9.1 Assignment Options are determined independently for each band.

A 9.2 For the 700 MHz Duplex, the Assignment Options for an Assignment Bidder comprise the set of frequency ranges that could feasibly be assigned to the Assignment Bidder and meet the requirements set out in Section 4.3.1.

A 9.3 For the 2.1 GHz, 2.3 GHz, 2.6 GHz FDD and 2.6 GHz TDD bands in the Assignment Stage, an algorithm will be used for the generation of Assignment Options that:

- ensures frequency-generic Lots are assigned as a contiguous block of frequencies;
- ensures that if a Bidder has won a fixed-frequency Lot at the end of a band and also frequency-generic Lots within the band, then whenever feasible the entirety of those Lots will form a single contiguous frequency range;
- ensures that if a Bidder has won both fixed-frequency Lots within a band and some, but not all, frequency-generic Lots within the same band, options for the location of its contiguous frequency-generic blocks would be provided such that a Bidder would have an option on whether the contiguous frequency generic lots are located next to one or the other fixed-frequency Lot;
- gives Bidders a variety of options for location of contiguous frequency-generic blocks across the band, but also tries to minimize misalignment of frequencies between Time Slices;
- ensures that any unassigned frequency-generic Lots in Time Slice 2 form a single frequency contiguous block; and
- uses any unassigned frequency-generic Lots in Time Slice 1 to pad the frequency assignments to winners (see paragraph A9.14 below) to improve frequency alignment across the two Time Slices.

Definition of Edge Lots and winners

A 9.4 Where a Lot Category consisting of frequency-generic Lots has frequency-specific Lots at adjacent frequencies, we will call these frequency-specific Lots the *Edge Lots* associated with that particular Lot Category. Therefore:

- The 2.1 GHz and 2.6 GHz FDD bands do not have Edge Lots;
- The 2.3 GHz and 2.6 GHz TDD bands both have Edge Lots in both Time Slices.

A 9.5 For bands with Edge Lots, the lower Edge Lots are the two fixed frequency Lots (one for each Time Slice) immediately below the frequency-generic Lots in that band. Similarly, the upper Edge Lots are those immediately above the frequency generic Lots.

A 9.6 For a band with Edge Lots, we define an *edge winner* to be a winner of frequency-generic Lots in that band who is a winner of *any* Edge Lots in *either* Time Slice.

A 9.7 For the avoidance of any doubt, if a Bidder wins only Edge Lots and no corresponding frequency-generic Lots in a band, we do not consider this Bidder to be an edge winner in that band. It does not need to take part in any frequency assignment for that band, as it has not won any frequency-generic Lots.

Measurement of mismatch across Time Slices

A 9.8 For the purposes of calculations described in this annex, frequency-generic blocks within a band will be numbered sequentially from lowest frequency block to highest frequency block. For example, in the 2.3 GHz Band, the frequency-generic blocks will be numbered 1 to 12 inclusive. An assignment of contiguous blocks to a winner will have a lowest and a highest numbered block.

A 9.9 Given an assignment of specific frequencies to a winner's frequency-generic Lots within a band, the Time Slice Variation (TSV) is defined as:

- the number of the highest frequency block assigned to that winner in either Time Slice plus one, less the number of the lowest frequency block assigned to that winner in either Time Slice;
- minus the maximum number of frequency blocks allocated to that winner across either Time Slice.

A 9.10 This definition means that the TSV for a Bidder who wins Lots in only one Time Slice is always zero. Also, if a Bidder is allocated the same numbered frequency blocks in both Time Slices, its TSV will also be zero. An example of calculating the TSV for a Bidder is shown below.

Example 1: Calculating TSV

Consider a band with six blocks in each of two Time Slices, and a particular Bidder who is assigned the blocks shaded in green:

Time Slice 1	1	2	3	4	5	6
Time Slice 2	1	2	3	4	5	6

To calculate the TSV for this Bidder:

- The highest number frequency block assigned to the Bidder across either Time Slice is 4;
- The lowest number frequency block assigned to the Bidder across either Time Slice is 1; and
- The maximum number of blocks assigned to the Bidder in either Time Slice is 3, in Time Slice 1.

Therefore, $TSV = 4 + 1 - 1 - 3 = 1$

A 9.11 For a band assigned in two Time Slices, the Total Time Slice Variation (TTSV) is the sum of the Time Slice Variations of all winners of frequency-generic Lots in that band. Unassigned Lots are not considered when evaluating the TTSV.

Partitions of winners

A 9.12 We define *partitions* of winners and various mismatch metrics applied to partitions:

- A *partition* of winners is a set of subsets of winners such that every winner is in exactly one subset. For example, given four winners A, B, C and D, there are 15 possible partitions, of which $\{\{A,B\}, \{C\}, \{D\}\}$ and $\{\{A,B,C\}, \{D\}\}$ are two examples. Possible partitions also include individual winners all being in singleton sets, i.e. $\{\{A\}, \{B\}, \{C\}, \{D\}\}$ ¹⁷⁴ and the partition containing just a single set, i.e. $\{\{A,B,C,D\}\}$.
- The *Partition Score* of a partition of winners is the sum, across the subsets of the partition, of the absolute value of the difference across Time Slices in the number of blocks assigned in total to winners within a particular subset. Therefore, given a partition $\{S_1, S_2, \dots, S_n\}$ consisting of n subsets of winners, the Partition Score is

¹⁷⁴ For the avoidance of doubt, a partition does not imply an ordering of its subsets.

$\sum_{i=1}^n |\sum_{b \in S_i} N_b^1 - \sum_{b \in S_i} N_b^2|$, where N_b^1 and N_b^2 are the number of blocks won by Bidder b in the first and second Time Slice respectively.

A 9.13 The Partition Score is a measure of how evenly a given partition of winners splits the available frequency-generic Lots.

A 9.14 Given a particular partition of winners, any unassigned Lots in the first Time Slice (if available) can potentially be used as padding in order for each subset to have as close as possible to the same number of Lots awarded in total in each Time Slice. Therefore, we apply the following definitions:

- The *Corrected Partition Score (CPS)* of a partition of winners is the lowest value of the Partition Score that can be achieved by hypothetically assigning all of the unallocated Lots in the first Time Slice (if any) to winners (in any possible way).
- A hypothetical assignment of unassigned Time Slice 1 Lots to winners that achieves the CPS has the effect of associating a certain number of those unassigned Lots in the first Time Slice to each subset of winners within the partition. Therefore, any partition of winners has an *Associated Unassigned Allocation (AUA)* of all unassigned Time Slice 1 Lots to the subsets of that partition that achieves the CPS.
- There will be at least one way of achieving the CPS, but in some cases there may be more than one way of doing this. In such cases, the AUA will be selected from amongst those for which the maximum number of unassigned Lots to any subset of winners in the partition is greatest. If there are still multiple possibilities after application of this rule, pick one at random.

Example 2: Partition Scores, CPS and AUA

Suppose the number of Lots won in a particular band is as set out in the table below:

Bidder	Time Slice 1 Lots	Time Slice 2 Lots
A	1	3
B	1	1
C,D,E	1	2
F,G	1	0

H	0	2
Unsold	5	0

Consider the partition $\{\{A\},\{B\},\{C,F\},\{D,G\},\{E\},\{H\}\}$. The absolute value of the difference between the number of Lots associated with each subset across Time Slices is:

- 2 for {A};
- zero for {B}, {C,F} and {D,G};
- 1 for {E}; and
- 2 for {H}

The Partition Score is therefore $2 + 0 + 0 + 0 + 1 + 2 = 5$

We then assign the five unsold Time Slice 1 Lots to calculate the CPS.

The AUA in this case is:

- two Lots assigned to A;
- one Lot assigned to E; and
- two Lots assigned to H.

In this case, the CPS is zero because the (corrected) difference in the Lots associated with each subset across the two Time Slices is zero for all subsets. In particular, including the allocation of unassigned Time Slice 1 Lots:

- {A} now includes three Lots in each Time Slice; and
- {E} and {H} now include two Lots in each Time Slice.

Cases for Edge Lots

A 9.15 We identify three distinct situations with respect to Edge Lots:

1. Frequency-generic Lot categories without Edge Lots (i.e. the 2.6 GHz FDD Band and 2.1 GHz Band);
2. For a band with Edge Lots (i.e. the 2.3 GHz Band and 2.6 GHz TDD Band), situations in which if there are any edge winners, there is no edge winner who has won both lower and upper Edge Lots in that band;
3. For a band with Edge Lots, situations where there is at least one edge winner in a band who has won both lower and upper Edge Lots

associated with that band.

A 9.16 We consider these three cases in this order – from simplest to more complex.

Case 1: Algorithm for bands with no Edge Lots

A 9.17 Any unassigned Lots in Time Slice 2 are treated as if they had all been won by a single Bidder, which will be called the TS2 Notional Winner. This is to ensure that if there are multiple unassigned Lots in Time Slice 2, they will form a contiguous range.

A 9.18 Bidders that have won Lots in both Time Slices will be placed in a common ordering within the band across both Time Slices. This means that if Bidder A receives a lower frequency assignment than Bidder B in Time Slice 1, and if both Bidders have also won Lots in Time Slice 2, Bidder A will also be placed below Bidder B in Time Slice 2.

A 9.19 The algorithm for generating Assignment Options proceeds in three steps:

1. Establish various possible orderings for winners of frequency-generic Lots;
2. Construct a candidate frequency plan for each winner ordering; then
3. Derive frequency Assignment Options for each winner of frequency-generic Lots.

Step 1: Possible winner orderings

A 9.20 We start with all winners of frequency-generic Lots, plus the TS2 Notional Winner if there are any unassigned Lots in Time Slice 2. The following recursive algorithm will be used to arrange winners into a tree by successively splitting the winners into smaller groups.

A 9.21 The algorithm builds a tree where each node is associated with a set of winners and some number of unassigned Lots for the Time Slice 1. A worked example is given below.

A 9.22 Start with the set of all winners (including the TS2 Notional Winner), which is set as the initial node of the tree. Then (using the definitions set out above):

- Form all possible partitions of those winners;
- Select the partition with the lowest possible CPS. This partition will have an AUA.
- If there are multiple partitions with the same lowest possible CPS,

then:

- Select, from amongst these, those partitions containing the greatest number of subsets;
- If there are still multiple partitions, select from amongst these to minimise the number of winners within the largest subset within a partition;
- If there are still multiple partitions, select from amongst these to maximise the maximum number of Time Slice 1 Lots associated to any subset within a particular partition;
- If there are still multiple partitions, select from amongst these to maximise the maximum number of unassigned Lots allocated to any subset of winners in the partition;
- If there are still multiple partitions, select one at random.

A 9.23 The selected partition will have some AUA of any unassigned Time Slice 1 Lots to each subset within that partition.

A 9.24 The selected partition defines a branching from the initial node such that each new node is a subset of winners within the partition. Each new node will have a certain number of unassigned Time Slice 1 Lots associated with its subset of winners given by the AUA of that partition.

A 9.25 We then reapply this algorithm recursively to any new nodes consisting of two or more Bidders, using the set of winners at that node and the relevant number of associated unassigned Time Slice 1 Lots (if any), until all branches lead to a singleton set of individual Bidders.

A 9.26 The set of possible winner orderings is created by combining all possible orderings of the branches within the constructed tree.

Example 3: Partitioning Bidders

Consider a band with 12 frequency generic blocks in each Time Slice, where the outcome of the Main Stage is such that:

- Bidders A, B, C and D have each won one Lot in Time Slice 1 and two Lots in Time Slice 2;
- Bidders E and F have each won two Lots in Time Slice 1 and one Lot in Time Slice 2;
- Bidders G and H have each won one Lot in Time Slice 1 and nothing in Time Slice 2; and
- Two Lots were unassigned in each Time Slice.

We refer to the TS2 Notional Winner (who wins two Lots in Time Slice 2) as U. Including, U, there are nine winners.

There are 21,147 partitions of the 9 winners (including the hypothetical winner U). Some of these partitions have a Corrected Partition Score of zero, and one of these partitions would be chosen.

For example, consider the partition $\{\{A,E\}, \{B,F\}, \{C\}, \{D\}, \{G,H,U\}\}$.

There are five subsets in this partition and its Partition Score is two, because:

- the subsets $\{A,E\}$ and $\{B,F\}$ are both assigned three lots in each time slice, so the difference is zero;
- the singleton subsets $\{C\}$ and $\{D\}$ are both assigned one lot in Time Slice 1 and two lots in Time Slice 2, so the absolute value of the difference is one for each;
- the subset $\{G,H,U\}$ is assigned two lots in each Time Slice, so the difference is zero.

Therefore, the sum across the subsets is $0+0+1+1+0=2$, so the Partition Score is 2.

However, note that we could assign one Time Slice 1 unassigned Lot to each of C and D. These subsets would then each be assigned two Lots in each Time Slice, so the CPS is zero.

There are no partitions in this example with a CPS of zero containing more than five subsets.

The largest subset in the partition identified above, $\{G,H,U\}$, contains three Bidders. However, there are partitions with a CPS of zero, five subsets, and a largest subset of two Bidders, for example, the partition $\{\{A,E\}, \{B,F\}, \{C,G\}, \{D,H\}, \{U\}\}$. Where the CPS is zero, the AUA is to give both unassigned Time Slice Lots to the Notional Bidder, U.

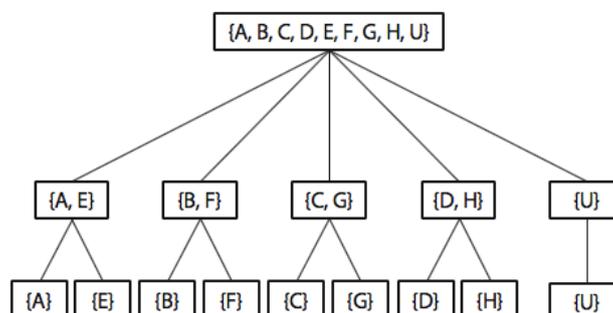
Therefore, the algorithm selects a partition with:

- a CPS of zero;
- five subsets of Bidders, of which the largest contains two Bidders; and
- an AUA that gives both unassigned Time Slice 1 Lots to Notional Bidder U.

Note that there are many of these partitions. For example, we could also have the partition $\{\{B,E\}, \{A,F\}, \{C,G\}, \{D,H\}, \{U\}\}$. So, one partition will be selected at random.

In the second iteration, since each subset contains at most two bidders, these will each be partitioned into two singleton subsets.

Assuming the partition $\{\{A,E\}, \{B,F\}, \{C,G\}, \{D,H\}, \{U\}\}$ is selected, the resulting tree is as follows:



As a result, there are 1920 winner orderings, generated by all the possible orderings of the five subsets from the first iteration and, for each of these, all orderings of the pairs of Bidders within the subsets. However, the number of Bidder Assignment Options will be considerably smaller, as illustrated in the later examples.

Step 2: Construction of a Candidate Frequency Plan for each winner ordering

A 9.27 For each winner ordering, we place the winners into the band in the order specified. This order is common across both Time Slices.

A 9.28 Any unsold Time Slice 1 lots are then placed between contiguous frequency ranges of winners in Time Slice 1 in order to minimise the Total Time Slice Variation (as defined above). If there are a number of band plans giving the same lowest Total Time Slice Variation, then those with the greatest value of the maximum number of Time Slice 1 unsold lots forming one contiguous range is taken. If there are still multiple band plans satisfying these criteria then one is chosen at random. This is the Candidate Frequency Plan for that winner ordering.

Step 3: Determination of Assignment Options

A 9.29 The Assignment Options presented to a Bidder will be:

- the frequency options that the Bidder would receive in any of the possible Candidate Frequency Plans; and
- for Bidders that are not an edge winner, the frequency options that any other Bidder winning the same number of frequency-generic Lots in the band as that Bidder in both Time Slices would receive in any

of the possible Candidate Frequency Plans.

A 9.30 This process ensures that the Assignment Options presented to two Bidders winning the same number of Lots in each Time Slice are the same.

Example 4: Steps 1-3 with two Bidders

Consider a band that has ten Lots in each of the two Time Slices, and two winners (A and B), who each win two Time Slice 1 Lots and four Time Slice 2 Lots.

Again, refer to the Notional Winner of two Time Slice 2 Lots as U.

Step 1

There are a number of ways of partitioning the winners to achieve a CPS of zero. Of these, the partition $\{\{A\},\{B\},\{U\}\}$, with an AUA giving two unassigned Time Slice 1 lots to each subset, would be selected as it has the greatest number of subsets (three).

This gives us six winner orderings (i.e. all possible orderings of A, B and U), set out below.

Step 2 (A's blocks are red, B's are blue, U's are green)

Winner ordering 1: (A,B,U; TTSV = 2)

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

Winner ordering 2: (A,U,B; TTSV = 4)

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

Winner ordering 3: (B,A,U; TTSV = 2)

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

Winner ordering 4: (B,U,A; TTSV = 4)

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

Winner ordering 5: (U,A,B; TTSV = 6)

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

Winner ordering 6: (U,B,A; TTSV = 6)

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

In each case we can improve the TTSV by moving unassigned Lots in Time Slice 1.

Consider winner ordering 1. There are three ways we could move unassigned Time Slice 1 Lots and reduce the TTSV to zero:

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

Of these three options, the first and the third have the greatest number of Time Slice 1 unsold lots forming one contiguous range. One of these two will be selected at random to be the Candidate Frequency Plan for this winner ordering.

Similarly, there are different ways we could move the Lots for the other orderings to reduce TTSV to zero. Suppose the following Candidate Frequency Plans were selected:

Winner ordering 1 Candidate Frequency Plan

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

Winner ordering 2 Candidate Frequency Plan

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

Winner ordering 3 Candidate Frequency Plan

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

Winner ordering 4 Candidate Frequency Plan

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

Winner ordering 5 Candidate Frequency Plan

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

Winner ordering 6 Candidate Frequency Plan

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

Step 3

The Assignment Options are the same for Bidders A and B, because they won the same amount as each other in each Time Slice. They are given by the frequency assignments that would be given to either Bidder in any of the Candidate Frequency Plans above:

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10

the purposes of determining frequency options:

- a hypothetical Bidder (called CD) with C's Time Slice 1 Lots and D's Time Slice 2 Lots; and
- a hypothetical Bidder (called DC) with D's Time Slice 1 Lots and C's Time Slice 2 Lots.

A 9.35 Therefore, CD is an upper edge winner and must be located adjacent to the upper Edge Lot to provide frequency contiguity.

A 9.36 After these substitutions by hypothetical Bidders, if necessary, we have that either the (hypothetical) edge winners get the lower (or upper) Edge Lot in both Time Slices, or one or more of those lower (or upper) Edge Lots is unassigned.

A 9.37 The same procedure is now applied to create Assignment Options as described in Case 1, but there will be an additional restriction on the Candidate Frequency Plans. Only winner orderings that respect the contiguity requirements between the Edge Lots and the frequency-generic Lots will be considered.

A 9.38 If any hypothetical Bidders have been introduced, then the resulting Assignment Options will be re-mapped to the actual winners. In particular:

- If hypothetical Bidders AB and BA had been introduced, then A's Assignment Options will be AB's Time Slice 1 option (i.e. only at the bottom of the band, adjacent to the lower Edge Lot) and BA's Time Slice 2 options. B's Assignment Options will be BA's Time Slice 1 options and AB's Time Slice 2 option (i.e. only at the bottom of the band, adjacent to the lower Edge Lot).
- If hypothetical Bidders CD and DC had been introduced, then C's Assignment Options will be CD's Time Slice 1 option (i.e. only at the top of the band, adjacent to the upper Edge Lot) and DC's Time Slice 2 options. D's Assignment Options will be DC's Time Slice 1 options and CD's Time Slice 2 option (i.e. only at the top of the band, adjacent to the upper Edge Lot).

A 9.39 Any winner of lower (upper) Edge Lots in both Time Slices will necessarily be placed at the bottom (top) of the frequency-generic Lots in both Time Slices and so does not need to make Assignment Bids (for that band).

Example 5: Case 2

Consider a band with Edge Lots, plus 12 frequency generic Lots in each Time Slice. The winners are:

- Bidder A, who wins the lower Edge Lot in Time Slice 1, two frequency-generic Lots in Time Slice 1, and three frequency-generic Lots in Time Slice 2;
- Bidder B, who wins the lower Edge Lot in Time Slice 2, three frequency-generic Lots in Time Slice 1 and two frequency-generic Lots in Time Slice 2;
- Bidder C, who wins three frequency-generic Lots in each Time Slice; and
- Bidder D, who wins the upper Edge Lots and four frequency-generic Lots in both Time Slices.

D will be placed at the top of the band and does not participate in the Assignment Stage.

We introduce two hypothetical Bidders:

- AB has two frequency-generic Lots in each Time Slice; and
- BA has three frequency-generic Lots in each Time Slice.

The partition of singleton subsets of all (hypothetical) bidders has a CPS of zero and is selected.

AB is placed at the bottom of the band under the contiguity requirements.

There are two possible orderings of the remaining Bidders, BA and C. So, there are two Candidate Frequency Plans. These are shown in the diagrams below where red blocks are A's, blue blocks are B's, green blocks are C's and yellow Lots are D's. Un-numbered blocks are the Edge Lots.

Winner ordering 1: (AB, BA, C, D; TTSV = 4)

	1	2	3	4	5	6	7	8	9	10	11	12	
	1	2	3	4	5	6	7	8	9	10	11	12	

Winner ordering 2: (AB, C, BA, D; TTSV = 10)

	1	2	3	4	5	6	7	8	9	10	11	12	
	1	2	3	4	5	6	7	8	9	10	11	12	

Bidders A, B and C each have two Assignment Options in this case, which correspond to the blocks shaded in their respective colours in the options above.

Note that winner ordering 2 has a higher TTSV, but nothing can be done to reduce it as there are no unsold Lots in this example.

Example 6: Case 2 with unassigned lots and restrictions on partitioning

Suppose, in a band with edge Lots and 12 frequency generic Lots, the outcome of the Main Stage was such that:

- Bidder A wins the lower Edge Lot in Time Slice 1 and one frequency-generic Lot in each Time Slice;
- Bidder B wins the lower Edge Lot in Time Slice 2, and two frequency-generic Lots in each Time Slice;
- Bidder C wins the upper Edge Lot in both Time Slices, two frequency-generic Lots in Time Slice 1 and one frequency-generic Lot in Time Slice 2;
- Bidders D, E and F have each won one frequency-generic Lot in Time Slice 1 and two frequency-generic Lots in Time Slice 2;
- Bidders G and H have each won one frequency-generic Lot in Time Slice 1 and nothing in Time Slice 2; and
- two Lots were unassigned in each Time Slice.

Again, we refer to the TS2 Notional Winner, who wins two Lots in Time Slice 2, as U. Including, U, there are nine winners.

In step 1, we replace Bidders A and B with two hypothetical Bidders:

- AB, who wins both lower Edge Lots, one frequency-generic Lot in Time Slice 1 and two frequency-generic Lots in Time Slice 2; and
- BA, who wins two frequency-generic Lots in Time Slice 1 and one frequency-generic Lot in Time Slice 2.

There are additional restrictions, relative to Case 1, to ensure that we only consider winner orderings that put the lower edge winner first and the upper edge winner last.

For example, consider the partition $\{\{AB,C\},\{D,BA\},\{E,G\},\{F,H\},\{U\}\}$.

This has a CPS of zero (with the AUA assigning two unassigned Time Slice 1 Lots to U) and the greatest possible number of subsets (amongst the partitions with CPS of zero), but it is ruled out because AB and C are in the same subset, which would make it impossible to place them at opposite ends of the band.

Assume that the first partition selected by the algorithm is $\{\{AB,BA\},\{D,C\},\{E,G\},\{F,H\},\{U\}\}$.

The second iteration splits these into singleton subsets.

We then calculate all possible winner orderings based on the resulting tree, but keep only the 36 winner orderings that have AB first, BA second, D second to last, and C last.

Note that because D has won the same as Bidders E and F in both Time Slices, it will still have multiple Assignment Options that coincide with those generated for all three Bidders.

Case 3: Upper and lower Edge Lots won by the same winner

A 9.40 In this case, it may be feasible to guarantee contiguity to either lower or upper Edge Lots, but not to both at the same time. Where there is a winner with conflicting contiguity requirements at multiple Edge Lots, we impose various subsets of edge contiguity requirements, applying as many of these requirements as possible providing that they are mutually compatible.

A 9.41 There are a number of sub-cases, which we consider below.

Case 3a

A 9.42 In this case, a winner has won a lower (or upper) Edge Lot in one Time Slice and an upper (or lower) Edge Lot in the other Time Slice, but no other Edge Lots. If there is a single Bidder in this situation, the configuration of Edge Lots is as shown below:

X	...	
	...	X

	...	X
X	...	

A 9.43 Notice that it is possible we could have two Bidders in this situation, in which case the configuration is as shown below.

X	...	Y
Y	...	X

Y	...	X
X	...	Y

A 9.44 In this subcase, contiguity between Edge Lots and frequency-generic Lots can be guaranteed in both Time Slices for any Bidder in this situation. Such a Bidder does not bid in the Assignment Stage, as the assignment of its frequency-generic Lots is determined by its Edge Lots.

A 9.45 For the purposes of determining frequency options for other Bidders, this Bidder is treated as two separate hypothetical Bidders, one winning Time Slice 1 Lots and the other Time Slice 2 Lots.

Example 7: Case 3a

Consider again an example with Edge Lots and 12 frequency-generic Lots, and suppose that the winners are as follows:

- Bidder A wins the lower Edge Lot in Time Slice 1 and the upper Edge Lot in Time Slice 2, as well as four frequency-generic Lots in each Time Slice;
- Bidders B wins four frequency-generic Lots in each Time Slice;
- Bidder C wins the lower Edge Lot in Time Slice 2 plus two frequency-generic Lots in each Time Slice; and
- Bidder D wins the upper Edge Lot in Time Slice 1, plus two frequency-generic Lots in each Time Slice.

Let A1 and A2 be the hypothetical Bidders winning A's Lots in Time Slice 1 and Time Slice 2 respectively.

We can then apply the Case 2 procedure, creating four further hypothetical Bidders to deal with D and E. The Bidders are then:

(Hypothetical) Bidder	Edge Lots	TS1 generic lots	TS2 generic lots
A1C	Both lower	4	2
CA1	None	2	0
B	None	4	4
A2D	None	0	2

DA2	Both upper	2	4
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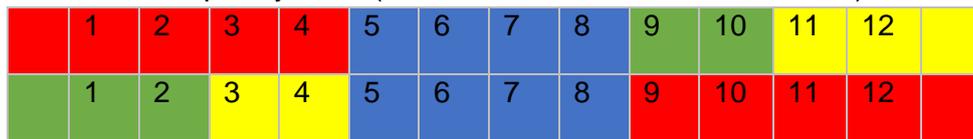
We select the partition $\{\{A1C,A2D\},\{B\},\{CA1,DA2\}\}$, which has a CPS of zero and three subsets. All other partitions with a CPS of zero contain only two subsets of Bidders (i.e. those with B added to one of the other subsets).

In calculating the winner orderings, the contiguity requirements imply that:

- $\{A1C,A2D\}$ must come first, with A1C being placed before A2D; and
- $\{CA1,DA2\}$ must come last, with DA2 being placed after CA1.

Therefore, in this example the algorithm only generates one winner ordering and one Candidate Frequency Plan, shown below (red = A, blue = B, green = C, yellow = D).

Candidate Frequency Plan: (A1C, A2D, B, CA1, DA2; TTSV = 24)



Winning Bidders are simply assigned the frequencies corresponding to this Candidate Frequency Plan and no Assignment bidding is required (for this particular band).

Case 3b

A 9.46 In this case, a winner has won lower and upper Edge Lots in the same Time Slice, but only one Time Slice.

A 9.47 The possible configurations are:

X	...	X
	...	

	...	
X	...	X

A 9.48 It is possible to have two winners in this situation:

X	...	X
Y	...	Y

Y	...	Y
X	...	X

A 9.49 In this subcase, for each Bidder in this situation, we generate Assignment Options for all Bidders by either applying the edge contiguity requirement at the lower end and disregarding it at the upper end or vice versa. We then apply the procedure set out for Case 2. This is then repeated, but with the contiguity requirement applied at the end previously disregarded (and ignored at the end contiguity was previously applied). Therefore, if there is just one Bidder in the Case 3b situation, Assignment Options are generated twice, whereas if there are two Bidders in this situation, they are generated four times (i.e. all combinations of applying the upper/lower contiguity requirement for each Bidder). For each Bidder, all the Assignment Options generated are merged.

Example 8: Case 3b Assignment Options

Suppose that, in a band with ten frequency generic Lots:

- Bidder A wins both Edge Lots in Time Slice 1 and five frequency-generic Lots in each Time Slice; and
- Bidder B wins both Edge Lots in Time Slice 2 and the other five frequency-generic Lots in each Time Slice.

By applying the different combinations of contiguity requirements, we get the following Candidate Frequency Plans (red blocks are A's, blue blocks are B's):

	1	2	3	4	5	6	7	8	9	10	
	1	2	3	4	5	6	7	8	9	10	

	1	2	3	4	5	6	7	8	9	10	
	1	2	3	4	5	6	7	8	9	10	

	1	2	3	4	5	6	7	8	9	10	
	1	2	3	4	5	6	7	8	9	10	

	1	2	3	4	5	6	7	8	9	10	
	1	2	3	4	5	6	7	8	9	10	

Case 3c

A 9.50 In this case, a winner has won three different Edge Lots in the same band.

X	...	X
	...	X

	...	X
X	...	X

X	...	X
X	...	

X	...	
X	...	X

A 9.51 It is not possible to have more than one winner in this situation. Each of the configurations above gives rise to two scenarios for generation of Assignment Options where conflicting edge contiguity requirements are dropped. For example, with the configuration

X	...	X
	...	X

Assignment Options are generated twice applying only the following combinations of consistent edge contiguity requirements (requirements that are ignored are shown with a dash):

X	...	-
	...	X

-	...	X
	...	X

A 9.52 The Case 2 method for generating assignments options is then run twice and the Assignment Options for each Bidder merged.

Example 9: Case 3c

Consider a band with Edge Lots, plus ten frequency-generic Lots in each Time Slice:

- Bidder A wins the lower Edge Lot in Time Slice 1 and both upper Edge Lots, plus three frequency-generic Lots in Time Slice 1 and four frequency-generic Lots in Time Slice 2;
- Bidder B wins the other lower Edge Lot in Time Slice 2, plus two frequency-generic Lots in Time Slice 1 and three frequency-generic Lots in Time Slice 2; and
- Bidder C wins three frequency-generic Lots in each Time Slice.

We are in Case 3b) as a result of Bidder A having won three Edge Lots.

First, we ignore the contiguity requirement for bidder A for the upper Edge Lot in Time Slice 1

Using the Case 2 method, we then have three hypothetical Bidders:

Hypothetical Bidder	Edge Lots	TS1 generic Lots	TS2 generic Lots
A1B	Both lower	3	3
BA1	None	2	0
A2	Upper (TS2)	0	4

The partition with a CPS of zero and the maximum number of subsets is then $\{\{A1B\},\{C\},\{BA1,A2\}\}$, where the AUA gives both unsold Time Slice 1 lots to $\{BA1,A2\}$.

Calculating the winner orderings such that the contiguity requirements (except that for the Time Slice 1 upper Edge Lot) are respected, then positioning the unsold Time Slice Lots to minimize the TTSV gives only one Candidate Frequency Plan (red = A, blue = B, green = C):

Winner ordering 1 (A1B, C, BA1, A2; TTSV = 11)

	1	2	3	4	5	6	7	8	9	10	
	1	2	3	4	5	6	7	8	9	10	

We then re-run the process, this time applying the contiguity requirement in Time Slice 1 at the upper edge (ignoring the lower Edge Lot in Time Slice 1). For this part of the process, since we are only interested in A's Lots in Time Slice 1 being contiguous at the upper edge, we do not associate the lower Edge Lot in Time Slice 1 with an edge winner. We therefore do not need to introduce any hypothetical bidders.

In this second iteration of the process, the partition $\{\{A\},\{B\},\{C\}\}$ is selected. The AUA assigns one unsold Time Slice 1 lot to $\{A\}$ and the other to $\{C\}$. The CPS is zero.

Again, we have just one winner ordering that respects the contiguity requirements. There are two ways of distributing the unsold Time Slice 1 Lots to minimize the TTSV. Suppose the following is chosen at random as the Candidate Frequency Plan:

Winner ordering 2 (B, C, A; TTSV = 0)

	1	2	3	4	5	6	7	8	9	10	
	1	2	3	4	5	6	7	8	9	10	

(Note that the alternative would have been to leave block 1 unassigned and instead allocate block 3 to B).

The Assignment Options offered to Bidders will be those included in either of these Candidate Frequency Plans. In particular:

- Bidder A will be able to bid for contiguity with either the upper or lower Edge Lot in Time Slice 1, and will be guaranteed contiguity with the upper Edge Lot in Time Slice 2;
- Bidder B will have two Assignment Options, with its Time Slice 1 Lots in different parts of the band and its Time Slice 2 Lots fixed at the lower edge; and
- Bidder C will only have one Assignment Option and will simply be allocated the frequencies associated with blocks 4 – 6 in each Time Slice.

Case 3d

A 9.53 In this case, a winner has won all Edge Lots.

X	...	X
X	...	X

A 9.54 Assignment Options are then generated four times, applying only the following combinations of consistent edge contiguity requirements:

-	...	X
-	...	X

X	...	-
X	...	-

X	...	-
-	...	X

-	...	X
X	...	-

A 9.55 The resulting Assignment Options are merged for each Bidder.

Example 10: Case 3d Assignment Options

The effect is that the Assignment Options for a Bidder who wins all four Edge Lots, plus frequency-generic Lots in both Time Slices, will be of the form:

	1	2	3	4	5	6	7	8	9	10	
	1	2	3	4	5	6	7	8	9	10	
	1	2	3	4	5	6	7	8	9	10	
	1	2	3	4	5	6	7	8	9	10	
	1	2	3	4	5	6	7	8	9	10	
	1	2	3	4	5	6	7	8	9	10	
	1	2	3	4	5	6	7	8	9	10	
	1	2	3	4	5	6	7	8	9	10	

Annex: 10 Determination of Winning Bids and Base Prices in the Main Stage

Winner determination

A 10.1 This section provides a formal description of the procedure for determining Winning Bidders, Winning Bids and Base Prices in the Main Stage.

Packages, Bidders and Bids

A 10.2 Suppose there are n Lot Categories, and Let L denote the set of all Lot Categories.

A 10.3 Let s_i denote the number of Lots available in Lot Category i .

A 10.4 We represent a Package of Lots as a vector $q = (q_1, q_2, \dots, q_n)$ where $q_i \geq 0$ is the number of Lots in Lot Category i . Therefore, $q_i \geq 0 \forall i \in L$.

A 10.5 Let J be the set of all Bidders. We will use $J' \subseteq J$ to denote subsets of the set of all Bidders at certain points below.

A 10.6 For any given Bidder, we only need to consider the highest Bid that the Bidder has made for any particular Package. Let B^j be the set of Bids made by Bidder j for non-zero Packages, including only the highest Bid for each of the Packages on which it has bid. $K^j = |B^j|$ is the number of different non-zero Packages for which Bidder j has bid. Let $\beta^{j,k} = (b^{j,k}, q^{j,k})$ denote bid $k \in \{1, \dots, K^j\}$ from Bidder j , in which Bidder j offers to pay up to $b^{j,k}$ for non-zero Package $q^{j,k}$.

A 10.7 A combination of Bids (across all the Bids made by Bidders) is represented as a vector

$$x = (x^{1,1}, x^{1,2}, \dots, x^{1,K^1}, x^{2,1}, \dots, x^{J,K^J})$$

where $x^{j,k}$ is a binary variable equal to 1 if the Bid $\beta^{j,k}$ of Bidder j is included in the combination and zero otherwise.

Feasible Combinations of Bids

A 10.8 A combination of Bids x is a Feasible Combination of Bids if and only if it satisfies the following two conditions:

$$\sum_{j \in J} \sum_{k \in B^j} x^{j,k} q^{j,k} \leq s_i \quad \forall i \in L$$

$$\sum_{k=1}^{K^j} x^{j,k} \leq 1 \quad \forall j \in J$$

These conditions require that:

1. the number of Lots allocated in each Lot Category is no more than the number of Lots available in that Lot Category; and
2. each Bidder wins at most one of the Packages on which it has Bid.

A 10.9 Let F denote the set of all Feasible Combinations of Bids.

Value of a Feasible Combination of Bids

A 10.10 Let r_i denote the reserve price for Lots in Lot Category i . A Feasible Combination of Bids $x \in F$ has a value $v(x)$ calculated as the sum of the included bid amounts plus the Reserve Price of any unassigned Lots:

$$v(x) = \sum_{j \in J} \sum_{k \in B^j} x^{j,k} b^{j,k} + \sum_{i \in L} r_i \left(s_i - \sum_{j \in J} \sum_{k \in B^j} x^{j,k} q_i^{j,k} \right)$$

Winning Assignment

A 10.11 The winning assignment (i.e. the winning Feasible Combination of Bids) must belong to the set

$$F^* = \arg \max_{x \in F} v(x)$$

of Feasible Combinations of maximum value.

A 10.12 The first tie-breaking rule requires that the winning assignment must belong to the set

$$F^{**} = \arg \max_{x \in F^*} \sum_{i \in L} r_i \left(\sum_{j \in J} \sum_{k \in B^j} x^{j,k} q_i^{j,k} \right)$$

If there are multiple Feasible Winning Combinations of Bids in the set F^{**} , one of these will be selected at random as the winning assignment.

A 10.13 Let $\omega = (\omega^{1,1}, \omega^{1,2}, \dots, \omega^{1,K^1}, \omega^{2,1}, \dots, \omega^{J,K^J})$ denote the winning feasible bid combination.

A 10.14 Let W be the set of Winning Bidders. If $\omega^{j,k} = 1$ for some k , then $j \in W$. Otherwise, if $\omega^{j,k} = 0$ for all k , then $j \notin W$.

Opportunity Cost

A 10.15 The Opportunity Cost of a group of Bidders $J' \subseteq J$, denoted as $C(J')$ is calculated as follows.

Let $F^{J'}$ denote the set of all Feasible Combinations of Bids that do not include any Bid from the set of Bidders J' , i.e.

$$F^{J'} = \{x \in F \mid x^{j,k} = 0 \quad \forall k \in B^j, \forall j \in J'\}$$

Let $V(J')$ denote the maximum value that is achieved across all of the Feasible Combinations of Bids in $F^{J'}$ where Bidders in the set J' are excluded from these combinations, i.e.

$$V(J') = \max_{x \in F^{J'}} v(x)$$

The Opportunity Cost of the set of Bidders J' is then defined as

$$C(J') = V(J') - \left(v(\omega) - \sum_{j \in J'} \sum_{k \in B^j} \omega^{j,k} b^{j,k} \right)$$

Determination of Base Prices

A 10.16 We denote the Base Prices as a price vector $p^* = (p^1, \dots, p^J)$, where p^j is the Base Price for Bidder j .

A 10.17 Base Prices must satisfy the (first) requirement that:

$$\sum_{i \in L} r_i \left(\sum_{k \in B^j} \omega^{j,k} q_i^{j,k} \right) \leq p^j \leq \sum_{k \in B^j} \omega^{j,k} b^{j,k} \quad \forall j \in J$$

As the Opportunity Cost for Bidders who have not been assigned any Lots is zero, this requires that the Base Price for Bidders who have not been assigned any Lots is also zero.

A 10.18 Base Prices must satisfy the (second) requirement that:

$$C(W') \leq \sum_{j \in W'} p^j \quad \forall W' \subseteq W$$

A 10.19 Let P denote the set of price vectors that satisfy the previous two conditions.

Let P^* denote the set of price vectors that satisfy the previous two conditions, and which minimise the sum of prices across all price vectors in P , so

$$P^* = \arg \min_{p \in P} \sum_{j \in W} p^j$$

The Base Prices must satisfy the (third) requirement that they must belong to the set P^* .

A 10.20 The Base Price must satisfy the (fourth) requirement that:

$$p^* = \arg \min_{p \in P^*} \sum_{j \in W} (p^j - C(\{j\}))^2$$

As this is a strictly convex quadratic optimisation subject to linear constraints, it has a unique solution.

Annex: 11 Relative Caps in the Primary Bid Rounds

A 11.1 This annex provides further details on the structure of the Relative Caps that are created during the Primary Bid Rounds, with a focus on the consequences of submitting Eligibility-reducing Relaxed Primary Bids.

Treatment of Initial Bids

A 11.2 With respect to the rules on Relative Caps, the Initial Bid submitted by a Bidder is effectively treated in the same way as a Primary Bid submitted during the Primary Bid Rounds, but with Round Prices equal to Reserve Prices. Under the Auction Rules, a Bidder's Initial Eligibility is set by its Initial Bid.

A 11.3 It is possible for Bidders to submit Relaxed Primary Bids for Packages of Lots with Activity in excess of the Bidder's Initial Eligibility in one or both Time Slices. For such Relaxed Bids, the last occasion when a Bidder would have been able to make this bid without exceeding Eligibility would have been as an Initial Bid (subject to not exceeding the Competition Caps). Therefore, the Application Stage acts as if it were the corresponding Constraining Round in such cases and the Initial Bid as a Constraining Package. Informally, this is the same as the Application Stage being a hypothetical "zeroth" Primary Bid Round in which an eligibility-reducing Bid had been made, setting the Initial Eligibility going into the first proper Primary Bid Round.

A 11.4 For these reasons and for simplicity, in this annex we do not explicitly differentiate between the Initial Bid and Primary Bids submitted during a Primary Bid Round as it does not affect the issues discussed.

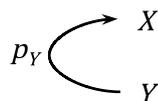
Arrow notation

A 11.5 The features of Relative Caps can be helpfully visualised using the following "arrow" representation.

A 11.6 Consider the case where a Bidder first bids for a Package of Lots X at price p_X and then, in the subsequent Round drops Eligibility to bid for a Package of Lots Y at price p_Y . This sets a Relative Cap on any subsequent bid $\beta(X)$ for Package of Lots X relative to the bid $\beta(Y)$ for Package of Lots Y , with the maximum difference in Bid Amounts determined by the difference in the prices for the two Packages of Lots in the Constraining Round (the Round in which the Bidder submitted the Bid for Y , i.e

$$\beta(X) \leq \beta(Y) + (X - Y) \cdot p_Y$$

A 11.7 We represent this diagrammatically as



A 11.8 The sequence of Rounds runs *down* the page (i.e. we first bid for X then for Y). An arrow runs *from* a Package of Lots *to* a Package of Lots it constrains. Therefore, in the diagram above, to move from the Package of Lots X to its corresponding Constraining Package Y , we need to move *backwards* along the arrow.

A 11.9 The arrow is associated with a price differential, i.e. $(X - Y) \cdot p_Y$. This is the quantity change moving from the Constraining Package Y to the constrained Package X valued at the prices p_Y in force when the Constraining Package was chosen. We can label the arrow with p_Y to emphasise that the quantity difference is valued at p_Y (which is in any case implicit without the label, as these are the Round Prices applying in the Constraining Round).

A 11.10 Key points to note are that:

- the link has a direction, running from a Constraining Package to a constrained Package;
- because each package has at most one Constraining Package, it follows that the Package of Lots chosen in any Round has at most one incoming arrow arriving at that Package of Lots;
- a single Package of Lots may (and typically will) constrain more than one other Package of Lots, and therefore there may be multiple outgoing arrows from a Package of Lots.

A 11.11 To indicate different types of bids made in the diagrams that follow:

- Let S denote a standard Primary Bid (i.e. not a Relaxed Primary Bid) where Eligibility is maintained in both Time Slices;
- Let S_- denote a standard Primary Bid where Eligibility is strictly reduced going forward for at least one Time Slice (and Activity is no greater than the Bidder's Eligibility in either Time Slice as this is not a Relaxed Primary Bid);
- Let R denote a Relaxed Primary Bid where Eligibility is maintained going forward (i.e. a Bid with Activity that is at least equal to the Bidder's Eligibility in both Time Slices, and strictly exceeds it in at least one); and

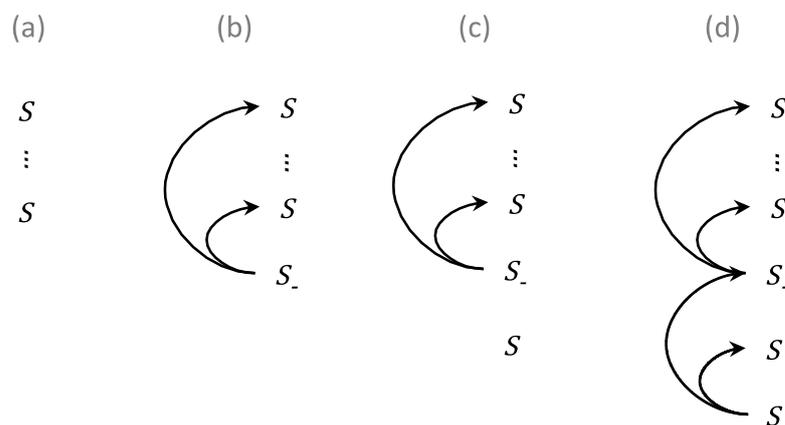
- Let R_- denote an Eligibility-reducing Relaxed Primary Bid i.e. a Bid with Activity that strictly exceeds the Bidder's current Eligibility in one Time Slice but is strictly less than the Bidder's current Eligibility in the other Time Slice.

	Eligibility-maintaining	Eligibility-reducing
Standard Primary Bid	S	S_-
Relaxed Primary Bid	R	R_-

A 11.12 The four categories are summarised in the table above. In these diagrams, we are largely concerned with the type of bid made in each Round (i.e. which of the four categories above occurs) rather than the exact composition of the Package of Lots bid for each in Round.

A simple example

A 11.13 We start with a very simple example in which Eligibility is reduced in steps and there are no Relaxed Primary Bids. The diagram below shows how the Relative Caps build up over successive Rounds as Eligibility is dropped.



A 11.14 In the diagram above:

- The Bidder starts by making a number of standard Primary Bids without dropping Eligibility, shown as a sequence of S 's. At first, no Relative Caps are in force, as the Bidder is maintaining its Initial Eligibility.

- b) The Bidder reduces Eligibility for the first time (shown as a Bid labelled S_1). This reduction in Eligibility establishes Relative Caps on all Package of Lots bid for in the previous Rounds.
- c) Suppose that the Bidder then makes a further standard Primary Bid without reducing Eligibility; a further S is added. This Package of Lots is uncapped at this point. (Note that if the Primary Bid Rounds stopped at this point, then bids on the Final Primary Package would constrain Supplementary Bids made on those packages subject to previous Primary Bids due to effect of the Final Price Cap).
- d) With the next reduction of Eligibility, which occurs in the next Round, a Relative Cap is established on each previous Package of Lots not already having a Relative Cap, including the Package of Lots subject to the previous Eligibility-reducing Primary Bid (i.e. the previous S_1).

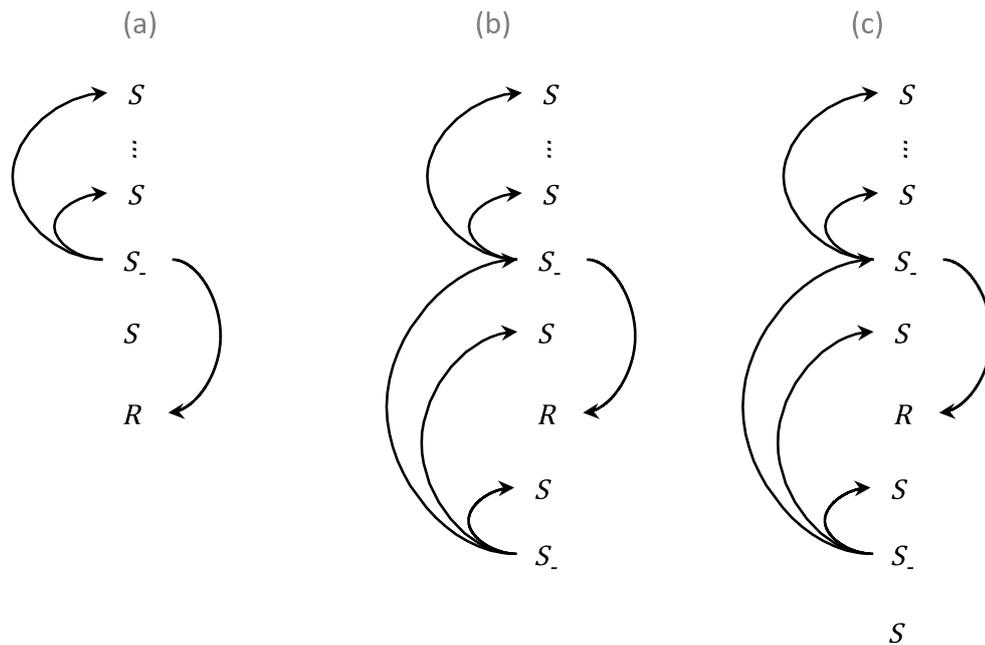
A 11.15 The key feature in this example is that the Relative Caps are chained from one Eligibility-reducing Primary Bid to the next. There are arrows connecting each S_1 back to the previous one in the diagram above.

Relaxed Primary Bids

A 11.16 We now consider the situation when we add Relaxed Primary Bids to these diagrams. In this subsection, we consider only the case of Relaxed Primary Bids that do not also lead to a reduction in Eligibility; Eligibility-reducing Relaxed Primary Bids will be considered in the following Section.

A 11.17 Any Package of Lots X subject to a Relaxed Primary Bid could have been subject to a standard (non-relaxed) Primary Bid in some previous Constraining Round when the Bidder was eligible to bid for X (but did not). A Relative Cap is established on X with regard to the Constraining Package Y that was subject to the Primary Bid submitted in that Constraining Round. By definition, Y must have been first bid for in some Round in which the Bidder reduced Eligibility, otherwise a Relative Cap would not have been set for X .

A 11.18 This is shown in the following example.



- a) *R* shows a Round in which a Relaxed Primary Bid was submitted for Package of Lots we call *X*. In this example, the Bidder has only made one reduction in Eligibility. The corresponding Constraining Package *Y* is, therefore, either that bid for in the only Round in which Eligibility was dropped (shown as the one *S*₁ in case (a) above) or the Initial Bid if Eligibility for Package *X* exceeds Initial Eligibility in either Time Slice; for the purposes of the example, we will assume the former case. The arrow runs from *S*₁ to *R*, as the Relative Cap applies to the Package of Lots subject to the Relaxed Primary Bid (*R*), and the Constraining Package is the previous Eligibility-reducing Primary Bid (*S*₁) made in the last Primary Bid Round when the Bidder was eligible to bid for Package *X*.
- b) The Bidder makes a further standard Primary Bid after the Relaxed Primary Bid, and then a further (non-relaxed) Eligibility-reducing Primary Bid (i.e. the lowest *S*₁ shown in case (b)). This imposes Relative Caps on all previous uncapped Packages of Lots up to and including the preceding *S*₁ bid.
- c) Notice that we obtain an unbroken chain of Relative Caps linking the *S*₁ Eligibility-reducing Primary Bids. The Package of Lots subject to the Relaxed Primary Bid *R* is then capped in relation to a Constraining Package subject to one of the Bidder's standard Eligibility-reducing Primary Bids (*S*₁). This Constraining Package is whichever Package of Lots the Bidder bid for when it was last eligible to bid for *R*.

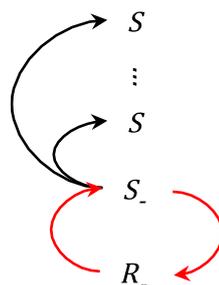
A 11.19 This unbroken chain of Relative Caps arises because each Constraining Package for which the Bidder is no longer eligible to bid in turn has a Constraining Package that is strictly smaller (in terms of Eligibility) in at least one Time Slice and no greater in the other Time Slice. This example allows all the Constraining Packages to be naturally ranked in relation to their size (in terms of Eligibility). Further Eligibility reductions will then append to the chain of Constraining Packages, forming a chain of Constraining Packages ultimately anchored to the smallest Constraining Package.

Eligibility-reducing Relaxed Primary Bids

A 11.20 We now consider the case where a Bidder submits an Eligibility-reducing Relaxed Primary Bid. This is a more complex situation and always creates a loop of Relative Caps. This is because:

- a) the Package of Lots subject to the Eligibility-reducing Relaxed Primary Bid is subject to a Relative Cap, as it is a Relaxed Primary Bid; and
- b) the submission of this bid also creates a Relative Cap on a Package of Lots subject to a previous Eligibility-reducing Primary Bid, as a consequence of this further reduction in Eligibility.

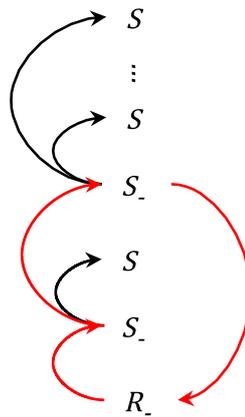
A 11.21 A simple example of an Eligibility-reducing Relaxed Primary Bid is shown below. Here the Bidder first makes a number of standard Primary Bids and maintains its Initial Eligibility (shown as the initial S 's). It then makes a standard Eligibility-reducing Primary Bid (the S_-). This drop in Eligibility creates Relative Caps on the Packages of Lots subject to previous Bids, as in our previous examples.



A 11.22 In the next Round, the Bidder then submits an Eligibility-reducing Relaxed Primary Bid (shown as R_-). As this is a Relaxed Primary Bid, it is subject to a Relative Cap, with the Constraining Package in this case being the Package of Lots bid for in the previous Round (supposing that the Bidder had sufficient Eligibility in that Round to bid for the Package of Lots that is now the subject of R_- as a standard Primary Bid, otherwise the Constraining Package would be the Initial Bid). This gives rise to the downward arrow (from S_- to R_-).

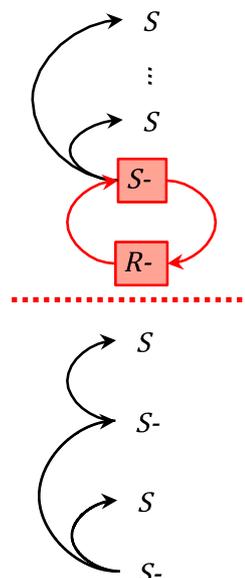
A 11.23 As this is an Eligibility-reducing Round, Relative Caps are also created on all previous uncapped Packages of Lots the Bidder is no longer eligible to bid for after submitting the Relaxed Primary Bid. This creates the upward arrow from R_- to S_- . Therefore, there is a loop of constraints created between R_- and S_- .

A 11.24 In general, any Eligibility-reducing Relaxed Primary Bid will create a loop, but it may involve multiple "steps" depending on how many Eligibility reductions there have been since the Bidder first bid for the Constraining Package. The example below illustrates a case in which the Constraining Package is two steps back in the sequence of Eligibility reductions. The loop is shown in red.



Bids following an Eligibility-reducing Relaxed Primary Bid

A 11.25 What happens after an Eligibility-reducing Relaxed Primary Bid? The example below shows a Bidder making a number of standard Primary Bids, followed by a standard Eligibility-reducing Primary Bid (S_-) and then an Eligibility-reducing Relaxed Primary Bid (shown as R_-). This creates a loop of constraints between R_- and the first S_- , as described above.



- A 11.26 In this example, there are then two subsequent drops in Eligibility after the R_bid . Consider the first Eligibility-maintaining standard Primary Bid (i.e. S) following the R_Bid . As there is no reduction in Eligibility, no additional Relative Caps are created.
- A 11.27 In the next Round, the Bidder reduces Eligibility (i.e. it submits an S_Bid). This creates a Relative Cap on all Packages of Lots with Eligibility greater than the Activity of the Package of Lots bid for in that Round that were not yet subject to a Relative Cap, as per part a) of Paragraph 4.69. Note, however, that the Bidder was not eligible in that Round to bid for the $R_Package$ of Lots (which was thus already subject to a Relative Cap), nor for any other Package of Lots for which it submitted a Primary Bid prior to having made the R_bid). Without any further provisions for setting Relative Caps, this creates a disconnection in the Relative Caps, as bids for the smaller Packages of Lots below the red dashed line do not constrain those above the line.
- A 11.28 Such a disconnection always happens immediately after an Eligibility-reducing Relaxed Primary Bid. This can be seen by considering the arrow coming into the R_bid , representing its Relative Cap. It is necessarily an arrow from above; because this is a Relaxed Primary Bid it is constrained by some Package of Lots already bid for in a previous eligibility-reducing Round. Because each Package of Lots receives at most one incoming arrow (i.e. has at most one Constraining Package), it follows that the R_bid cannot be constrained by subsequent Bids.
- A 11.29 Such a disconnection would be contrary to the intention of the Activity Rules that are designed to impose constraints on the Primary Bids and Supplementary Bids Bidders can submit based on their bidding behaviour in earlier Primary Bid Rounds.
- A 11.30 We, therefore, apply part b) of Paragraph 4.69, which states that submission of an Eligibility-reducing Bid will set a Relative Cap for one (if any exist) of the Packages of Lots for which the Bidder has already submitted an Eligibility-reducing Primary Bid in an earlier Round (potentially replacing a pre-existing Relative Cap on that Package of Lots)¹⁷⁵. This ensures that the chain of Relative Caps remains connected following an Eligibility-reducing Relaxed Primary Bid and a subsequent further reduction in Eligibility. The effectiveness of this rule relies on the property that, whenever a loop of constraints exists, it is *always* possible in a subsequent Round to submit a Relaxed Primary Bid for at least one of the Packages of Lots included in the loop.

¹⁷⁵ In particular, we choose the Package of Lots most recently subject to an Eligibility-reducing Primary Bid out of the Packages of Lots that the Bidder could have bid for in the current Eligibility-reducing round.

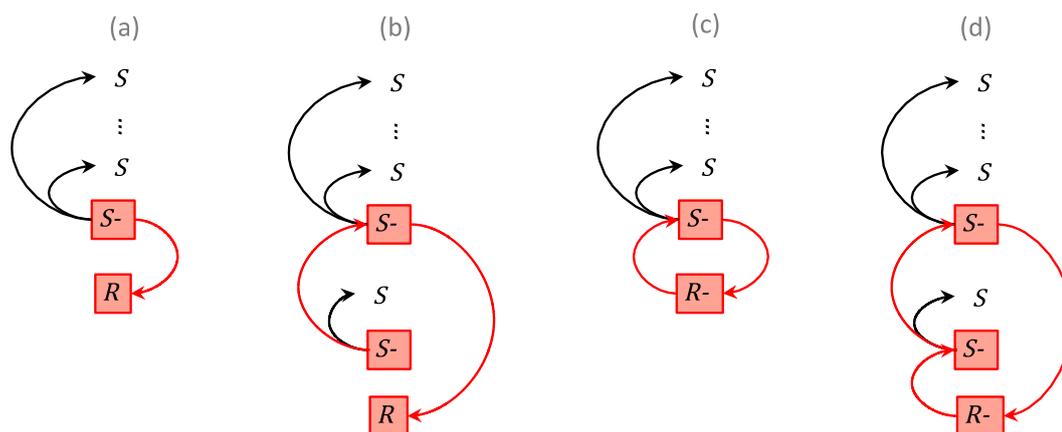
A 11.31 In order to demonstrate how this rule works, we first need to explore the consequences of there being a "loop" of Relative Caps in a little more detail.

Permissibility of Relaxed Primary Bids

A 11.32 Relaxed Primary Bids are only possible in situations where these are consistent with the Relative Caps that result from previously submitted bids. In particular, in order to be able to make a Relaxed Primary Bid, it is necessary that any required Chain Bids do not exceed the current Round Prices.

A 11.33 The Packages of Lots potentially subject to Chain Bids are easily identifiable in these arrow diagrams, by following the arrows backwards from the Relaxed Primary Bid until a Package of Lots is reached that the Bidder is currently eligible to bid for. The first step backwards identifies the Constraining Package of the Package of Lots subject to the Relaxed Primary Bid. The second step backwards identifies the Constraining Package of the first Constraining Package and so on.

A 11.34 Consider first cases (a) and (b) in the illustration below. These are examples in which a Relaxed Primary Bid does not reduce Eligibility. The Relaxed Primary Bid is at current Round Prices. The Relative Cap on the Relaxed Primary Bid requires a minimum Bid Amount for its Constraining Package. In turn, there is a required minimum Bid Amount for that package's Constraining Package and so on. These are the Chain Bids, which are found by backtracking along the arrows (shown in red). For the Relaxed Primary Bid to be allowed, none of these implied Chain Bids may exceed the price of the corresponding Package of Lots in the current Round.



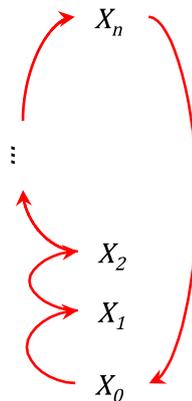
A 11.35 Consider now cases (c) and (d). These are similar to cases (a) and (b), except now the Relaxed Primary Bid is assumed to be eligibility-reducing. In these examples, the Package of Lots subject to the preceding Eligibility-reducing Primary Bid, which was uncapped prior to the submission of the Eligibility-reducing Relaxed Primary Bid, becomes subject to a Relative Cap once the

Relaxed Primary Bid is made. The result is the loop of Relative Caps shown in red.

A 11.36 We can still apply the same procedure following arrows backwards from the Relaxed Primary Bid, but when this is also an eligibility-reducing Bid, we will eventually return back to the Package of Lots subject to the Relaxed Primary Bid from which we initially started. In order for the Relaxed Primary Bid to be possible, we need:

- a) the loop of Relative Caps to be mutually compatible; and
- b) the minimum Bid Amounts (which would apply to any necessary Chain Bids) not to exceed the prices for each Constraining Package traversed at current Round Prices.

A 11.37 A general example of the loop of Relative Caps that results from the submission of an Eligibility-reducing Relaxed Primary Bid is shown below, where X_0 is the Package of Lots subject to the Eligibility-reducing Relaxed Primary Bid. X_n is the Constraining Package of X_0 . Then X_r has a Constraining Package X_{1-r} for $r = 1, \dots, n$.



A 11.38 In order to make this Relaxed Primary Bid for X_0 , the Relative Caps will need to be mutually consistent. This has a simple geometric interpretation. Each arrow has an associated "length", which is the price difference between the constrained Package of Lots and the Constraining Package valued at the prices applying in the relevant Constraining Round.

A 11.39 A condition for the loop of Relative Caps to be consistent is that:

The price difference associated with the Relative Cap that results from the submission of X_0 (i.e. the new "arrow" from X_0 to X_1) cannot exceed the sum of price differences associated with the Relative Caps that link X_0 back to X_1 (implied by the "arrows" that go from X_1 to X_n and

ultimately to X_0)¹⁷⁶.

A 11.40 Consider first the sum of price differences associated with the arrows linking X_0 to X_1 (anticlockwise). If X_0 receives a Bid at the current Round Prices, then the Relative Cap imposed by X_n on X_0 implies a minimum Bid Amount needed for X_n . This minimum is the Bid Amount for X_0 plus the price difference represented by the down arrow from X_n to X_0 . Then, a Bid for X_n requires a minimum Bid Amount for X_{n-1} (an up arrow); a Bid for X_{n-1} requires a minimum Bid Amount for X_{n-2} (an up arrow) and so on. Eventually, having travelled completely around the loop, we find an implied minimum Bid Amount for X_n . Therefore, the sum of these price differences represents the maximum price difference between X_0 and X_1 that is consistent with these Relative Caps.

A 11.41 Consider now the price difference represented by the arrow going from X_0 to X_1 . This price difference is the difference between X_0 and X_1 at current Round Prices. However, if the price difference between X_0 and X_1 at current Round Prices were greater than the maximum price difference between X_0 and X_1 that is consistent with these Relative Caps, then a Relaxed Primary Bid for X_0 would not have been possible.

A 11.42 Note also that we can generalise this condition as follows:

The price difference associated with a Relative Cap that is chained within a loop of Relative Caps cannot exceed the sum of price differences associated with all other Relative Caps within the loop¹⁷⁷.

A 11.43 In other words, the price difference associated with any one arrow within a loop cannot exceed the sum of price differences associated with all other arrows within the loop. If this requirement were not satisfied, the Relative Caps would not be mutually consistent.

Consequences of looped Relative Caps

A 11.44 As we have demonstrated above, whenever an Eligibility-reducing Relaxed Primary Bid is made, a loop of Relative Caps will result. Starting from the Package of Lots bid for, if we find its Constraining Package, then that package's Constraining Package and so on, we will always eventually loop back to the original Package of Lots that is subject to the Relaxed Primary Bid. Moreover, for any permissible Relaxed Primary Bid, the differentials associated with these Relative Caps must be consistent when traversing the loop.

A 11.45 As a result of this loop of constraints, it follows as a direct logical consequence

¹⁷⁶ Note that differentials may be positive or negative.

¹⁷⁷ Again, note that price differences may be positive or negative.

that in any subsequent Round it will be possible to make a Relaxed Primary Bid for at least one of the Packages of Lots within this loop. This is true for every subsequent Round as long as the loop is maintained. Which specific Package of Lots within the loop could be the subject of a Relaxed Primary Bid may depend on the Round Prices, and in some cases, a Relaxed Primary Bid may be possible for more than one of the Packages of Lots in the loop. However, it will always be possible to bid for *at least one* Package of Lots in the loop regardless of the Round Prices.

A 11.46 Therefore, in the loop shown above, in any Round subsequent to the Eligibility-reducing Relaxed Primary Bid for X_0 , it will always be possible to make a Relaxed Primary Bid for at least one of the Packages of Lots X_0, X_1, \dots, X_n . An elementary proof of this is provided at the end of this Annex.

A 11.47 A direct consequence of this property is that, following an Eligibility-reducing Relaxed Primary Bid for a Package of Lots X_0 , in the first subsequent Round in which Eligibility is reduced further (by submitting an Eligibility-reducing Primary Bid for some Package of Lots Y), a Relaxed Primary Bid could have been made on at least one of the Packages of Lots X_0, X_1, \dots, X_n within the loop of Relative Caps.

A 11.48 Specifically, let us suppose that the Bidder could have bid for X_j . As the Bidder has chosen Y in preference to X_j in an Eligibility-reducing Round, it is possible to impose a Relative Cap on X_j (with Y as the Constraining Package) to reflect this preference. This in turn would mean that the chain of Relative Caps before and after an Eligibility-reducing Relaxed Primary Bid remains connected.

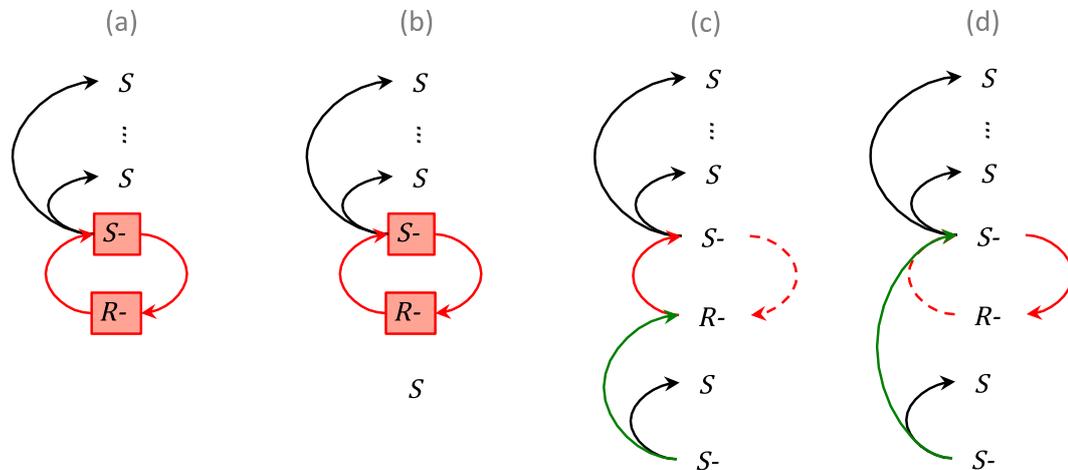
A 11.49 Note, however, that Package of Lots X_j will already be subject to a Relative Cap. This must be so as, by definition, it is a member of a loop of Relative Caps. However, if X_j is then subject to a Relative Cap from Y , then X_j would be subject to two Relative Caps. This is an undesirable feature as it would place unnecessary constraints on the Bidder. Also, if further Eligibility-reducing Relaxed Primary Bids were made that resulted in a loop that again included X_j , it would be possible that X_j could end up having even more than two Relative Caps, creating significant complexity.

A 11.50 To avoid this problem, the existing Relative Cap on X_j can simply be replaced by the new Relative Cap against Y . This amounts to re-setting the Constraining Package (and Constraining Round) for X_j .

Examples of resetting the Constraining Package

A 11.51 An example is provided in the illustration below. Case (a) shows the situation directly after the Bidder has made an Eligibility-reducing Relaxed Primary Bid

(R_-). A loop of Relative Caps is created (shaded red), which means that in any subsequent Round it will always be possible to make a Relaxed Primary Bid for at least one Package of Lots in the loop.



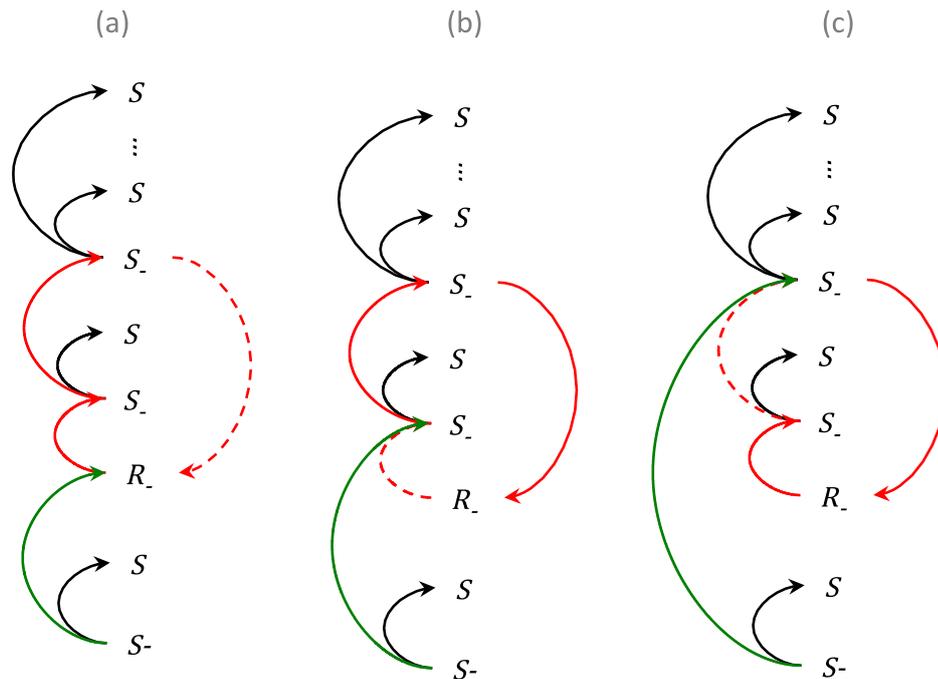
A 11.52 The Bidder then makes a standard Primary Bid that does not reduce Eligibility, shown as case (b). As there has been no reduction in Eligibility, no new Relative Caps are introduced. The Package of Lots subject to the last Primary Bid remains uncapped until such time as there is a subsequent reduction in Eligibility. The loop of Relative Caps involving R_- remains for now.

A 11.53 Now suppose that the Bidder drops Eligibility (by submitting an S_- bid). We know that the Bidder is also able to make a Relaxed Primary Bid in this Round for at least one of the two Packages of Lots within the loop of Relative Caps.

A 11.54 In case (c), let us suppose that the Bidder would be able to submit a Relaxed Primary Bid for the Package of Lots in the loop most recently bid for (i.e. the R_- package). We can impose a new Relative Cap (the green arrow) and remove the previous Relative Cap (shown as a red dashed arrow).

A 11.55 Conversely, if the Bidder cannot bid for the R_- Package of Lots, it will be able to make a Relaxed Primary Bid for the other Package of Lots in the loop (the first S_- package). This is shown as case (d). Notice that in both cases (c) and (d) the loop of Relative Caps is eliminated and the disconnection issues discussed above do not occur.

A 11.56 In the diagram below, we illustrate the same approach at work in a slightly more complex example in which there are three Packages of Lots in a loop of Relative Caps. Once this loop is established, we know that it will always be possible to make a Relaxed Primary Bid for at least one of the three Packages of Lots in the loop; however, we do not know in advance which one, as this will depend on Round Prices.

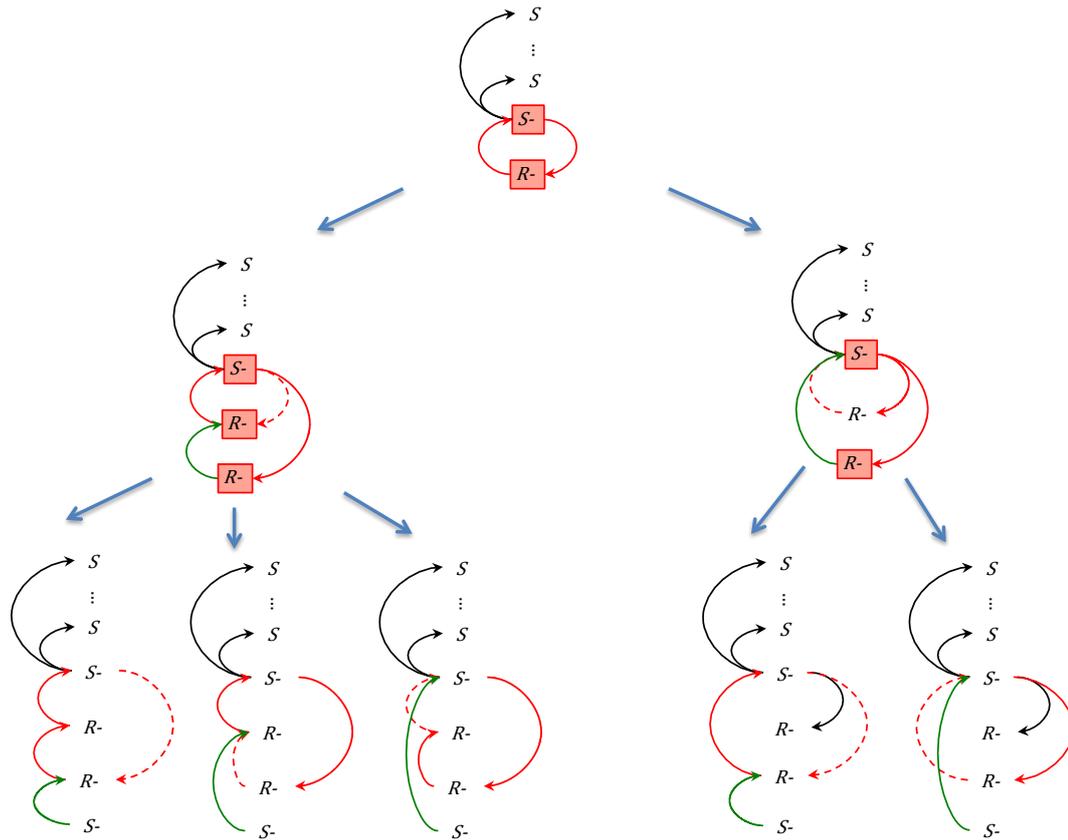


A 11.57 As any of the three Packages of Lots within the loop might be subject to a Relaxed Primary Bid in the most recent Round, we show three cases. The green arrow shows the new Relative Cap. A Relative Cap is then dropped (dashed red arrow) such that each Package of Lots receives just one incoming arrow.

A 11.58 In the event that there is more than one Package of Lots within the loop of Relative Caps that the Bidder could submit a Relaxed Primary Bid for, we only create a new Relative Cap for one of those Packages of Lots, specifically the one most recently subject to an Eligibility-reducing Primary Bid. This permits maximum flexibility for revision of valuations (e.g. due to common value uncertainty) within the constraints of the Relative Caps. Therefore, in the example above, if it were possible to make a Relaxed Primary Bid on more than one of the Packages of Lots in the loop, then case a) would be chosen in preference to case b), which would be chosen in preference to case c). This establishes a new Relative Cap for the Package of Lots most recently added to the loop (from those that Bidder could have bid for in the current Round).

Eligibility-reducing Relaxed Primary Bids following a loop

A 11.59 So far, we have considered only a standard Eligibility-reducing Primary Bid following the establishment of a loop of constraints, which then causes this loop to be cut and re-joined through a new Relative Cap. However, what if the next reduction of Eligibility occurs through an Eligibility-reducing Relaxed Primary Bid? This situation is shown in the example below:



A 11.60 We start with a loop of two Relative Caps, which is then followed by an Eligibility-reducing Relaxed Primary Bid. This causes the previous loop of constraints to be cut, but a new constraint is then established. There are two cases to consider, depending on whether the new R_ Bid is capped by the previous R_ Bid, establishing a new loop of three Relative Caps, or capped by the previous S_ Bid, resulting in a new loop of two Relative Caps (in the diagram above we show the latter case).

A 11.61 Whichever of these two cases occurs, suppose that the Bidder then makes a standard Eligibility-reducing Primary Bid, shown as the final S_ in the lowest tier of diagrams above. This will then cut the existing loop of constraints, depending on which preceding Package of Lots establishes the Relative Cap. Therefore, in all cases we end up with all Packages of Lots being part of a chain of Relative Caps and there being no loops.

Auction rules for setting Relative Caps

A 11.62 The principles for creating Relative Caps discussed above, including the replacement of Relative Caps to break loops of constraints, can be neatly condensed into the rules specified in Paragraphs 4.69 – 4.70 of the Information Memorandum. These specify that:

“The submission of Eligibility-reducing Primary Bids will result in a

Relative Cap being created on certain Packages of Lots that the Bidder could have bid for in that Round, but chose not to. Specifically, when a Bidder submits an Eligibility-reducing Primary Bid Z, then:

- a) this will set a Relative Cap with respect to that Round on any Packages of Lots with Eligibility greater than the Activity of Z in any of the Time Slices and which were not yet subject to a Relative Cap; and
- b) if the Bidder had already submitted any Eligibility-reducing Primary Bids in earlier Rounds, then this will set a Relative Cap for one of the Packages of Lots for which the Bidder has already submitted an Eligibility-reducing Primary Bid - specifically the Package of Lots for which the Bidder submitted its most recent Eligibility-reducing Primary Bid (prior to Z) out of those Packages of Lots for which the Bidder would have been able to submit a Primary Bid (relaxed or ordinary) in the in the Round in which the Bidder submits a Bid for Z.

If the Package of Lots identified in part b) of Paragraph 4.69 above is already subject to a Relative Cap (set by an Eligibility-reducing Primary Bid submitted in an earlier Round), that pre-existing Relative Cap is replaced by the new Relative Cap created by the Eligibility-reducing Primary Bid for Z.”

A 11.63 To demonstrate how these rules work, suppose that Package of Lots Y is the Package of Lots subject to the most recently submitted Eligibility-reducing Primary Bid. There are two cases to consider when a Bidder subsequently reduces Eligibility further by submitting an Eligibility-reducing Primary Bid for a Package of Lots Z:

- 1) **The Eligibility-reducing Primary Bid for Y was *not* a Relaxed Primary Bid:** Part a) of the Relative Cap setting rules sets new Relative Caps for all Packages of Lots the Bidder was eligible to bid for at the start of the Round, but is no longer eligible to bid for following the Eligibility-reducing Primary Bid for Z. Note that these Packages of Lots must include the Package of Lots subject to the most recent previous Eligibility-reducing Primary Bid, which is the Package of Lots that would be identified for a new Relative Cap under part b) of the rules.¹⁷⁸ In this

¹⁷⁸ If Y is the Package of Lots subject to the most recent Eligibility-reducing Primary Bid prior to bidding for Z, and the Bid for Y was a standard Primary Bid (i.e. not a Relaxed Primary Bid) the Bidder would have had sufficient Eligibility (in both Time Slices) to submit a Primary Bid for Y instead of Z. We also

case, part b) therefore has no additional impact on the Relative Caps that are created.

- 2) **The Eligibility-reducing Primary Bid for Y was a Relaxed Primary Bid:** Part a) again sets new Relative Caps for all Packages of Lots the Bidder was eligible to bid for at the start of the Round, but is no longer eligible to bid for following the Eligibility-reducing Primary Bid for Z. However, without any further rules there would be a loop of constraints (created by the Eligibility-reducing Relaxed Primary Bid for Y) and we would face the problem of a disconnection in the Relative Caps, as described above. This is resolved by applying the rules set out in Paragraph 4.69 part b) and Paragraph 4.70¹⁷⁹. We know that in the Round in which the Bidder bid for Z, it would have been possible to instead have submitted a Relaxed-Primary Bid for at least one of the Packages included in the loop of constraints. We know also that there were no reductions in Eligibility between the most recent Eligibility-reducing Primary Bid within the loop of constraints (i.e. the Bid for Y) and the Bid for Z. Consequently, the Package of Lots for which the Bidder submitted its most recent Eligibility-reducing Primary Bid (prior to Z) out of those Packages of Lots for which the Bidder would have been able to submit a Primary Bid in the in the Round in which the Bidder submits a Bid for Z *must* be one of the Packages of Lots within the loop. This is the Package of Lots that would be identified under part b) of the rules for setting Relative Caps. Therefore, where a loop of constraints exists and the Bidder subsequently submits an Eligibility-reducing Primary Bid, we know that a new Relative Cap will always be set for one of the Packages of Lots within the loop. The pre-existing Relative Cap on that Package of Lots will be replaced, the loop will be broken, and connection across the Relative Caps created during the Primary Bid Rounds will be maintained.

Proof of possibility of a relaxed bid given a loop of Relative Caps

A 11.64 Suppose that a loop of Relative Caps has become established amongst the Packages of Lots X_0, X_1, \dots, X_n . The Constraining Package of X_r is X_{r-1} for $r = 1, \dots, n$ and the prices in the Constraining Round p_{r-1} . The Constraining Package of X_0 is X_n and the prices in the Constraining Round p_n .

A 11.65 Let X_0 be the Package of Lots within the loop that was subject to the most

know that no other Eligibility-reducing Primary Bids were submitted between the Bids for Y and Z. Package Y therefore meets the criteria for being “*the Package of Lots for which the Bidder submitted its most recent Eligibility-reducing Primary Bid (prior to Z) out of those Packages of Lots for which the Bidder would have been able to submit a Primary Bid (relaxed or ordinary) in the in the Round in which the Bidder submits a Bid for Z*”.

¹⁷⁹ Relating to the replacement of pre-existing Relative Caps.

recent Eligibility-reducing Relaxed Primary Bid. Such a bid must exist within the loop, otherwise the loop of constraints would not have formed.

A 11.66 The Relative Caps in force amongst X_0, X_1, \dots, X_n are then:

$$\beta(X_1) \leq \beta(X_0) + p_0 \cdot (X_1 - X_0)$$

$$\beta(X_2) \leq \beta(X_1) + p_1 \cdot (X_2 - X_1)$$

⋮

$$\beta(X_n) \leq \beta(X_{n-1}) + p_{n-1} \cdot (X_n - X_{n-1})$$

$$\beta(X_0) \leq \beta(X_n) + p_n \cdot (X_0 - X_n)$$

where $\beta(X_i)$ is the highest Bid so far for X_i .

A 11.67 These constraints are mutually compatible. In particular, as a Relaxed Primary Bid for X_0 was possible at prices p_0 , the Relative Caps admit a solution where

$$\beta(X_0) = p_0 \cdot X_0 \text{ and } \beta(X_r) = p_0 \cdot X_0 + d_i \text{ for } i = 1, \dots, n$$

for some differences d_1, \dots, d_n with the solution satisfying $\beta(X_i) \leq p_0 \cdot X_i$ (i.e. none of the Chain Bids exceed the price of the corresponding Package of Lots at prices p_0 in force when the Bid for X_0 is made).

A 11.68 Now consider the possibility of a Relaxed Primary Bid in some subsequent Round where the Round Prices $p \geq p_0$.

A 11.69 As the Relative Caps only constrain *differences* between Packages of Lots, for any choice of b the Bids defined by

$$\beta(X_0) = b \text{ and } \beta(X_r) = b + d_i \text{ for } i = 1, \dots, n$$

must satisfy the Relative Caps. On setting $b = p_0 \cdot X_0$, we know already from above that $\beta(X_i) \leq p_0 \cdot X_i \leq p \cdot X_i$.

A 11.70 Now increase b until one of the constraints $\beta(X_i) \leq p \cdot X_i$ first becomes an equality, which occurs when

$$b = \min_{i=0, \dots, n} (p \cdot X_i - d_i)$$

where $d_0 = 0$. Let j be the Package of Lots on which this minimum is achieved.

A 11.71 The Relative Caps will still be satisfied for this higher b (as these constraints are independent of b). We have thus a situation in which X_j receives at Bid at

Round Prices p and no other Package of Lots in the loop exceeds Round Prices p , i.e.

$$\beta(X_i) = b + d_i \leq p \cdot X_i \text{ for all } i = 0, \dots, X_n \text{ and}$$

$$\beta(X_j) = b + d_j = p \cdot X_j \text{ for some } j$$

A 11.72 Therefore, a Relaxed Primary Bid for X_j is possible at Round Prices p .

A 11.73 This demonstrates that at least one of X_0, X_1, \dots, X_n will allow a Relaxed Primary Bid at Round Prices p . However, notice that X_j is not necessarily unique, as there may be multiple choices of d_1, \dots, d_n consistent with the Relative Caps.

Annex: 12 DotEcon Report on Exposure Pricing

Vickrey and minimum revenue core pricing in combinatorial spectrum awards

A report for ComReg

13 May 2020

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Executive Summary

Aims of the study

This study was commissioned by ComReg with three aims:

- First, it assesses the pricing mechanism in the CCA including a survey of the available literature on combinatorial clock auctions (CCAs) and considers their advantages and limitations.
- Second, and in light of the previous assessment of CCAs, we consider whether providing more information in the course of the clock rounds would be of benefit to bidders and, if so, methods that can be used to help bidders form expectations about what they might need to pay within a CCA (subject to not compromising efficiency or risking creating incentives for gaming).
- Third, it provides a proof-of-concept for methods providing additional information about the potential prices that bidders might pay, using actual and simulated auction data.

Combinatorial auctions and when they should be used

ComReg has used different auction formats

Spectrum auction design is necessarily a matter of “horses for courses”. The nature of allocation problems varies from award to award in terms of the technical constraints on what outcomes are feasible, in the structure of bidders’ demands and in the conditions of competition. Reflecting this, ComReg has used a variety of different auction formats, including combinatorial clock auctions, combinatorial sealed bid auctions and simple clock auctions.

CCAs are useful tools, especially where there are complementarities

Combinatorial clock auctions are a useful tool for the spectrum auction designer. They can allow spectrum rights to be split by the auctioneer and then reassembled by bidders, whether by frequency block, or regionally (as in ComReg’s 2017 3.6 GHz auction), by time (as in ComReg’s 2012 MBSA) or other means. Because bids are made for packages of lots, rather than each bid being for an individual lot, bidders do not face aggregation risks. Because CCAs are open auctions (with multiple rounds, where bids can be revised, unlike a sealed-bid), they can also reduce the impact of common value uncertainty where this is a significant feature of bidders’ valuations.

It is also straightforward to impose constraints of many different forms on the permitted outcomes (for example, to protect downstream competition) and to bolt on various ancillary policy objectives; this is possible because the CCA determines winning bids through an optimisation process applied at the end of the auction. For example, in ComReg’s 2012 MBSA process it was possible to use this structure to price options for existing licensees to liberalise their licences.

Therefore, there is a variety of reasons why a CCA might be an appropriate auction format to use. The most common reason is that there are significant complementarities between lots. Any assessment of the performance of the CCA relative to other formats should, therefore, focus on situations where there are material complementarities between lots and a need for an open format with package bidding makes a CCA a candidate.

Allocation with complementarities

Allocation problems become more complex with complementarities

Complementarities raise difficult economic questions about how to allocate resources efficiently. Spectrum auctions have drawn heavily on concepts from economic models of market allocation, in particular the use of prices as a decentralised mechanism for efficient allocation of scarce resources. The essential idea is that, if we can create a mechanism in which bidders state what they want at given prices, these prices can then be adjusted so that total demand can be accommodated within the available supply. We do not need full information about how bidders value numerous different possibilities; it suffices to know what they want at a limited number of price points. The early spectrum auctions run by the FCC in the US using the Simultaneous Multiple Round Ascending (SMRA) auction were based on this idea of a price adjustment process clearing a market, originally developed in the nineteenth century.¹

Two conditions need to be satisfied for any approach to efficient allocation based on decentralisation through prices to be successful:

- First, the process of adjusting prices – which is essentially a local search process – needs to converge to an efficient outcome²;
- Second, within an auction process, we need to create incentives for bidders to report their true demand at given prices.

Both requirements are frustrated by the presence of complementarities.

Local vs global characterisation of efficiency

In the absence of complementarities, the more lots a bidder already has, the smaller will be the incremental value of gaining an *additional* lot (so-called *diminishing returns*). Under these conditions, we can find the efficient allocation of lots across bidders through a price adjustment process. This is because, if an outcome is inefficient, then there is a feasible reallocation of lots from one bidder (or bidders) to another bidder (or bidders) that increases the total value of winning bids. A consequence of diminishing returns is that if there

¹ Walras, Léon (1874). *Éléments D'économie Politique Pure, Ou, Théorie De La Richesse*.

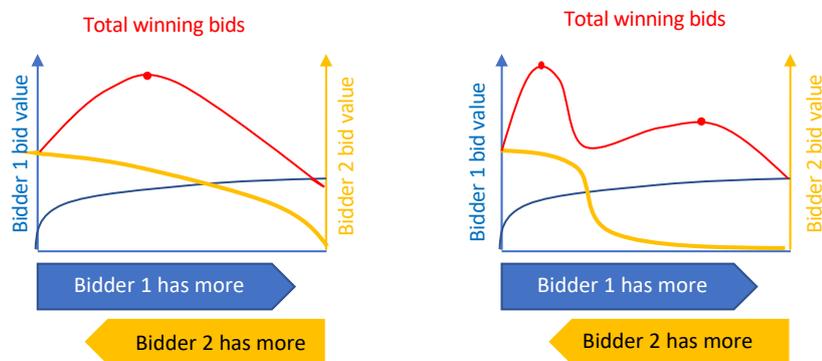
² This is not guaranteed, even with many small atomistic agents. See, for example, Sonnenschein, Hugo (1972). "Market excess-demand functions". *Econometrica*. 40 (3): 549–563.

is such a superior reallocation, then even if it involves moving around many lots it is also the case that moving a single lot can produce an improvement.

This observation means that, when there are diminishing returns, we can characterise an efficient outcome locally. If no rearrangement of single lots amongst bidders produces an improvement, this is sufficient to guarantee that this is the globally efficient outcome.

The intuition is shown in the left-hand diagram below, imagining how a given number of lots might be split between two bidders with diminishing returns valuations. There is a unique point at which the total value of the bidders' two allocations is maximised, both globally and locally.

Figure 1: Examples of allocation problems with and without diminishing returns



In contrast, once there are complementarities, small rearrangements of lots could lower the total value of winning bids, but a sufficiently large rearrangement could produce an improvement, as shown on the right-hand diagram above. The total value of winning bids has two local maxima. In such a case, we require information about bidders' demand at a wide variety of different prices in order to find the efficient outcome. A local search method based on adjusting prices in response to statement of demand by bidders might now fail to reach a globally efficient outcome and become stuck at a local maximum. Therefore, once we have complementarities, the problem of constructing an auction mechanism to find an efficient allocation is much harder.

How CCAs help when there are complementarities

The CCA addresses this problem by collecting multiple, mutually exclusive bids from bidders in the course of the auction. All of these bids then go into a single optimisation mechanism – the winner determination – that finds a globally optimal outcome amongst the various feasible combinations of bids that might be accepted. Of course, this does not by itself guarantee that an overall efficient outcome is necessarily achieved, as this depends on the winner determination having a sufficient variety of bids available to work with, and bidders not misrepresenting their preferences.

The clock stage of the CCA allows the auction to explore what might be a potential market clearing outcome. This also reveals whether significant numbers of lots might remain unallocated at the end of clock rounds, in which case, with complementarities, there is a potential that some other quite different outcome might in fact be efficient. The clock rounds give bidders some information about which packages they could potentially win and would be worth making supplementary bids for (what are often called 'efficiency relevant' packages). Therefore, there is a good chance that, even with strong complementarities, we can explore a sufficient range of outcomes – out of a literally astronomic number of possibilities – for a reasonably efficient outcome to be achieved.

Bidding incentives

Vickrey auctions and truth telling

The second issue is bidding incentives, which are created primarily by the approach taken to setting prices for winning bids. Ideally, we would want bidders to have incentives to bid straightforwardly at their valuations for different packages. This can be fully achieved by using a Vickrey auction, where each bidder pays their individual opportunity cost (i.e. the value denied to other bidders by that winner being allocated its winning lot). It can be shown that, under this pricing rule, bidders can do no better than bidding at valuation for each package *regardless* of what strategies rivals adopt (i.e. truthful bidding is a dominant strategy).³

Content losers

The difficulty with using Vickrey pricing once there are complementarities is that it can result in outcomes where winners pay unreasonably low prices. Lots may be awarded to winners at prices that losers may be prepared to outbid. The essence of the problem is that losers might enjoy some complementarities across lots, but these complementary lots have been fragmented across different winners. Although each of those winners is individually paying enough to justify not allocating its specific lots to others, collectively they are not paying enough, as losers would be prepared to pay more for packages formed by combining lots won by a number of winners.

There are further related problems from using Vickrey pricing when complementarities are present:

- the auctioneer may raise the revenue from the auction by excluding bidders; and

³ Strictly we are ignoring the possibility of other dynamic equilibria being sustainable in multiple round auction, though these possibilities will be limited in practice due to typical spectrum auctions having rules that limit transparency. The statement in the main is, however, correct without qualification for a sealed-bid combinatorial auction with a Vickrey pricing rule.

- bidders may have a monetary incentive to split into multiple subsidiaries which participate in the auction as separate bidders.

Core pricing

These problems are overcome by using so-called *core pricing*, where each winner and group of winners must pay at least their respective *collective* opportunity cost (i.e. the value denied to others by awarding lots to that group). This ensures losers will not have expressed bids for combinations of lots exceeding the prices paid by winners. It is a reasonable requirement on prices in any format using winner determination. It also captures intuitions about what bidders should expect to pay in an open competitive process, in that winners would not expect to win a price that could elicit counter-offers from other bidders at a higher price (allowing for a counter-offer to be for the lots of multiple winners).

Incentive distortions from core pricing

Because core pricing involves winners paying more than Vickrey prices, it is no longer strictly the case that bidders have simple incentives to bid at valuation. Nevertheless, we can seek to minimise any such incentive distortions by keeping winning prices as low as possible subject to the floors set by individual and collective opportunity cost imposed by winners. This is so-called *minimum revenue core* (MRC) pricing, the approach used in CCAs to date.

Therefore – and in a sense that can be formalised – MRC pricing maximises bidders' incentives to bid in line with valuations within the constraint that losers are content. To the extent that there are incentives to deviate from truthful bidding, these are ultimately the unavoidable consequence of complementarities within valuations. For example, if all bidders had diminishing returns to their valuations (i.e. no complementarities), and expected others to bid in line with such valuation structures, then all bidders would know that the eventual winning MRC prices would certainly be equal to Vickrey prices; given this knowledge, bidding at value would be the optimal strategy for all bidders.

Implications for assessing performance

The preceding theoretical observations have important practical consequences:

- First, the CCA is primarily intended to deal with situations in which there are material complementarities between lots. Therefore, it is important that any tests of the format assume such a valuation structure.
- Second, where complementarities are present and there is an exceedingly large number of potential outcomes (as with multiple band spectrum auctions with many lots), we need to have realistic expectations about the efficiency of *any* real-world auction mechanism. Given a limited number of bids, it is not possible to search across all feasible outcomes and efficient outcomes cannot be locally characterised. Therefore, we must rely on eliciting enough information for bidders to be able to make a limited number of efficiency-relevant bids, from which

the winner determination process then selects the most efficient outcome.

- Third, ensuring that winners pay enough to keep losers happy *must necessarily* entail some incentive distortions when there are complementarities, even though such distortions are unlikely to arise practically in spectrum awards.

Performance of CCAs

As discussed above, CCAs may have attractive features when faced with complex allocation problems with complementarities, as can arise naturally in spectrum auctions. However, for the fundamental reasons above, it is not possible to create auction mechanisms that deal perfectly with general situations with complementarity.

Therefore, we need to assess the performance of CCAs keeping this fundamental limitation in mind. This said, there are three main conflicting areas of potential concern:

- incentives to underbid caused by MRC pricing;
- overstating bids to drive up rivals' prices; and
- failure to make a sufficient number and variety of supplementary bids, which in turn limits the variety of outcomes explored in winner determination.

Coalitional winning and incentive distortions

Free-riding incentives The MRC pricing methodology used in CCAs (and second-price sealed-bid combinatorial auctions more generally) involve unavoidable incentive distortions related to coalitions of winners needing to pay above their individual Vickrey prices. MRC pricing can create a situation in which some winners are effectively competing within the winner determination process as if they are a coalition, needing *collectively* to out-bid a loser who wants complementary lots spread across those winners. If these bidders anticipate this possibility, it can create incentives to free-ride, lowering the amount bid in order to get others within the coalition to take a greater share of the cost of beating the loser.⁴ This could have negative consequences for efficiency, as if such coalitional winners lower their bids as a result of such incentives, they might end up losing.

⁴ There are two mechanisms at work here. First, the requirement that no bidder pays in excess of its bid means that a discrete reduction in bid amount may limit the price a bidder pays and force other bidders to cover a greater share of collective opportunity cost. Second, the sharing rule used to splitting collective opportunity costs might lead to a bidder submitting a lower bid for its winning package, but keeping bids for larger packages the same, increasing other bidders' individual opportunity costs, leading to them being allocated a greater share of the collective opportunity cost.

*Complementarities
as the underlying
cause*

This possibility of coalitional winners free-riding on each other and underbidding relative to valuation is an unavoidable consequence in the presence of complementarities of the requirement that winners pay a sufficient amount such that losers would not be willing to offer more. Therefore, this possibility is not of itself a specific criticism of the CCA, but rather it is a general feature of any reasonable allocation mechanism in the presence of complementarities. The only way this incentive problem can be mitigated is if coalitional winners pay less than MRC prices, which can in turn cause losers to be prepared to make a counter-offer above the prices the winners pay.

However, these collective free-riding effects are likely to be limited in most practical applications due to the difficulty of identifying whether specific bids are likely to win in coalition with other winners. In most spectrum auctions, bidders will not have sufficient information about rivals to make a meaningful assessment of these possibilities and the risks of failing to win if bids are lowered. To the extent that a winner is most likely to pay its individual opportunity cost (i.e. Vickrey price), with additional coalitional price contributions being unlikely, any incentive for such free-riding is weak; this is exactly the situation observed in many spectrum auction outcomes using MRC pricing, where due to competition focusing on marginal spectrum, bidders ultimately pay only Vickrey prices in many cases.

Price driving bids

The fact that bidders set rivals' prices has given rise to a variety of criticisms of the CCA on the grounds that it gives opportunities for malicious bidding. We note that these criticisms are not specifically linked to the use of the MRC pricing rule, as the same arguments would also apply to the simple Vickrey auction and indeed even a sealed-bid Vickrey auction. Therefore, these are - at heart - really criticisms of second-price auctions in general. In all these cases, the concern is that bidders might overstate their bids for packages larger than the packages they expect to win to make other winners pay more.

*What is the benefit
of making rivals pay
more?*

All such arguments are predicated on bidders having a motive to make other bidders pay more. There are two coherent theories that might give rise to such benefits, but the importance of such motives is highly debateable:

- It could be that rivals are capital constrained, and that being deprived of cash makes them less effective competitors in downstream service markets. Whilst possible, this seems unlikely to be a significant issue for well-resourced telecoms operators and spectrum costs in any case form only a small part of the overall cost base. Furthermore, when operators

decide how to price their services, spectrum costs are a fixed and largely sunk⁵ cost; prices will be determined by conditions of competition, not by how much was spent for spectrum;

- It could be that shareholders and capital markets lack the information needed to assess in absolute terms whether managers have delivered a good auction outcome, so compare prices paid across winners, rather than evaluating the absolute surplus that the bidder is likely to have enjoyed (i.e. the difference between the valuation of spectrum won and the price paid). The obvious flaw with this argument is that if investors anticipate bidders driving up rivals' prices, then they should not then put much weight on relative prices paid in order to evaluate performance. Furthermore, it opens up policy and corporate governance issues well beyond that of spectrum auction design. For instance, if investors are unable to assess the value of spectrum needed to enable a service innovation, how then would they assess the appropriate level of network investment needed alongside? What would matter most in such circumstances is that spectrum regulators release spectrum at an appropriate time given technological and standards developments, so that there is sufficient clarity around how spectrum will be used for capital allocation to be efficient, but not create so much delay that innovation is held back.

Risks of price driving

Even if there were such motives for making rivals pay more, these would need to be balanced against the risks of modifying bidding behaviour to achieve this. Under both MRC and Vickrey pricing, raising rivals' prices requires bidders to overstate the valuation difference between the package they actually want to win and larger packages that they do not actually want to win (specifically packages including both their own winning package and additional lots that their rivals will win). If a bidder bids for its desired package at valuation, then this entails bidding above valuation for the larger package. Within a CCA, there is also the possibility that this could lead to distortions of the clock rounds, with bidders staying on larger packages for longer than their valuations would suggest in order to relax constraints on supplementary bids for larger packages.

Clearly such strategies entail some risk. It is possible that the bidder could win the larger package at a price at which it would prefer to have won the smaller package. Bidders do not know how far they can drive rivals' prices without winning an unwanted larger package, as they do not know rivals' bids. In many situations, bidders are in broadly symmetric situations and can expect to have similar valuations; this implies a substantial risk of winning unwanted large

⁵ Typically, only some part of overall spectrum costs – such as annual licence fees – will be avoided if licences are given up.

packages if bids are overstated. Therefore, we must contrast the concrete downside risk of winning the wrong package relative to a bidder's own preferences, against rather speculative benefits from making its rivals pay more.

Pricing driving is about objectives, rather than auction format

Therefore, what is really in question is the objectives of bidders, rather than the auction format as such. If we have a situation in which a bidder knows about the valuation of a rival and, for some reason, has an interest in driving up the price that its rival pays, then strategies to achieve this will be available in any auction format. The issue of price driving is not specific to the CCA (or indeed second-price auctions more generally). Rather it raises broader questions beyond auction format, such as why a bidder would have such an incentive to raise rivals' prices and whether the structure of lots leaves specific bidders exposed to price driving (e.g. if they are commonly known to need specific lots and have fewer alternatives than other bidders).

Downstream market power

If there are concerns about potential price driving behaviour, in essence this amounts to a concern that some bidders have incremental valuations for larger packages of lots (relative to smaller ones) that are excessive. One reason this might arise is if winning larger packages might confer some additional downstream market power by denying spectrum to others. However, clearly this is not a situation that should occur in a well-designed spectrum auction, as there should be measures in place, such as spectrum competition caps or reservations, to ensure that downstream competition is protected. Therefore, to the extent that bidders make bids for packages larger than those they expect to win, this should reflect reasonable competition for additional spectrum rather than any anticompetitive motive.

Incentives to compete for quantity

We note that auctions using MRC or Vickrey pricing (such as CCAs, but also second-price sealed-bid auctions) typically lack the incentive present in SMRAs and clock auctions to reduce the quantity sought in order to moderate prices (so-called strategic demand reduction). Therefore, we can expect competition for additional quantities amongst bidders to be more intense in CCAs than in SMRAs or other types of clock auction. However, provided that valuations for larger quantities are not inflated by an anticipation of downstream market power, more intense competition should not be considered as price driving behaviour; to the contrary, a potential inefficiency associated with SMRAs and clock auctions reducing incentives to compete for more spectrum is being avoided. Where we see competition for larger amounts of spectrum than bidders win, this cannot be simply equated with price driving behaviour.

Missing bids

Experiments with few supplementary bids

Some experimental trials of CCAs have found that bidders tended to be reluctant to submit a full range of supplementary bids for packages they might win. This could lead to inefficient outcomes if supplementary bids do not cover efficiency-relevant packages.

Missing bids could also lead to pricing disparities, as the rivals of such bidders will face less competition and pay lower winning prices. This may have featured in the early Swiss CCA in 2001 (though bid data is not publicly available), though CCAs were novel at that time and there is little evidence of such problems in more recent CCAs.

In our view, these results are largely an artifice of the experimental setup, using test subjects with little understanding of the consequences of supplementary bids and perhaps assuming that the auction was largely settled at the end of the clock stage. This is not a realistic simulation of how sophisticated and well-resourced bidders behave in real-world spectrum auctions. Where data is publicly available from CCAs (such as for the UK and Canada) there is no evidence of bidders failing to make use of the opportunity to make supplementary bids.

Exposure pricing

Unknown financial exposure

One criticism of the CCA (and second-price auctions more generally) is that it creates practical problems for bidders, as they may need to make bids for a package higher than the eventual price they pay. In contrast, clock auctions and SMRAs are pay-as-bid, so bidders always know their financial exposure.

Uncertainty arises because auction revenues are minimised subject to opportunity cost floors

The reason for differences between winner bid amounts and prices paid in the CCA is that competition between bidders occurs within the winner determination run at the end of the auction, as well as in the clock rounds. Winning prices are minimised (subject to opportunity cost floors) in order to create the best incentives possible to bid in line with valuations, subject to losers being content with winning prices. Therefore, to the extent that there is uncertainty about winning prices, this is caused by the MRC pricing methodology seeking to minimise auction revenue subject to winners paying enough. Whilst certainty about winning prices might be decreased by bidders paying more (for example, bidders could pay the amount of their bids, rather than MRC prices), this is incompatible with providing incentives to bid in line with value and so could compromise efficiency.

Evaluating likely winning prices

Information is typically available to bidders in the clock rounds of a CCA to allow them to understand the extent to which they might expect ultimately to pay close to their bids amounts, or might pay significantly less. In particular, as rival bidders reduce demand

through the clock rounds, this limits their supplementary bids and with this the opportunity costs they can cause. For example, if there is still excess demand in a clock round such that the entire package a bidder is bidding for could be taken by other bidders, there is the potential that bidder could have to pay the entirety of its bid. However, as excess demand falls, there may come a situation in which rivals have insufficient bid eligibility to compete for the entirety of a bidder's package. In effect, the bidder now has some lots "in the bag" by this point in the auction; clock prices may, however, still be increasing for these lots even though the bidder has effectively secured them.

Whilst it is possible for bidders to make some of these assessments themselves, using only the history of aggregate demand reported (the typical information policy for most CCAs) it might be computationally challenging to make full use of this information. Therefore, one possibility is for the auctioneer to perform these calculations and to report so-called *exposure prices*. This is the greatest amount that a bidder would need to pay for a given package in the current clock round in the event that the clock rounds stopped at this point without any unallocated lots at that point, and rivals made supplementary bids within the constraints set by their bid histories and then the bidder won the package in question.

Bidder-specific discounts

Exposure prices take a simple form. Each bidder would have a bidder-specific discount which would be applied to the clock prices of any package (subject to any minimum price for that package); the discount is the same for all packages, though may vary across bidders. Often, there will be no discounts at the start of the clock rounds if rivals will have sufficient eligibility to be able to compete for all lots that the bidder might want. However, as their eligibility falls, eventually some lots are "in the bag" and a discount could emerge.

Discounts can increase or decrease

It is not necessarily the case that bidder-specific discounts would always increase from one clock round to the next. This is because, although restrictions on supplementary bids cumulate as eligibility reductions are made during the clock rounds, it is also the case that clock prices are increasing, which relaxes the final price cap. Therefore, if a bidder makes a bid for a package in a clock round where there is a positive discount, no guarantee is being offered that the bidder will enjoy this discount in full (i.e. pay at most the current clock price less the discount), as the clock rounds could continue and the discount could reduce. The discount is purely additional information being provided to the bidder about what it would pay at most if the clock rounds stopped *now* and it won that package. Therefore, when a bidder makes a clock bid at a certain level, it is still possible that if it wins that package it could have to pay up to the full amount of its bid, even if that bidder were notified of a positive discount at the start of that round.

Gaming potential If bidder-specific discounts are provided as additional information to bidders, it is very unlikely that this could be used to facilitate gaming, as the information being provided is highly aggregated and does not allow individual bidders' bid histories to be inferred. Therefore, we consider that there is a low risk associated with offering this information additionally to aggregate demand information.

Simulations

Feasibility of calculating exposure prices We have run a number of simulations of exposure pricing during CCA clock rounds, using both Canadian 600 MHz auction data and simulated bid histories. This provides a proof-of-concept for exposure prices, showing that it is feasible to calculate them in the course of the clock rounds of CCA. The examples demonstrate that bidder-specific discounts may emerge later in the clock rounds, but that they may decrease as well as increase in the course of the clock rounds.

Under-sell in the final clock round These simulations also demonstrate that where there are significant complementarities, this may lead to unallocated lots at the end of the clock rounds. This under-sell may arise, as the clock rounds use linear (per lot) prices that are uniform across bidders, which may be unable to support an efficient outcome when there are complementarities. However, exposure prices notified to bidders during the clock rounds are calculated on the presumption of no under-sell in the final clock round and depending on the extent of the undersell exposure prices in the final clock round may be more or less informative. It is important that bidders understand this when interpreting what exposure prices are telling them.

If there turns out to be under-sell in the final clock round, there is no guarantee that a package can be secured at the exposure price applying in that round. Indeed, in some cases it may be necessary for a bidder to increase its final clock bid in order to guarantee winning its final clock bid if there is under-sell (a so-called knock-out bid). This is because rivals can place all-or-nothing bids that include both unsold lots and the bidder's package.

Exposure prices summarise the state of competition at a particular point in the clock rounds of a CCA. Therefore, unsurprisingly, the usefulness of exposure prices to bidders will vary significantly from case to case. They are most informative when there is only a small amount of under-sell at the end of clock rounds. This is because competition in the clock rounds has gone a long way to resolving the auction outcome. However, if there is significant under-sell, then there is more competition yet to occur in the supplementary bids round, so exposure prices become less informative.

Relationship of this study to MBSA2

This study is independent of MBSA2

This project was commissioned independently of ComReg's current on-going consultation process for the forthcoming Multiband Spectrum Award (MBSA2). The analysis provided in this report is intended to be of general applicability and to help to inform public discourse about ComReg's future spectrum awards. However, clearly there is some cross-over. In particular, some consultees in the MBSA2 process have raised general concerns about price driving in CCAs (which we consider not to be a major concern for the reasons set out above) and also uncertain financial exposure due to winning prices being typically less than bid amount (though this results from MRC pricing minimising the winning prices).

Exposure prices provide an additional tool

We consider that it might be useful to consider reporting exposure prices to bidders as a minor amendment of the information policy in MBSA2. Our simulations demonstrate this approach is feasible and would provide some additional information to bidders about the maximum they might pay if the clock rounds stopped and there was no under-sell in the final clock round.

It is possible for bidders to perform similar calculations using aggregate demand information reported to them during the clock rounds, in which case providing exposure prices could be seen as a measure to level the playing field to remove any advantages of more sophisticated and better resourced bidders able to undertake such calculations. However, the auctioneer has access to additional information – the full bid histories of all bidders – which can be used to create a somewhat tighter bound of winning prices and so provide, in certain cases, some additional information. We do not see any significant risks from doing this.

1 Introduction

1.1 Background

ComReg's objectives ComReg has a statutory duty to encourage the efficient use and ensure the effective management of radio spectrum. In dispatching this duty, ComReg has used a variety of spectrum award formats in the past, including a Sealed Bid Combinatorial Auction⁶⁷, Simple Clock Auction⁸ and a Combinatorial Clock Auction ("CCA"). The CCA has been used effectively in the Multi-Band Spectrum Award (2012) and 3.6 GHz Award (2017). ComReg is also planning to use a CCA for its forthcoming MBSA₂ award. Through these various auctions, ComReg has itself significantly contributed to the development of the CCA format, for instance by bringing relaxed bidding rules into effect for the first time.

Prices vs bids in CCAs The CCA uses a form of second-price rule (*minimum revenue core* or *MRC* pricing) that requires winning bidders (individually and jointly) to pay a price based on the opportunity cost of awarding them the spectrum they have won, rather than the amount of their winning bid(s). This means that the price a winning bidder would be required to pay for the package it wins could be significantly below the bid amount submitted.

During several of the consultation processes for awards run (or to be run) using a CCA, ComReg has received comments from stakeholders in relation to the difficulties this potential difference can create for bidders. In particular:

- Budget-constrained bidders do not know whether a bid above budget (if winning) would result in a price above or below budget. They then face difficult decisions over how best to represent their valuations in their bids (i.e. in relation to the risk of bidding above budget, and the trade-off between maintaining value differences across bids for different sized packages and bidding to valuation for smaller packages); and
- Uncertainty over the difference between the bid amount and the price to be paid can create challenges for internal governance processes, in that bids might need to be authorised to higher levels than winning prices ultimately paid.

⁶ <https://www.comreg.ie/industry/radio-spectrum/spectrum-awards/1800-mhz-spectrum-release-2013/>

⁷ <https://www.comreg.ie/publication/26-ghz-spectrum-award-response-to-consultation-and-decision>

⁸ <https://www.comreg.ie/industry/radio-spectrum/spectrum-awards/400mhz-band-spectrum/>

Objectives of this report

For these reasons, ComReg has commissioned DotEcon to conduct an assessment into the use of Vickrey and minimum revenue core pricing in spectrum awards, and in particular to consider whether additional information could be provided to bidders about the winning price that would likely arise from any bids made during the course of a CCA if they were ultimately successful. This report considers the difficulties that stakeholders have argued could arise with the CCA format, assesses the significance of these critiques, and reviews whether there are superior alternatives, with a particular focus on the pricing rules and the information policy of the CCA format.

1.2 Structure of this report

Structure of this report

In section 2, we outline basic economic ideas about the role of markets and prices in achieving efficient allocations of scarce goods, discussing how prices allow for decentralising the exchange of information but have fundamental limitations when demand profiles are *non-convex* due to complementarities (i.e. synergies between different lots). We relate these ideas to ascending price auctions, thinking about spectrum auctions in particular, and outline the motivation for using the CCA when complementarities are present.

In section 3, we discuss how the rules of the CCA have evolved since its first implementation, in part with the aim of the clock round being more informative. We define the sets of rules that we consider later in our simulation exercise.

In section 4, we include a detailed review of the advantages and disadvantages of the CCA. We aim to list reasons why, under certain circumstances, a CCA could result in an inefficient outcome and then consider the materiality of these issues. However, it is important to keep in mind that the CCA is often used in circumstances in which there are complementarities between lots, in which case there are likely to be significant inefficiencies from using other common formats, such as clock auctions and SMRAs and fundamental theoretical challenges in securing efficient allocation.

In section 5, we consider the advantages and disadvantages of alternative pricing methodologies that could be employed in the CCA, including giving bidders what we call *exposure prices* in the course of the clock rounds. Exposure prices are upper bounds on what a bidder might pay if it eventually wins a particular package under certain assumptions given the information available at that point in the auction. Annex A provides technical details of calculating exposure prices.

In section 6, we provide a proof of concept of exposure pricing using both data from real auctions (see Annex B for details) and also using simulated auction data.

In Section 7 we set out our conclusions.

1.3 Conventions and terminology

Terminology

We will use some common terms throughout:

- In CCAs, bids are made for *packages* of lots;
- Bidders have *valuations* (or *values*) for packages of lots;
- *Surplus* is a bidder's valuation for some package of lots, less the price it pays to win them;
- A *surplus-maximisation strategy* is choosing a package of lots to maximise surplus;
- A *myopic* strategy where a bidder chooses how to bid in a particular auction round without regard to any impact of its decision on future rounds;
- An example of myopic bidding is *truthful*, or *straightforward bidding*, where a bidder chooses its surplus-maximising package in each clock round and then makes supplementary bids in a CCA at valuation.

Non-convexities

A common theme running through this report is contrasting situations in which the incremental value to a bidder of winning a lot is either decreased or not affected by winning other lots, from situations in which its incremental value could be increased by winning other lots. This latter case is usually called a 'non-convexity' of the bidder's preferences. A particular example would be a synergy between certain lots (though non-convexities can take many other forms).

Tie-break convention for our examples

Throughout the report we provide a number of examples to illustrate the points being made. For the purpose of consistency within these examples, we assume throughout that when prices are such that a bidder/buyer is indifferent between two options having the same surplus (i.e. value of that option, less the price paid to achieve it), it will choose the option that has greater value.

2 Role of prices in auctions

2.1 Decentralisation and prices

When prices can decentralise finding efficient outcomes

One of the oldest ideas in economics is that markets can be a good way of decentralising the efficient exchange of goods in an economy. This idea goes all the way to Adam Smith's invisible hand⁹. Economic agents respond to prices and markets equilibrate prices, leading to efficient allocation provided appropriate assumptions are made about the nature of tastes and technologies. Therefore, we do not need a central planner with intimate knowledge of consumers' tastes and firms' production possibilities to achieve an efficient distribution of resources.

The essential assumption behind these market efficiency results is an absence of 'non-convexities'. This means that there are no increasing return in production and that consumer demands respond smoothly as prices change. Hurwicz (1977) has shown that if, in an economy, firms face convex constraints and consumers have convex preferences, prices are the informationally efficient way of arriving at the efficient allocation. In this context, prices are:

- *linear* in the number of units of a good (i.e. the price of a number of units is the price multiplied by the number of units); and
- *uniform* (i.e. equal) for all agents within the economy (and so are anonymous, in that prices do not differ between different agents).

Nisan and Segal (2006) extend this result showing that any communication scheme for finding a value-maximising allocation in a private-information economy must also discover supporting prices. Therefore, in the absence of non-convexities, linear, uniform prices are intrinsic to finding efficient allocations.

Price-based demand discovery in auctions

In the context of a typical spectrum allocation problem, absence of non-convexities means that there are no complementarities between spectrum lots, so that the value of one lot does not increase if awarded with other lots. In this case, we can ensure an efficient allocation by asking bidders to respond to prices set by the auctioneer and then adjusting those prices. For example:

- if an auctioneer wants to sell a fixed supply of items and the valuations each bidder holds for different lots are independent of each other, it is possible to sell the items one by one; and
- if an auctioneer wants to sell a fixed supply of items and some bidders consider some lots to be, to some extent, substitutable, the auctioneer can use an ascending price auction format (such

⁹ Adam Smith (1759) "The Theory of Moral Sentiments".

as the SMRA), where bidders respond to increasing prices by either reducing demand or switching to different lots.

The idea of dynamic price adjustment or 'tâtonnement' to clear markets is also an old one.¹⁰ However, in auctions we also need to be concerned about providing incentives for bidders to reveal demand progressively. For this reason, we usually have some form of activity rule that involves prices increasing where there is excess demand, but otherwise staying constant.

2.2 Non-convex demand structures

If buyers have complementarities reflected in their demand responses, the convexity assumption needed for Hurwicz's result about using uniform, linear prices to find efficient allocations is violated. The best allocation that can be supported by prices may not be Pareto-optimal¹¹ (so that there is at least one agent who can be made better off without making any other agent worse off). Since large spectrum auctions will typically involve some complementarities between lots, it is important to consider the impact of this potential market failure.

Failure of the gross substitutes condition

Let us consider multi-item auctions where items are collected into one or more homogeneous categories. We define the *gross substitutes condition* as 'the valuation of two packages together must be at most equal to the sum of the individual valuations of the packages'. We say that a set of prices (one for each item category) *supports an allocation* if at these prices the bidders would request the packages assigned to them in that allocation. In an auction with at least two bidders and two homogeneous items, if at least one of the bidders has valuations that do not satisfy the gross substitutes condition, there may be no set of uniform linear prices¹² which support the optimal allocation (see de Vries et al, 2005, for more analysis and the example below for a simple illustration).

¹⁰ Walras, Léon (1874). *Éléments D'économie Politique Pure, Ou, Théorie De La Richesse*.

¹¹ A Pareto-optimal allocation is one that maximises total value to buyers and is such that any redistribution of the goods that is beneficial to one buyer is detrimental to one or more other buyers.

¹² Prices are linear if the price for a combination of items is equal to the sum of the individual prices for the items. Prices are uniform if they are the same for each bidder.

Example 1: Fallibility of linear anonymous prices under complementarities

Consider an auction with two homogeneous items in one category and two bidders (X and Y). These are their valuations:

Quantity	X's valuation	Y's valuation
1	€400	€700
2	€1,000	€900

The optimal allocation is one where each bidder gets one item and the total value achieved is €1,100. However, there is no uniform linear price for the items at which the bidders will submit demand for one item each. In particular, there is no linear price at which X's demand is exactly 1.

In an ascending auction with reasonable reserve prices and increments, the demand (from X and Y respectively) at a price above €200 and not exceeding €500 per item would be 2 and 1. The auction would then finish with price just above €500 per item, with demand 0 and 1 i.e. X would win nothing, Y would win one item, and the other item would be inefficiently unsold.

The problem set out in the example above stems from the fact that bidder X has a marginal valuation for the second item which is higher than its marginal valuation for the first (i.e. for bidder X, the items are complements), so by the time a price is reached at which bidder X no longer wants to acquire a second item, it also does not want to buy a single item and drops its demand from two to zero. In this specific scenario it would be possible to fix the problem by implementing a non-linear pricing mechanism that supports increasing marginal values i.e. by allowing pricing of two items at more than double the price of one item. For example, a price of €200 for one item and €1,100 for two would have supported the optimal allocation. However, this is not always a feasible solution, as the example below shows.

Example 2: Fallibility of non-decreasing uniform prices under complementarities

Consider an auction with two homogeneous items in one category and two bidders (X and Y). These are their valuations:

Quantity	X's valuation	Y's valuation
1	€300	€600
2	€1,000	€800

The optimal allocation is one where bidder X gets two items and the total value achieved is €1,000. However, there is no uniform linear price for the items which supports the optimal outcome.

A set of non-linear uniform prices (p_1 for one item and p_2 for two items) would have to fulfil the following conditions to support the optimal allocation:

- $p_1 \geq p_2 - (\text{€}1,000 - \text{€}300)$ and $p_2 \leq \text{€}1,000$, so that X buys exactly two items; and
- $p_1 > \text{€}600$ and $p_2 > \text{€}800$, so that Y does not buy anything.

Since $p_1 > \text{€}600$ and $p_2 \leq \text{€}1,000$, the marginal price of the second item would be at most €400, which is smaller than the marginal price of the first item.

Uniformity is the problem, not just linearity

The example above proves that there are scenarios in which uniform prices with non-decreasing marginal amounts cannot solve the problem of inefficient undersell (i.e. when lots are unsold but there is demand for them) and/or aggregation risk posed by complementarities in valuations. Another example considering heterogeneous goods is given below.

Example 3: Complementarities between heterogenous goods warranting bundle discounts

Consider an auction with two items and two bidders (X and Y). Valuations are:

Items	X's valuation	Y's valuation
a	€50	€70
b	€10	€40
a & b	€100	€80

For X, the items are complementary. The optimal allocation is one where X gets both items and the total value achieved is €100.

Suppose that prices need not be linear, so that a price p_{ab} can be set for the package of both items that differs from sum of the prices of the individual items ($p_a + p_b$). However, suppose that these prices are the same for both bidders, so still uniform.

A set of prices which support the efficient outcome would have to satisfy the following conditions:

- $p_a > €70$, $p_b > €40$ and $p_{ab} > €80$, so that Y does not buy anything; and
- $p_{ab} \leq €100$, $p_a \geq p_{ab} - €50$ and $p_b \geq p_{ab} - €90$ so that X buys both goods.

Since $p_a > €70$, $p_b > €40$ and $p_{ab} \leq €100$, the bundle of the two goods would have to be discounted compared to the sum of the prices of the two items.

2.3 Practical impact of non-convexities

We have provided above examples to demonstrate that linear and uniform prices (and even non-linear uniform prices with non-decreasing marginal amounts) may not support optimal allocations when there are non-convexities. However, this does not render prices inappropriate in auctions. Their importance will vary depending on the particular set-up.

2.3.1 Number of bidders and lot complexity

Non-convexities and the number of bidders

A major strand of theoretical economic research has been concerned with finding circumstances under which the impact of non-convexities on the efficiency of market outcomes is small. Most importantly, there is a relation where the more atomised the buyers are (i.e. the smaller an individual buyer's share of the overall demand is) the closer the best price-supported equilibrium will be to the Pareto-efficient equilibrium. For rather deep mathematical reasons, the number of agents affected by non-convexities at the best price-supported equilibrium is related to the number of different types of

goods.¹³ Therefore, if we have many economic agents, then only a small proportion of agents, and hence of market demand if they are all small, will be affected by non-convexities. These results have been used to justify approximate efficiency of market economies under less onerous theoretical restrictions (than say, assuming all goods are gross substitutes for all buyers).¹⁴

Cases where non-convexities have limited impact

If there is a sufficient number of bidders in an auction and few lot categories, then even if the bidders' demands exhibit strong complementarities, inefficiency caused by use of uniform, linear prices may be limited. For example, suppose that we have a single lot category and many bidders. Each bidder has a complementarity in the form of a minimum number of lots being required. If an SMRA-type auction is used, where there are standing high bids, then some bidders might receive fewer than their minimum required number of lots if they are outbid on some, but not all, lots on which they are standing highest. Such bidders win these lots, but at a price where they would prefer not to have won them.¹⁵ However, with careful auction design, such as use of a hybrid SMRA/clock auction (where all lots are treated as identical within a single category) together with rules to minimise the number of bidders receiving only part of their demand¹⁶, the number of bidders receiving fewer lots than their minimum requirement can be kept small, potentially to just one bidder.¹⁷ Therefore, if there are many winners, and no winner is too large relative to the available supply, this may limit the impact of inefficiencies caused by imposition of uniform, linear prices.

Typical multiband auctions

Unfortunately, many spectrum auctions do not have such benign circumstances. It is not uncommon to have a small number of bidders (often just incumbent operators and a small number of entrant challengers, if any) and even fewer winners. More elaborate multiple band auctions may involve a fair number of lot categories, which may be increased further if there is regional licensing, or if

¹³ This is a result of the Shapley-Folkman lemma. See Starr, Ross M. (1969), "Quasi-equilibria in markets with non-convex preferences (Appendix 2: The Shapley-Folkman theorem, pp. 35-37)", *Econometrica*, 37 (1): 25-38,

¹⁴ See for example Aumann, Robert J. (January 1966) "Existence of competitive equilibrium in markets with a continuum of traders". *Econometrica*. 34 (1): 1-17.

¹⁵ Withdrawal rules might be used to allow such a bidder to give up winning lots in such a case, but then the auctioneer would end up with unallocated lots that could not be awarded at the prevailing uniform, linear price. However, this would be inefficient if others have value for those lots.

¹⁶ Ofcom's 2018 auction of 2.3 and 3.4 GHz spectrum provides an example of such rules. When standing highest bidders were determined, a procedure was used to minimise the number of bidders receiving some, but not all, of the lots they demanded.

¹⁷ More generally, if we have a multi-band auction in which complementarities are within-band, rather than across-band, then a carefully designed SMRA/clock hybrid auction should be able to often limit the number of bidders stranded with standing high bids that they do not want at the prevailing price to no more than the number of lot categories.

frequency-specific lots are needed because of particular usage restrictions (for example, at band boundaries to protect adjacent out-of-band users). Therefore, some spectrum auctions may be such that non-convexities could have a significant impact if uniform, linear prices were imposed. There may be further concerns if just some bidders have certain complementarities (such as entrants have cross-band complementarities, but incumbents with existing spectrum holdings having primarily within-band complementarities). Under these circumstances, if we restrict outcomes only to those supported by uniform linear prices, there may be risk of material inefficiency, often taking the form of some spectrum being unsold or allocated in an unusable manner.

2.3.2 Use of combinatorial auctions

Combinatorial auctions can explore more potential outcomes

Under these less favourable circumstances, combinatorial auctions have the advantage that they can explore a much wider range of potential outcomes than can ever be explored through bidders making demand statements faced with uniform, linear prices.

A sealed-bid combinatorial auction with an appropriate second-price rule will be typically very efficient at achieving the optimal allocation provided that all efficient-relevant bids are made. It will allow bidders to express their valuations fully while minimising incentives to report untruthful valuations. It is not limited to only exploring potential outcomes that can be supported by uniform, linear prices.

Managing outcome complexity

However, if there are many items on sale, the complexity of bidding in such auction can be significant. For example, an auction with 10 homogeneous items in each of 10 heterogeneous categories will yield 11^{10} (26 billion) possible combinations of items (i.e. packages) on which bids could be placed. It is unrealistically to expect bidders to be able to bid on all these combinations. Therefore, we need to either:

- provide some bidding language to allow parsimonious representation of valuations for a large number of packages through a much smaller number of parameters; or
- provide a mechanism by which bidders can determine which packages have the potential to be winning (i.e. 'efficiency-relevant packages') to allow them to make a much smaller number of focussed bids.

The problem with the former approach is that it is necessary to make some assumptions about how bidders' valuations are likely to be structured. The auction designer may lack such information and it is possible that particular choices may advantage or disadvantage particular types of bidders. The latter approach is that adopted in the CCA.

*Rationale for the
CCA*

The idea behind the CCA is that often, bidders' aggregated preferences will be *approximately* convex but there will be some *local* complementarities between certain lots for some bidders. In that case, an ascending uniform, linear price mechanism can be used to arrive at an *approximately* optimal allocation. This is the clock stage. Then, a sealed-bid element that follows will make it possible for bidders to correct any inefficiencies by collecting bids for other packages. In this model, in the sealed-bid stage bidders will only have to consider relatively small deviations from their clock stage outcome, which are far less numerous.

Example 4 (below) shows an example where there is a local non-convexity, but it is still possible for a clock auction to approximate an efficient outcome. The assumption of complementarities being local is important, as the clock stage of a CCA then discover an approximate outcome and this dramatically narrows the range of potential outcomes that need to be investigated by the follow-up supplementary bidding stage. Without this assumption, there is a fundamental limitation to achieving efficient allocation in complex cases, as achieving efficiency might require information to be elicited about bidders' valuations on an astronomical number of packages. Such problems outside the scope of typical auction applications.

Example 4: Local complementarities having a limited impact on ascending price auctions

Consider a single spectrum band divided into 10 blocks which will be sold using a CCA. In the clock stage, the blocks are treated as 10 homogeneous items organised into one category.

There are 5 participating bidders. The value of the improvement in the mobile service brought by the spectrum is strictly decreasing with each block won. However, each bidder has a fixed infrastructure cost that it has to bear to use any number of the blocks. As a result, valuations have the following structure: there is a moderate positive value to winning 1 block (compared to not winning anything), but a strictly higher marginal valuation for winning the second block compared to the first one. There is a strictly lower marginal valuation for winning the third block compared to the first one and progressively smaller marginal valuation for each subsequent block. As a result, the only 'lumpiness' is in the valuation for two blocks, which is strictly larger than twice the valuation for one block.

This is an example of such valuations (here represented by the marginal valuations for successive blocks):

Block	A	B	C	D	E
1 st	€109	€101	€108	€126	€144
2 nd	€125	€121	€149	€148	€178
3 rd	€89	€79	€86	€94	€115
4 th	€68	€73	€79	€85	€85
5 th	€53	€65	€62	€73	€81
6 th	€43	€51	€53	€61	€62
(1 st + 2 nd) / 2	€117	€111	€128.5	€137	€161

Providing valuations do not exactly coincide, the price increments are sufficiently small and the bidders bid truthfully such a scenario would result in demand dropping by at most 2 between any pair of consecutive rounds. The clock stage will end with at most 1 unsold block.

According to the valuations in the table above, these would be the bid history:

Price	A's bid	B's bid	C's bid	D's bid	E's bid
€110	2	2	2	2	3
€111	2	2	2	2	3
€112	2	0	2	2	3

In this case, there is exactly one unsold lot at the end of the clock stage when B drops demand from 2 to 0.

3 The Combinatorial Clock Auction

3.1 Motivation for the CCA

Demand characteristics

The Combinatorial Clock Auction was developed to deal with situations with multiple lot categories where bidders have complex demand structures with complementarity and substitutability and where pre-packaging is not feasible. In these scenarios there are a number of complexities and risks that might jeopardise the efficiency of the award that other existing auction formats could not sufficiently deal with.

This situation can (and often does) arise in multi-band spectrum awards where:

- there may be complementarities across lots (for example, within a band, across bands, across regions or across time periods);
- different combinations of lots might be substitutable, creating a need to switch between combinations of lots as prices change, rather than switch individual lots;
- spectrum requirements and demand structures may differ across bidders, so pre-packaging would overly restrict the options for distributing the spectrum across users efficiently.

3.1.1 Aggregation risk

Complementarities create aggregation risks

When there are complementarities across lots, bidders may be exposed to *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. This is not as much of an issue when a bidder's marginal valuations for additional lots are decreasing with the number of lots won, as winning some, but not all lots sought only increases the value of those won. However, with complementarities the value of multiple lots together is greater than the sum of the individual values of the lots (as described above), In this case, winning bidding for a combination of lots, but winning only a subset, could result in paying more for those lots than they are worth, as synergy benefits are not achieved.

In spectrum awards, significant complementarities across lots may occur for a variety of reasons:

- bidders may have a minimum bandwidth requirement in a particular band that exceeds the size of the individual lots available;
- some bidders might want to increase their bandwidth in steps greater than the lot size;

- there may be technical efficiencies from acquiring larger bandwidths that may give rise to increasing returns to scale from acquiring additional lots (at least for some bandwidths);
- bidders may get benefits from acquiring a portfolio of spectrum across multiple bands (e.g. to provide support to different devices or to obtain a combination of low frequencies for a coverage layer and high frequencies for additional capacity);
- bidders may get benefits from acquiring a portfolio of spectrum across multiple regions (e.g. ComReg's 3.6 GHz Award);
- lots may correspond to spectrum licences for different time periods, which bidders may wish to combine (e.g. ComReg's MBSA award);
- there might be obligations such as coverage commitments that are procured alongside the sale of spectrum licences, where the coverage commitment might increase the need for spectrum.¹⁸

Package bidding

The CCA removes aggregation risk by allowing for 'package bidding', where bidders can bid for multiple packages of lots each with a single bid amount, rather than being required to place separate bids for the individual lots that form the package. If a 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).

3.1.2 Allocation with complementary and substitutable lots

Limitation of uniform, linear prices

As we have seen in section 2, where there are multiple complementary and/or substitutable lots (or combinations of lots), using uniform linear prices to establish the outcome (i.e. asking bidders what they would most want at given prices, and increasing prices if there is excess demand) does not necessarily yield an optimal allocation. This is because such an approach cannot extract full information about bidders' valuation structures that can then be used to determine how best to distribute the lots on offer based on value. This could lead to an outcome where the lots are not assigned to bidders efficiently (i.e. in a manner that yields the maximum value across winning bidders) and could even lead to lots being inefficiently unsold.

Finding efficient outcomes has a non-local character and requires more information than can be gained through simply asking for demand at set prices. Sometimes this is relatively simple, for example if bidders have minimum requirements for what they need to win, but otherwise decreasing marginal value. In other situations,

¹⁸ See Ofcom's initial proposals for an auction of 700 MHz and 3.6 GHz spectrum that used a CCA with coverage obligations included as lots. This has now been superseded due to an agreement between operators and the UK Government on coverage improvements. See <https://www.ofcom.org.uk/consultations-and-statements/category-2/proposal-auction-regulations-700mhz-3.6-3.8-ghz>

for example with complex complementarity and substitutability involving multiple lot categories, it can be less straightforward. Often, the auction designer does not know in advance about the structure of bidders' valuations, especially for entrants.

A CCA collects bids without the limitation of uniform, linear prices

The CCA helps to mitigate these issues by allowing bidders to submit a range of bids for different combinations of lots at (largely) discretionary bid amounts that can accurately reflect their demand structures. The auctioneer is then able to consider a wide range of potential allocations across bidders taking into account the complementarities and substitutability (implied by the relative bid amounts for different packages) and then to determine winning bids by taking the feasible combination of bids of greatest total value (the process of *winner determination*).

To support efficiency, combinatorial auctions typically use a second-price rule that helps to incentivise truthful bidding (i.e. bidding in line with valuations) so that the outcome can be based on accurate information about bidders' demands. The pricing rule in the CCA is discussed further below. It does not impose any requirement that the winning prices be uniform or linear.

3.2 General structure and mechanics

The CCA comprises 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 rounds

The clock stage evolves over a number of rounds. At the beginning of each round, the auctioneer announces prices for each lot category. During a round, bidders specify the number of lots in each category they would like to acquire at these prices. No information about other bidders' bids 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, discussed in detail below. These impose restrictions on the bids a bidder can submit in the clock rounds based on their bidding behaviour in previous clock rounds.

There are various possible approaches that can be taken to the information released to bidders during the clock rounds, but it is common to release only limited information, rather than full details of all bids made to limit gaming behaviours. Typical approaches include:

- disclosing the aggregate demand by lot category (typically used by ComReg in previous CCAs);

- disclosing only that aggregate demand for a lot category lies in some range, rather than the precise value of aggregate demand;
- only telling bidders whether a lot category is subject to excess demand (i.e. demand exceeds supply).

The first approach is commonly adopted so that the clock rounds can provide aggregate information to reduce common value uncertainty.

Supplementary bids round

In the supplementary bids round, bidders can make their final offers for alternative, mutually exclusive, packages determined by the bidder. The bids that a 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.

Winner determination

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 will therefore be those that generate the highest possible 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. Prices are usually set using some form of second price rule, which we discuss in section 3.4 below.

3.3 Activity rules

Price discovery

Open auctions with multiple rounds help bidders by allowing them to observe information about their competitors' demand for the available lots and subsequently revise their own valuations. This process can benefit bidders in cases where there are bidder information deficits when a bidders' bids or preferences across different packages would have been different if it had more information about the nature of demand. These include common value uncertainty, complex conflicts in demand and potential for bidder error. For example, common value occurs where there are shared uncertainties about the underlying value of the assets being auctioned that affect all bidders, even if there are idiosyncratic factors affecting the valuations of each bidder). Auctions with an open stage allow bidders to pool their combined information about the common value of the lots which can aid efficiency of the outcome¹⁹. This process is usually called *price discovery*.

¹⁹ Strictly, once there are common values this is the 'ex-post efficiency', which is the efficiency of the outcome once the private information of bidders has been pooled by the auction mechanism.

Need for activity rules to control open rounds

However, for an open stage of an auction to be effective as a means for price discovery, it is necessary that the demand expressed by bidders each round is reflective of their valuations. Otherwise the demand information observed would at best be meaningless and could in fact be detrimental to the efficiency of the award if bidders misinterpret it. Activity rules are therefore used to prevent (or disincentivise) bidders from withholding or misrepresenting information about their own demand until late in the auction.

Activity rules impose restrictions on what bidders can bid for in each round based on their bidding behaviour in previous rounds. They ensure that there are consequences for bidders from not bidding to valuation throughout the auction, who might then be unable to fully express their demand in later stages and ultimately win a less preferred combination of lots than they might otherwise have been able to. As such, the activity rules help to incentivise bidders to bid straightforwardly, rather than engaging in any sort of strategic or gaming behaviour designed to manipulate the auction outcome, such as hiding demand or overstating demand to drive prices for others.

Demand goes down when prices go up

A fundamental concept behind activity rules is that bidding should be progressive – as prices go up, demand should go down. Therefore, on a very basic level, activity rules typically will be designed such that when bidders reduce demand (i.e. bid for fewer lots than before, presumably in response to increasing prices) they cannot then increase their demand later on at higher prices.

Substitution between categories

This simple idea becomes much more complicated once we introduce multiple categories of lots that bidders can switch between. In scenarios where lots are perfect substitutes, the activity rules might be set such that bidders simply cannot increase the number of lots they bid for as the open stage of the auction progresses. However, this approach is often not sufficient when there are multiple lot categories that are imperfect substitutes, since:

- it supports strategies whereby bidders can hide demand in less valuable lots only to reveal their true demand for the more valuable lots later on, undermining intentions behind the open stage; and/or
- it could create barriers to switching between different combinations of lots if lots are substitutable but not on a one-to-one basis e.g. if I want one category A lot or two category B lots (depending on relative prices), I could not bid for one A lot and then switch to two B lots when category A became too expensive.

Eligibility points

Activity rules can use eligibility points to help tackle these problems. Each lot in the auction is attributed a number of eligibility points, and each bidder starts every round with a certain level of eligibility to bid

(at the beginning of the auction a bidder is allocated its initial eligibility).

Eligibility and activity

Under a simple eligibility points based activity rule (as would be used, for example, in a simple clock auction), in each round a bidder's activity (the sum of eligibility points associated with the lots the bidder submits a bid for in the round) cannot exceed its eligibility at the beginning of the round. For each new round the bidder's eligibility is set to the bidder's activity in the previous round.

Set relative eligibility points

The eligibility points set a substitution ratio between different lots which reflect an allowed rate of switching between different lot categories.²⁰ This means that:

- the eligibility points can be set such that bidders cannot (or at least find it more difficult to) hide demand in less valuable lots only to bid for more valuable lots later on²¹; and
- if the points ratios are set correctly, bidders are better able to switch between substitutable combinations of lots.

However, under this simple approach bidders could face difficulties with bidding in line with valuations if:

- the eligibility points ratios are not sufficiently reflective of the differences in value across different lots for all bidders (in which case bidders may still face barriers to switching across different combinations of lots); and/or
- prices evolve in such a way that a larger package (in terms of total associated eligibility points) becomes relatively cheaper than smaller packages *after* a bidder had reduced its demand (and eligibility), in which case the bidder would no longer have sufficient eligibility to bid for the larger and more profitable package at current prices.

These are potentially serious issues. It may not be possible to set eligibility points in a way that reflects switching preferences for all bidders, either because these are unknown or – more fundamentally

²⁰ For instance, suppose there are two lot categories, A and B. Lots in each of these categories are assigned one and two points respectively. The total demand of a bidder would be measured as the number of A lots the bidder bids for times the eligibility points for A lots, plus the number of B lots the bidder bids for times the eligibility points for B lots. Therefore, the bidder would be able to switch between two A lots and one B lot without changing its total demand.

²¹ Suppose there are two lot categories (A and B) each with two lots. Suppose also that a bidder wants to acquire two lots (either two A lots or two B lots), and that the A lots are expected to be worth approximately double the value of the B lots. If the activity rules only take into account the number of lots bid for, a bidder could hide its demand for the A lots by bidding on the two B lots and then switching to the A lots later on, misrepresenting its true demand at the beginning of the auction. If instead an eligibility points rule were imposed, with the A lots each being assigned two eligibility points, and the B lots each assigned one eligibility point, the bidder would have to bid for the two A lots from the beginning and while those are the lots it is interested in – if it bid for the two B lots instead, it would not have sufficient eligibility to switch to the A lots later in the auction.

– that these differ across bidders. In this case, switching becomes impeded. What might otherwise have been a simultaneous auction with demand switching back and forth across a number of categories as relative prices change, become sequential, with some categories being resolved before others, due to switching of demand from one category to another being irreversible. This may impede price discovery.

As discussed in more detail below, there are additional, more complex, activity rules that can be applied to help mitigate these problems, in particular the use of '*relaxed activity rules*'. These rules allow bidders to switch around between different packages in the clock rounds provided choices are consistent with surplus-maximisation against some fixed set of preferences. Unlike eligibility points, they avoid the need to make implicit assumptions about the form of those preferences.

Supplementary round

In the CCA, activity rules are also needed on the supplementary bids that bidders can make based on their bidding behaviour in the clock rounds. The following subsections discuss in further detail the various alternative activity rules that have been applied over the years in different iterations of the CCA.

3.3.1 Absolute caps

The first CCAs (including the L-band and 10-40 GHz auctions in the United Kingdom, in 2008, and the 2.6 GHz auction in the Netherlands, in 2010) used the simple clock auction activity rule for the clock stage, and so-called 'absolute' caps on the bids that the bidder could make in the supplementary bids round for packages with eligibility greater than the bidder's eligibility in the final clock round. The maximum bid amount was determined by the clock price of the corresponding package in the last round in which the bidder had sufficient eligibility to bid for that package. Therefore, suppose that a bidder starts with eligibility E and reduces to eligibility E' in round X , then its bids for packages with eligibility greater than E' but no greater than E will be capped at the price of the package in round X .

Table 2: Absolute caps – example

Suppose that we have a single lot category with each lot having one eligibility point.

Suppose that a bidder starts bidding for five lots, reduces its demand to three lots when the price per lot is 10, and subsequently to two lots when the price per lot is 12. The clock stage ends with the bidder still bidding on two lots.

The supplementary bids the bidder can make for packages with eligibility greater than two are subject to absolute caps, equal to the cost of the package in the last round in which the bidder was eligible to bid for the package. Thus:

- any bids for packages with more than five lots will be capped at the reserve price of the package;
- if the bidder wishes to increase its bid for the package with five lots, this will be capped at 50, and if it wishes to make a bid for a package of four lots, this will be capped at 40;
- if the wishes to increase its bid for the package with three lots, this will be capped at 36;

if the bidder wishes to increase its bid for the package with two lots, or if it wishes to make a bid for the package with a single lot, then these bids are not capped, so the bidder can make these bids without limitations.

This variant of the CCA addresses aggregation risks and switching impediments by allowing bidders to make alternative offers for multiple mutually exclusive packages. However, under the absolute cap rule, bidders who want to be able to bid at valuation for all packages can only do so if they make clock bids for the largest package they might still want to acquire, rather than for their preferred package at clock prices, as shown in the following example.

This deficiency was known at the time, but the approach was used nevertheless due to the simplicity of the activity rules. As these were the first CCAs and entirely unfamiliar to bidders, there were concerns that complex rules might be difficult for bidders to understand.

Table 3: Implications of clock bids for absolute caps - example

Suppose a bidder has the following valuations and its preferred package is determined by the amount of surplus it would obtain:

Lots	Value
5	50
3	35
2	30

When the price per lot is 6 or lower, then the bidder wishes to acquire five lots. However, if the price increases to 7 per lot, then the bidder would actually prefer to acquire two lots (at a price of 14, giving a surplus of 16 with its valuation of 30) than five or three lots (at their respective prices of 35 and 21, which would yield the corresponding surplus of 15 and 14 respectively).

However, if the bidder drops demand to two lots, then in the supplementary bids round it will face an absolute cap of 35 for the package of five lots, and an absolute cap of 21 for the package of three lots. Therefore, the bidder will not be able to make bids that reflect its valuations. If the bidder wishes to maintain the option to make bids at valuation for these packages (which might be relevant depending on the bids from other bidders), then it will need to continue to bid for five lots until the price of five lots is equal to or exceeds its valuation (e.g. when the price reaches 10 per lot), then switch to the package of three lots until the price of three lots is equal to or exceeds its valuation (e.g. when the price reaches 12 per lot), and only then drop to bidding for two lots.

Absolute caps give incentives to bid for the largest profitable package, rather than the most preferred one

As a result, the absolute cap activity rules give incentives for bidders to bid for the largest (in terms of eligibility points) profitable package they can afford, rather than the package they would prefer at clock prices (i.e. the package with the greatest surplus). This has a number of undesirable consequences:

- by bidding on largest profitable packages, bidding in early rounds may more driven by budget than by valuation;
- as the demand from bidders reflects the maximum number of lots they would want to acquire, the clock rounds tend to overshoot the market clearing outcome;
- the final clock prices may be a poor indicator of the actual prices that winners will need to pay.

Clearly bidders can also work out the incentives created by the absolute cap activity rule and will interpret the clock rounds in this light. Therefore, the open rounds may still help reduce common value uncertainty. Provided the amount of excess demand is reported, bidders can observe at what prices approximate market clearing occurred. However, because the clock rounds may then carry on further, bids may be required significantly above eventual winning prices. These concerns are evident in the UK 10-40 GHz

auction in 2008,²² which was one of the earliest implementations of the CCA and used absolute caps.

The auction was for the award of spectrum in the following bands:

- 10 GHz – ten 2x10 MHz national lots;
- 28 GHz – two 2x112 MHz national lots and three 2x112 MHz geographically limited sub-national lots;
- 32 GHz – six 2x126 MHz national lots; and
- 40 GHz – six 2x250 MHz national lots.

The bids in the last clock round were as follows:

Table 1: Final clock round bids in the UK 10-40 GHz auction

Bidder	10 GHz	28 GHz Nat.	28 GHz Sub-nat. 1	28 GHz Sub-nat. 2	28 GHz Sub-nat. 3	32 GHz	40 GHz
Arqiva	0	2	0	1	0	0	0
BT	0	0	0	0	0	1	2
Digiweb	2	0	0	0	0	0	0
Faultbasic	0	0	0	0	1	0	1
MLL	0	0	0	0	0	0	0
Orange	0	0	0	0	0	3	0
RedM	0	0	0	0	0	0	0
T-Mobile	8	0	0	0	0	2	1
Transfinite	0	0	1	0	0	0	0
UKBB	0	0	0	0	0	0	1
Excess supply	0	0	0	0	0	0	1

In contrast, the winning bids after the supplementary bids round were as follows (quantities that are different to those in the last clock round are highlighted in orange):

²² Information about the auction, and bid data, can be obtained from <http://webarchive.nationalarchives.gov.uk/20160702162827/http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/awards-archive/completed-awards/1040award/> (accessed on 19 May 2017).

Table 2: Winning bids in the UK 10-40 GHz auction

Bidder	10 GHz	28 GHz Nat.	28 GHz Sub-nat. 1	28 GHz Sub-nat. 2	28 GHz Sub-nat. 3	32 GHz	40 GHz
Arqiva	0	2	0	0	0	0	0
BT	0	0	0	0	0	1	0
Digiweb	2	0	0	0	0	0	0
Faultbasic	0	0	0	0	1	0	0
MLL	0	0	0	0	0	1	1
Orange	0	0	0	0	0	2	0
RedM	0	0	0	1	0	0	0
T-Mobile	8	0	0	0	0	2	1
Transfinite	0	0	1	0	0	0	0
UKBB	0	0	0	0	0	0	4
Excess supply	0	0	0	0	0	0	0

The final clock prices also appeared to be a poor predictor for (and much higher than) the prices paid by winners.

Table 3: Winning prices in the UK 10-40 GHz auction

Bidder	Final clock price of package	Price paid by winner
Arqiva	1,414,000	260,500
BT	594,000	179,000
Digiweb	138,000	39,000
Faultbasic	130,000	30,000
MLL	745,000	179,000
Orange	1,188,000	261,000
RedM	37,000	10,000
T-Mobile	1,891,000	319,000
Transfinite	97,000	20,000
UKBB	604,000	120,000
Total	6,838,000	1,417,500

3.3.2 Relative caps

Relative caps in the next wave of CCAs

A second batch of CCAs (the 2.5 GHz and 800 MHz auctions in Denmark in 2010 and 2012, the multi-band auctions in Switzerland in 2012, the Netherlands in 2010 and Slovenia in 2014, and the UK 4G auction in 2014) used the so-called *relative caps*. The activity rules for the clock rounds under the relative caps rule continue to be the same as for a simple clock auction and for the CCA with absolute caps. However, the caps that applied to supplementary bids were not set at the 'absolute' price of the package in the round in which the bidder was last eligible to bid for the package; instead, the cap was set 'relative' to the bid amount for the package for which the bidder actually bid for in that round (the 'constraining package').

The relative cap rule utilises the fact that for every package that is larger than the package on which the bidder placed its bid in the final clock round, there is a clock round in which the bidder would last have been able to bid on the package under normal eligibility constraints. The fact that a bid was placed on another, smaller, package (the constraining package), locks in the maximum value difference between the larger and the smaller package: the bid on the larger package cannot be higher than the bid on the constraining package by more than the difference valued at the clock prices in the constraining round.

Choice consistency

The underlying idea is based on *revealed preference*. Suppose that a bidder chooses package A over B when prices are p_a and p_b respectively. Suppose that valuations are v_a and v_b for the two packages. If the bid chose its preferred package, then this must have greater surplus, so $v_a - p_a \geq v_b - p_b$. In turn this implies an upper bound on what the value of the package not chosen can be, i.e. $v_b \leq v_a + (p_b - p_a)$.

The relative cap simply requires that the difference in bids must respect this same relationship, so that the maximum bid for B cannot exceed the bid for A plus the price difference between the packages in the round where the bidder chose A over B. The relative caps are applied to supplementary bids for all packages except that for which the bidder bid in the final clock round. The relevant clock prices to calculate the caps on packages with equal or less eligibility than that for which the bidder bid in the final round, are those in the final clock round.

Incentive consequences

Relative caps provides incentives for bidders to make clock bids for their most preferred package amongst those with eligibility no greater than the bidder's eligibility in the round. This contrasts to the absolute cap, which we saw earlier creates incentives to bid for the largest profitable package within available eligibility.

Figure 4: Relative caps example

Assume that the bidder has the same valuations for different lots as in the previous example.

Lots	Value
5	50
3	35
2	30

If the price is 7 per lot, then the bidder can bid for two lots (the surplus maximising package at the current price) without limiting its options for bidding at valuation for the packages with three and five lots.

Suppose that the clock stage finishes with a price of 9 per lot. The relative caps that would apply to the bidder's bids on the packages for which it has valuations would be equal to the bid that the bidder makes for the package of two lots, plus the difference in price between the package subject to the cap and the package of two lots in the round when the bidder loses the eligibility to bid for the package subject to the cap. If the bidder dropped its eligibility when the price was 7 per lot, then if its bid for the package of two lots were B , then its relative caps would be:

- for the package of three lots, $B + 7$;
- for the package of five lots, $B + 21$.

Therefore, if the bidder makes a bid at valuation for two lots, then its relative caps will be 37 and 51 respectively. Thus, the bidder will be able to make bids at valuation for all packages.

Advantages of relative caps

Using relative caps instead of absolute caps improves the informational value of the clock stage, especially with respect to helping bidders in identifying their efficiency-relevant packages. Indeed, the bids in the last clock round can be expected to be more indicative of the winning outcome. In addition, the clock stage should take less time to resolve excess demand than under absolute caps as bidders no longer have any incentive to bid on the largest profitable package.

Notwithstanding this, under the relative caps activity rules there are still switching impediments during the clock stage, which can distort the information about demand disclosed during this stage. These limitations can occur when bidders are switching between packages with different eligibility that include lots in different categories and the difference in price between these packages narrows after the bidder has dropped eligibility. This is illustrated in the following example.

Figure 5: Constrained choices in the clock stage under the relative caps

For example, suppose that we offer A lots, with one eligibility point each, and B lots, with two eligibility points each (for example, A lots could be 2x5 MHz blocks and B lots could be 2x10 MHz blocks).

Suppose that a bidder is willing to pay up to:

- 10 for one A lot;
- 15 for one B lot; or
- 17 for two A lots.

Suppose that the price for A lots starts at 5 and the price for B lots at 10. The bidder starts bidding for two A lots, since that maximises its surplus at the starting prices. Suppose that at a later round (round x) prices reach 8 for A lots and 14 for B lots. The bidder switches to a single A lot (as it would have a surplus of 2 instead of 1 if it bid for the B Lot and 1 if it bid for two A lots). But then in the following rounds suppose that the price of A lots continues to increase to 9 and then 10, whilst the price for B lots remains at 14. The bidder may then wish to switch to bidding for a B lot.

If the activity rules in the clock stage are that a bidder's activity cannot increase relative to the preceding round (as is the case in an SMRA auction, clock auctions and CCAs with absolute or relative caps), then the bidder will not be able to switch to bidding for the B lots, as this would require increasing its activity from one (bidding on a single A lot) to two (bidding for a B lot). Instead, the bidder will need to make a constrained choice between continuing to bid for a single A lot or drop out altogether.

However, such a switch would be consistent with the bidder's revealed preferences, and thus with the relative cap that will apply to a bid for a B lot in the supplementary bids round. Indeed, the relative cap on a bid for a B lot would have been set in round x, when the price difference between an A lot and a B lot was 6. As the bidder has made a bid for a single A lot of 8, then the relative cap on the bidder's bid for a B lot is $(8+6)=14$. Indeed, the bidder can increase its bid for a single A lot in the supplementary bids round, which will also raise its cap for its bid on a B lot. If the bidder makes a bid of 9 or 10 for a single A lot, then the bidder can bid up to $(9+6)=15$ or $(10+6)=16$ for a B lot, and hence it will be able to bid at its valuation of 15.

Bids pushed into the supplementary round by switching impediments due to eligibility points

As a result, if the difference in price between lots with a large number of eligibility points and lots with a low number of eligibility points narrows during the clock stage, then bidders may be unable to make a clock bid for their preferred package at clock prices, but will nevertheless be able to express such preference in the supplementary bids round. As a result;

- clock bids may not accurately reflect bidders' preferences, but rather their preference over the restricted set of packages with eligibility no greater than the bidder's eligibility in the corresponding round;
- the bids submitted in the last clock round may still be a poor indication of the winning bids;

- the final clock prices may be a poor indicator of the actual prices that winners will need to pay.

Switching impediments in the UK 4G auction

The UK 4G auction in 2013²³ provides a clear example of this situation. An important factor in this auction was that the reserve price and eligibility points assigned to lots in different lot categories were very uneven, so that during the clock stage a bidder would not be able to switch from 2.6 GHz lots to 800 MHz lots, or from TDD 2.6 GHz lots to FDD 2.6 GHz lots. As a result, excess demand for different lot categories resolved sequentially.

Competition was initially intense for all categories, but as 800 MHz spectrum became increasingly expensive, excess demand was resolved. This happened before there were any significant reductions in the demand for 2.6 GHz spectrum. As competition for 2.6 GHz spectrum continued to push the price of 2.6 GHz lots (whilst the price of 800 MHz remained stable), the price difference between 800 MHz and 2.6 GHz lots narrowed, and thus 2.6 GHz lots became relatively expensive. It is plausible that as a result some bidders might have preferred to switch to 800 MHz spectrum, but this would not have been possible under the activity rules.

Further increasing uncertainty about the final outcome, one bidder dropped demand for 800 MHz after excess demand had been resolved, so that the clock stage ended with excess supply of 800 MHz spectrum. This increased the chances that winning bids might differ materially from the clock bids in the last clock round, as 800 MHz spectrum was very valuable,²⁴ and so it was likely that the highest value outcome would involve assigning all of the 800 MHz spectrum.

A further complication in this auction is that it adopted a 'competition constraint', effectively a reservation of spectrum but without specifying in which band. In practice this meant that Hi3G was guaranteed to win a package that would at least include 2x5 MHz of 800 MHz spectrum, or 2x20 MHz of 3.6 GHz FDD spectrum. Hi3G's bids eventually expressed indifference between these alternative reservations if relative prices were the same as relative reserve prices. As a consequence, Hi3G won 800 MHz spectrum at reserve, given that the bids in the auction suggested that the value

²³ Information about the auction, and bid data, can be obtained from <http://webarchive.nationalarchives.gov.uk/20160702162827/http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/awards-archive/completed-awards/800mhz-2.6ghz/> (accessed on 18 May 2017).

²⁴ The final clock price for a single 2x5 MHz block of 800 MHz spectrum was about a third of the total clock price for all of the 2.6 GHz FDD spectrum (which included a total of 70 MHz)

(footnote continued)

of 800 MHz relative to that of 2.6 GHz FDD at reserve was slightly overstated.

The eventual winning bids were substantially different to the bids submitted in the final clock round. The bids in the last clock round are given below.

Table 4: Final clock bids in the UK 4G auction

Bidder	800 MHz lots (2x30 MHz) ²⁵	2.6 GHz FDD (2x70 MHz) ²⁶	2.6 GHz TDD (45 MHz)
EE	-	-	45 MHz
H3G	-	2x20 MHz	-
Niche	-	2x10 MHz	-
Telefónica	2x10 MHz	2x20 MHz ²⁷	-
Vodafone	2x10 MHz	2x15 MHz	-
Excess supply	2x10 MHz	2x5 MHz	-

In contrast, the winning bids after the supplementary bids round were (quantities that are different from those in the last clock round are highlighted in orange).

Table 5: Winning bids in the UK 4G auction

Bidder	800 MHz lots (2x30 MHz)	2.6 GHz FDD (2x70 MHz) ²⁸	2.6 GHz TDD (45 MHz)
EE	2x5 MHz	2x35 MHz	-
H3G	2x5 MHz	-	-
Niche	-	2x15 MHz	20 MHz

²⁵ 800 MHz spectrum was offered as four 2x5 MHz blocks without a coverage obligation and one 2x10 MHz block with a special coverage obligation. To simplify this discussion here we only consider demand in terms of the bandwidth included in bids.

²⁶ 2.6 GHz FDD spectrum was offered as high-power, exclusive use, or low-power concurrent use. Here we simplify the demand/supply by expressing it in the equivalent high-power demand, given that only one bidder was bidding for low-power concurrent use in the last clock round (and seemingly due to strategic reasons rather than reflecting genuine demand for that use).

²⁷ Bid as low-power concurrent use.

²⁸ All if the 2.6 GHz FDD spectrum was assigned as high-power, exclusive use.

Telefónica	2x10 MHz	-	-
Vodafone	2x10 MHz	2x20 MHz	25 MHz

The final clock prices also appeared to be a poor predictor for the prices paid by winners, as shown below. However, in this auction the competition constraint may have had an effect on winning prices, but may not have been fully reflected in clock prices.

Table 6: Winning prices in the UK 4G auction

Bidder	Final clock price of package	Price paid by winners
EE	1,067,000,000	588,876,000
H3G	423,000,000	225,000,000
Niche	373,600,000	186,476,000
Telefónica	846,000,000	550,000,000
Vodafone	1,336,000,000	790,761,000
Total	6,609,400,000	2,341,113,000

3.3.3 Relaxed activity rules

Benefits of relaxed activity rules

The so-called relaxed activity rules, used in the Irish multi-band (2012) and 3.6 GHz (2017) auctions in Ireland were developed in response to concerns raised by bidders about the uncertainty they faced in the supplementary bids round, both with respect to whether they would win anything and with respect to the prices they may need to pay. The relaxed activity rules reduce this uncertainty by:

- facilitating switching in the clock stage when this is consistent with the revealed preference caps that apply to the bidder in the supplementary bids round;
- further restricting the bids that bidders can make in the supplementary bids round by imposing revealed preference caps with respect to the bidder's choice in the last clock round.

These rules are more permissive in the clock rounds, avoiding the problems potentially created by the eligibility point rule, where a bidder might be unable to switch categories, or to be able to switch and then not switch back.

Final price cap in the supplementary bids round

In the supplementary round, this approach reduces the scope for bidders to make bids that reflect a preference that is not consistent with their final clock bid, and thus the extent to which they can offer an improvement over the outcome that would involve accepting the clock bids in the last clock round. As a result, this allows bidders to calculate the minimum bid that they would need to make in order to ensure that they win their final clock package (and thus the maximum price they may need to pay for this package if they were to win it).²⁹

Principles for relaxed activity rules

The underlying principles of the relaxed activity rules are that:

- bidders should be able to make clock bids that are consistent with their revealed preference from earlier rounds in which they reduced eligibility, i.e. they should be allowed to make bids that are feasible in the supplementary bids round;
- bidders should not be allowed to defer these bids to the supplementary bids round, as this undermines the informative value of the clock rounds; and
- the set of bids made by a bidder should at all times be fully consistent with relative caps.

These rules relax the constraint that bidders may only make clock bids for packages with eligibility no greater than the bidder's eligibility. Instead, the relaxed activity rules allow bidders to make a bid for a package with eligibility greater than the bidder's eligibility (a 'relaxed' bid) if the relative cap that applies to bids for this package is equal to or greater than the clock price of the package in the round. In order to reflect the fact that bidders may increase bids for constraining packages in the supplementary bids round, bidders are also allowed to do this during the clock stage (by submitting so-called 'chain bids')³⁰ if this would be required for the bidder to make a relaxed bid in the round, subject to the following constraints:

- all of the bids made by the bidder in the round must be consistent with their respective relative caps;
- none of the bids can exceed the clock price of their corresponding package in that round; and
- these bids must be at the smallest amount that would be required for the bidder to be able to make its relaxed bid.

²⁹ This amount is sometimes referred to as the 'knock-out bid'. Under the relaxed activity rules, the knock-out bid is equal to the bid that the bidder made in the last clock round, plus the clock price of any lots that were in excess supply at the final clock prices. A bidder who makes such a bid would be guaranteed to win the package they bid in the last clock round (unless they also make bids for other packages above the price of the package in the last clock round, in which case they might also win one of these packages). Therefore, submitting the knock-out bid allows a bidder to ensure it would not leave the auction empty-handed. This approach is typically subject to the position with regard to unsold Lots in the final clock round not changing (e.g. it is possible that some bids may subsequently be excluded for breach of auction rules or failure to pay deposit etc.)

³⁰ These are the rules used by ComReg in its MBSA and 3.6 GHz auctions.

Making a relaxed bid does not increase the bidder's eligibility – eligibility in the following round is equal to the smallest of either the bidder's eligibility or its activity in the most recent round.

*Relationship
between relaxed bids
and supplementary
bids*

The relaxed bidding rules are just a means to allow bids that would otherwise have had to be deferred to the supplementary bids rounds to be made as clock bids provided these consistent with bidding behaviour so far in the clock round. In the CCA, all bids, regardless of whether they are clock bids or supplementary bids are considered within the winner determination. Therefore, the main benefit of relaxed bidding rules is that they give flexibility to bidders to allow them to bid on preferred packages during the clock rounds, thereby making the clock stage more informative.

Notice that relaxed bidding rules cannot be adopted in an SMRA or a simple clock without leaving scope for bidders to exploit the relaxation in order to defer showing their true demand to later in the auction or to engage in vexatious bidding at little risk.³¹ They work within a CCA specifically as they provide some additional flexibility in the clock rounds, but do not fundamentally expand the packages that bidders can ultimately bid for and which enter the winner determination process.

Figure 6: Relaxed activity rules in the clock stage - example

Assume the same set-up and valuations as in the previous example. The available lots include A lots (with one eligibility point per lot), and B lots (with two eligibility points per lot).

A bidder's valuations are:

- 10 for one A lot;
- 15 for one B lot; and
- 17 for two A lots.

If the bidder starts bidding for two A lots and switches to a single A lot when prices are 8 for A lots and 14 for B lots, then the applicable relative caps are (where X denotes the highest bid that the bidder makes for a single A lot):

- for one B lot, $X + 14 - 8 = X + 6$; and
- for two A lots, $X + 16 - 8 = X + 8$.

Suppose that, whilst the price of B lots remains unchanged, the price of A lots increases to 9. The bidder can now continue to bid for an A lot or switch to a B lot, as the bidder's highest bid so far for an A lot is 8, so its relative cap for a B lot is 14. Suppose that the bidder bids for a B lot.

Now suppose that in the following round, the price of B lots increases to 15, and the price of A lots to 10. The price of a B lot is now above the bidder's relative cap given its highest bid for an A lot. However, the bidder can still continue to bid for a B lot if it also increases its bid for an

³¹ See also 'DotEcon Assessment of consultation responses to Document 19/59R', ComReg Document 19/124a, §174.

A lot, in order to raise the applicable relative cap on its bid for a B lot. Specifically, the bidder can submit a clock bid for a B lot if it also submits a chain bid of 9 for an A lot, which raises its cap for a B lot to 15.

Supplementary bid round activity rules

At the same time as relaxing the activity rules in the clock stage, the relaxed activity rules tighten the activity rules in the supplementary bids round, by adopting the so-called final price cap. The final price cap is applied to all bids in the supplementary bids round, except that for the package that the bidder bid for in the last clock round. The final price cap requires that the bid for any such package must not exceed the bidder's bid for the package it bid for in the last clock round plus the difference in clock prices between these two packages in the last clock round. Essentially, the final price cap operates like a relative cap, but requiring that revealed preference is maintained relative to the choice made in the last round.

The final price cap has two effects:

- it prevents bidders from deferring relaxed bids to the supplementary bids round, as if the bidder has failed to make the relaxed bid by the last clock round, then the final price cap will not allow for this bid; and
- it reduces the scope for improving on the bids made in the last clock round, thus reducing the uncertainty faced by bidders about how the supplementary bids round might change the situation at the end of the clock rounds.

Figure 7: Final price cap - example

Again, we assume there are A lots (with one eligibility point per lot), and B lots (with two eligibility points per lot), and a bidder has the following valuations:

- 10 for one A lot;
- 15 for one B lot; and
- 17 for two A lots.

Suppose that the clock stage ends when the price for A lots was 8 and the price of B lots 14, with the bidder bidding for a single A lot. The final price caps on the packages considered by the bidder would be the same as the relative caps (where X denotes the highest bid that the bidder makes for a single A lot):

- for one B lot, $X + 14 - 8 = X + 6$; and
- for two A lots, $X + 16 - 8 = X + 8$.

With these caps, the bidder can make bids at valuations.

Suppose instead that the clock stage ends when the price for A lots is 9 and the price of B lots 14, with the bidder bidding for a single A lot. The final price caps on the packages considered by the bidder would be:

- for one B lot, $X + 14 - 9 = X + 5$; and

- for two A lots, $X + 18 - 9 = X + 9$.

Note that the final price cap on the bidder's bid for one B lot is now tighter than the relative cap as described in Figure 5. However, the bidder can still make bids at valuations.

Suppose instead that the clock stage ends when the price for A lots is 10 and the price of B lots 14, with the bidder bidding for a single A lot. The final price caps on the packages considered by the bidder would be:

- for one B lot, $X + 14 - 10 = X + 4$; and
- for two A lots, $X + 20 - 10 = X + 10$.

The final price cap on the bidder's bid for one B lot is now even tighter and, as a result, if the bidder bids at valuation for one A lot, then it cannot make a bid for this package (one B lot) at valuation (it would be able to bid at most 14).

Conversely, if the bidder had instead used the flexibility provided by the relaxed activity rules to make a clock bid for a B lot (along with a chain bid of 9 for an A lot if necessary) and the clock rounds ended at that stage, then the final price cap would be set with respect to the bidder's highest bid for a B lot. Therefore, the final price caps on the packages considered by the bidder would be (where Y denotes the highest bid that the bidder makes for a B lot):

- for two A lots, $Y + 20 - 14 = Y + 6$; and
- for one A lot, $Y + 10 - 14 = Y - 4$.

This means that if the bidder makes a bid at valuation for a B lot (thus at 15), then the applicable caps are 21 and 11 respectively, so that the bidder can make bids at valuation for these packages within the cap (17 and 10 respectively). At the same time, these bids will be consistent with the relative caps, as if the highest bid made by the bidder for one A lot is 10, then the relative caps for one B lot and two A lots are 16 and 18 respectively.

3.3.4 Simplified revealed preference cap

Canadian CCAs

An alternative approach to reducing the uncertainty faced by bidders in the CCA was developed by Ausubel and Cramton (2011) and used, for example, in Canada for the 700 MHz auction in 2014 and the 2500 MHz auction in 2015. The so-called *simplified revealed-preference cap (SRPC)* also uses relative caps on supplementary bids that are based on revealed preferences from rounds in which bidders reduce eligibility, along with the final price cap. However, the relative caps are imposed somewhat differently.

Key differences from Irish CCA rules

Instead of relative caps applying only to the packages with eligibility greater than that of the package the bidder bids for but no greater than the bidder's eligibility in a round when eligibility is reduced, under SRPC rules relative caps apply to all packages with eligibility greater than that of the package the bidder bids for. This means that packages may be subject to several relative caps, as every eligibility

reduction will impose a relative cap on all packages with eligibility greater than that of the package for which the bidder bids.

No chain bids with SRPC rules

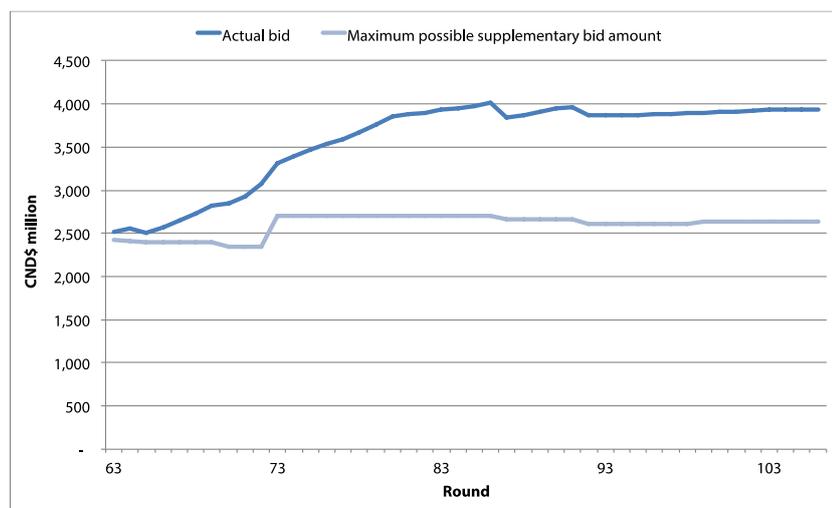
Another difference is that under this approach the set of bids submitted by a bidder is not required to satisfy all relative caps at all times. As under the relaxed activity rules, the SRPC rules allow bidders to make clock bids for packages that exceed their eligibility within that round. However, the possibility of making these bids is not determined by the applicable relative caps given the bids currently made for constraining packages in previous clock rounds, but instead only by comparison of the difference in prices between packages in the present clock round and that in clock rounds in which the bidder reduced eligibility. As a result, the SRPC rules do not require that bidders who make a relaxed bid must also raise their bid for any constraining packages in order to increase the relative cap on the package. This contrasts with the relaxed activity rules used by ComReg, when chain bids might be required to ensure that a relaxed bid does not lead to any relative caps being violated.

Potential for bids to violate relative caps

A consequence of the SRPC rules is that relative caps may be violated by subsequent relaxed clock bids. In the supplementary bids round, bidders will only need to satisfy relative caps for packages for which they make new bids. Therefore, if a bidder leaves a clock bid unmodified during supplementary bids round, it is possible that this bid could violate a relative cap (by being too low relative to packages it constrains).

This aspect of the SRPC can be problematic, because it allows bidders to bid in a way that is not consistent with earlier bids made in the clock rounds. For example, in the Canadian 700 MHz auction, Rogers reduced its eligibility substantially in round 53 (from a total of 2,437 to 2,283 eligibility points), and then made relaxed clock bids from round 62 onwards, ending the clock phase on a package which had 2,374 eligibility points. Under the activity rules, these relaxed clock bids could be placed without adjusting the bid amount for the constraining package (i.e. the package on which Rogers placed its bid in round 53). Had these bids been made as supplementary bids, they would have been constrained by the highest bid amount for the constraining package and the price difference at prices in the constraining round. Figure 8 below shows the substantial difference between the bids that were made as relaxed clock bids, and the maximum bid amount for the corresponding packages if the bids had been supplementary bids without raising the clock bid for the constraining package.

Figure 8: Actual clock bids vs. supplementary bid cap in the Canadian 700 MHz auction



Source: ISED Canada, *Bidding Information — 700 MHz Auction (2014)*, <http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11085.html>

Conclusions

Whilst the SRPC rules are slightly simpler than the relaxed bidding used in recent ComReg auctions, this does introduce some undesirable features. In particular, when a bidder reduces its demand, under SRPC rules this is less committing, in the sense that it might be possible to make subsequent clock bids for larger packages exceeding current eligibility without having to maintain consistency with previous bids made for even larger packages. Furthermore, the SRPC rules do not maintain a broad neutrality between rule for making clock bids and for making supplementary bids that is a feature of ComReg's rule, in that with SRPC rules it may be possible to make clock bids that do not satisfy activity rules for supplementary bids. This could create incentives to make certain bids as a clock bids because they would not possible later as supplementary bids, which could in some cases distort the clock rounds.

3.3.5 GARP-based activity rule

Canada's subsequent auction (the 600 MHz auction in 2019) adopted GARP-based activity rules. The GARP-based activity rule was intended to further reduce the scope for the final outcome to deviate from demand in the final clock round, by reducing the ability of bidders to submit supplementary bids that deviate significantly from their expressed preferences in the clock rounds.

The GARP-based activity rules impose stricter constraints on bidders, as it uses a greater number of applicable relative caps – these are applied not only with respect to eligibility-reducing rounds, but with respect to all clock rounds starting with the last round in which the bidder had sufficient eligibility to bid on the package

subject to caps (excluding those rounds before the final clock round in which the bidder bid for packages of the same or larger size than this package). Therefore, the GARP rule includes the constraints that would arise under the standard relative caps approach, and also additional constraints. Thus, the GARP-based activity rule is stricter as it may prevent a bidder from submitting some bids that would have been possible using a WARP-based activity rule.

However, as in the case of the simplified revealed-preference cap, the GARP-based CCA still does not require that all relative caps must be satisfied at all times and does not require bidders to raise their bids for constraining package through chain bids or in the supplementary bids round.

3.4 Pricing rules in the CCA

The CCA uses a second-price rule, where bidders do not pay the amount of their bids, but rather a price determined by the opportunity cost of denying the spectrum to other bidders. This detaches the prices to be paid from the amount of a bidder's winning bid, thereby reducing incentives to shade bids and risk an inefficient outcome, as we show below.

3.4.1 Vickrey prices

Second price rule

The simplest form of opportunity cost pricing is so-called *Vickrey pricing*, where each bidder pays its individual opportunity cost.

In the context of a purchase of a good (or a basket of goods), the opportunity cost of the good is the value that it would have in their best use had it not been transferred to the purchaser. In an auction, the opportunity cost of awarding a bidder B its winning package is evaluated as the difference between:

- the value that bidders other than B would achieve through the auction in a hypothetical value-maximising scenario where bidder B makes no bids and is awarded no goods; and
- the value achieved by bidders other than B in the value-maximising scenario with true bids.

Reserve prices are often incorporated into this calculation by adding a 'reserve bidder' for each individual lot that 'bids' for the respective lot at its reserve price. These reserve prices can be thought of as the auctioneer expressing a value for retaining lots as unsold. These reserve bids are then taken into account when determining winning bidders and prices, with the consequence that a bidder would only win an additional lot if its marginal value for the lot (as implied by the bidder's bids) is at least the reserve price for the lot.

*Dominant strategy
to bid at valuation*

Vickrey pricing provides clear incentives for each bidder to bid at its valuation for each package of lots. Under a Vickrey pricing rule, since a bidder's own bids will determine which package (if any) it wins, but will not affect what price the bidder pays for the package, it is a dominant strategy to bid at valuation for each package. This means that bidding at valuation is optimal for the bidder regardless of the strategy adopted by other bidders. Vickrey pricing is the only pricing rule that has this attractive feature.

*Why Vickrey pricing
is not often used*

Despite this attractive feature of providing theoretically perfect bidding incentives, Vickrey pricing is seldom used in practice for combinatorial auctions. Where some bidders have a demand structure that includes complementarities across lots (i.e. they value a number of lots together more highly than the sum of the individual valuations of those lots if won alone), Vickrey prices may be unreasonably low. This can arise where lots are spread across a number of winners, but one or more losers would enjoy some complementarity if those lots were combined. In this case, each winner might be *individually* paying enough that losers would be prepared to offer more (this is achieved by Vickrey pricing), but a group of winners might *collectively* not be paying enough, as other bidders would be prepared (on the basis of bids they have already made) to pay more.

Therefore, when lots are complements, Vickrey pricing may determine winning prices that are too low relative to reasonable expectations about what competition between bidders should deliver. For example, Vickrey prices might be below those expected to result from an open outcry auction in which bidders, or groups of bidders, could make improving counteroffers.

Table 7: Example - Vickrey Prices are not in the core

Suppose that we have two lots, A and B, and three bidders.

- Bidder 1 values A at €9;
- Bidder 2 values B at €9; and
- Bidder 3 values the package including both A and B at €15, but has no value for A or B individually (i.e. A and B are complements for Bidder 3).

All three bidders submit a bid for their lot/package of interest at valuation.

The highest value can be achieved by awarding A to Bidder 1 and B to Bidder 2. Bidders 1 and 2 have won jointly against Bidder 3.

Vickrey prices are given by individual opportunity costs:

- In the absence of Bidder 1, both lots would be assigned to Bidder 3. The value of the revised set of winning bids is therefore €15, and the value of original winning bids less Bidder 1's winning bid is €18 - €9 = €9. Bidder 1's opportunity cost (Vickrey Price) is therefore calculated as €15 - €9 = €6.
- Bidder 2's opportunity cost is also €6, calculated in the same way as for Bidder 1.

The auction revenue (sum of prices paid by the two winning bidders) under Vickrey pricing is €12. However, Bidder 3 had offered €15 for lots A and B together. Therefore, the Vickrey prices are not in the core as they are not sufficient to outbid Bidder 3's losing bid, and Bidder 3 (who would have been willing to pay more for A and B than was charged to the winning bidders) would be an 'unhappy loser'.

Day and Milgrom (2007) list three desiderata with regards to pricing mechanisms:

- that there is no rejected bid for a set of goods that is higher than the price finally paid for those goods;
- that auction revenues increase with additional bidders; and that
- bidders have no incentives to participate as multiple entities (known as "shills").

They provide a simple example illustrating how Vickrey prices do not satisfy these desiderata, which we reproduce with commentary in the box below.

Example 5: Simple illustration of the properties of Vickrey prices

Consider two items (A and B) and three bidders (X, Y and Z). These are the bids made by the operators in the reverse auction.

Item	Offer from X	Offer from Y	Offer from Z
A	0	10	0
B	0	0	10
A and B	10	0	0

The optimal allocation is one where bidder Y gets item A and bidder Z gets item B. Both of their Vickrey prices are 0. It is undesirable to charge the bidders their Vickrey prices because:

- there is a bidder (X) who was bidding for Y's and Z's winnings and was prepared to pay more than Y and Z paid in total;
- if bidder Y was excluded, either bidder X or Z would win and pay 10. Therefore, excluding a bidder can produce a higher revenue which could lead to more efficient outcomes downstream, which is an undesirable incentive for the auctioneer; and
- if instead of bidder Y and Z there was a company having a single valuation of 20 for the two items together, it would have an incentive to participate as two bidders who would behave like Y and Z. The winnings would be the same, but the price is 0 instead of 10.

3.4.2 Minimum revenue core prices

CCAs predominantly use the more sophisticated *minimum revenue core (MRC) pricing* rule. Core pricing fulfils Day and Milgrom's three desiderata (above). In particular, Day and Milgrom prove that there are no incentives to use shells if and only if the pricing mechanism is core-selecting.

Joint opportunity cost floors

Under this approach every possible *group* of winners will pay at least the *joint* opportunity cost that that group of winners impose on other bidders. Joint opportunity cost considers what additional value might be created for *other* bidders if a given group of winning bidders were hypothetically excluded from the auction. This creates floors on the prices to be paid by winners (individually and jointly) that ensure that losers are content and not prepared to pay more for lots than paid by any winner or group of winners.³² These floors, coupled with a rule that a bidder cannot be charged more than the value of its winning bid, defines *core prices*.

Minimising revenue

Minimum revenue core (MRC) pricing imposes the additional condition that revenue (i.e. the total of prices paid by winners) is

³² In spectrum awards, efficient allocation is typically the main objective of the auction, rather than maximising revenue. Revenue may nonetheless be raised as revenue is a by-product of an efficient competitive allocation process. See Section 4.1 – ComReg Document 18/103d

minimised, subject to prices being in the core and exceeding joint opportunity cost floors for every possible group of winners. MRC pricing is formally equivalent to bidders paying the least amount necessary such that if they had bid that amount (instead of their bid amount) for the package they won (and reduced their other bids by a similar amount), then they would have still won. Therefore, it ensures that winners pay enough for the losers to be content with the auction outcome, but subject to this requirement, that winners pay the least amount possible.

Table 8: Example – core prices may need to account for joint opportunity cost

Following on from the previous example:

There are two lots, A and B. Bidder 1 bids €9 for A; Bidder 2 bids €9 for B; Bidder C bids €15 for the package comprising A and B.

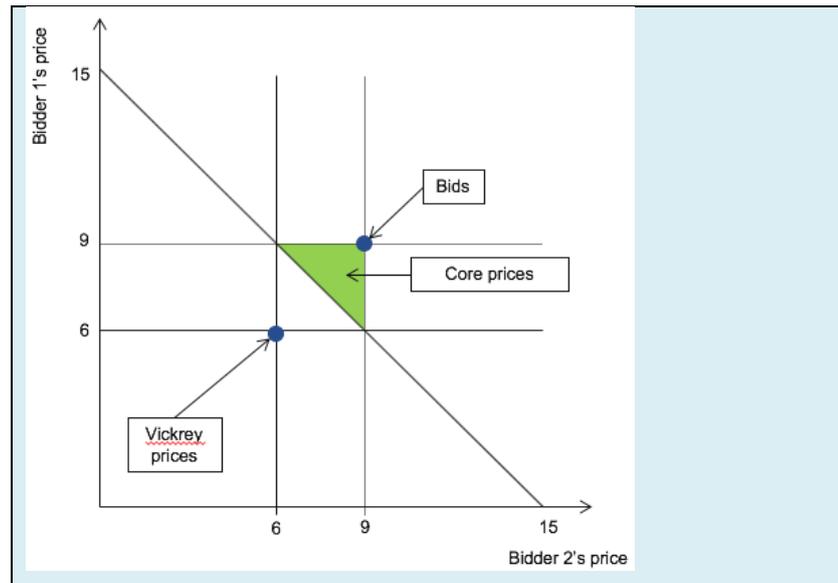
The outcome under a pure Vickrey Pricing rule is that Bidder 1 gets A for €6, Bidder 2 gets B for €6, and bidder C is an unhappy loser because it would have been willing to pay more than €12 (the joint price paid by Bidder 1 and Bidder 2) for both lots.

Under a core pricing approach, we need to also consider the joint opportunity cost for Bidder 1 and Bidder 2 together. In the absence of *both* Bidder 1 and Bidder 2, both lots would be assigned to Bidder 3. The value of the revised set of winning bids is therefore €15, and the value of original winning bids less Bidder 1's winning bid and Bidder 2's winning bid is €18 - €9 - €9 = €0. The joint opportunity cost for Bidder 1 and Bidder 2 is therefore calculated as €15 - €0 = €15.

For prices to be in the core, they need to be set such that Bidder 1 and Bidder 2 each pay at least their own individual opportunity cost, together pay at least their joint opportunity cost, but neither pays more than their own bid amount.

Let p_A^1 be the price paid by Bidder 1 for A, and p_B^2 be the price paid by Bidder 2 for B. For the prices to be in the core, they must satisfy:

- $9 \geq p_A^1 \geq 6$
- $9 \geq p_B^2 \geq 6$
- $p_A^1 + p_B^2 \geq 15$



*Relationship
between MRC and
Vickrey prices*

By construction, core prices cannot be, for any bidder, lower than Vickrey prices. Vickrey prices may belong to the set of core prices and are certain to belong to it if the valuations implied by bidders through their bids exhibit no complementarities between the items. If Vickrey prices belong to the set of core prices, they will be the unique MRC prices. However, if there are complementarities between goods which prevent Vickrey prices from being core prices, there might be multiple MRC price vectors (i.e. one price for each winner).

*Vickrey-nearest MRC
prices*

In such case, a second rule is needed to determine the 'core adjustments' – the differences between the actual allocation prices and the Vickrey prices which are necessary for the allocation prices to be in the core. A common approach in CCAs is to minimise the distance³³ between the winning prices (selected from amongst the MRC prices) and the Vickrey prices.

As Ausubel and Baranov (2017) note about minimum-revenue core prices, "*it is important for the regulator to make an appropriate choice of core adjustment. [...] the core adjustment [...] affects the fundamental fairness of the treatment of large versus small bidders*". They also note that efficiency is not a major concern in the choice of this rule, since systematic minimisation of the bid-shading incentives arising from the core adjustments is impractical. This is because such decision would require knowledge of the beliefs that bidders hold about other bidders' valuations. They observe that "*to date, all*

³³ Euclidean distance is often used, which is equivalent to minimising the sum across winners of the squares of the differences between winning prices and Vickrey prices.

(footnote continued)

implementations have used some variant of a 'Nearest-Vickrey³⁴' payment rule that selects a unique set of payments from the minimum revenue frontier by minimising the Euclidian distance to the Vickrey–Clark–Groves payments". In other words, out of all valid minimum-revenue core price vectors, auctioneers choose the vector with the smallest sum of squares of the implied core adjustment

Table 9: Example - Vickrey-nearest minimum revenue core prices

Following on from the previous example:

Two lots, A and B.

Bidder 1 bids €9 for A; Bidder 2 bids €9 for B; Bidder C bids €15 for the package comprising A and B.

Bidder 1 wins A, Bidder 2 wins B, and bidder C wins nothing

For the prices paid by Bidder 1 and Bidder 2, p_A^1 and p_B^2 respectively, to be in the core, they must be set such that:

- $9 \geq p_A^1 \geq 6$
- $9 \geq p_B^2 \geq 6$
- $p_A^1 + p_B^2 \geq 15$

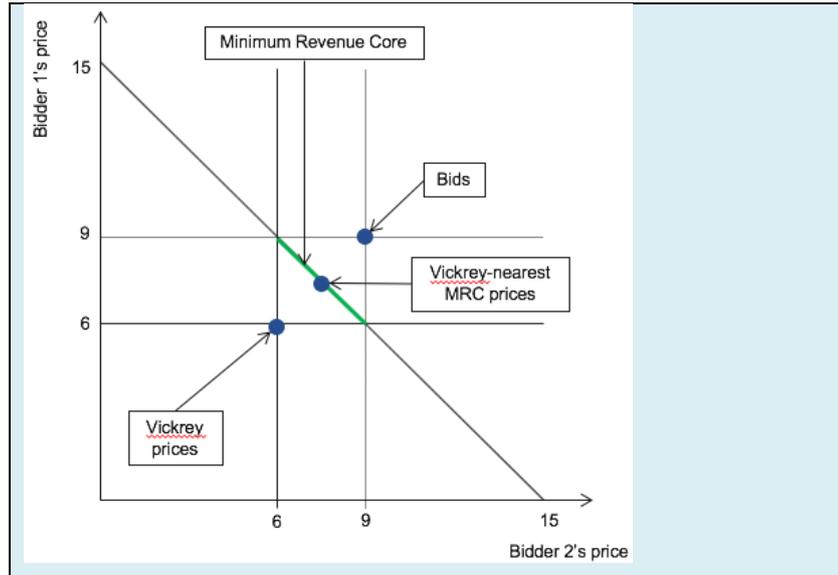
Under these constraints, we know that Bidder 1 and Bidder 2 must collectively pay above the sum of their individual opportunity costs (specifically they must together pay at least €15), but clearly there is an infinite set of prices that would meet the criteria for being in the core.

Minimum-revenue core prices are those that are in the core but minimise the total paid by winning bidders. In this case the set of minimum revenue core price vectors is determined by setting $p_A^1 + p_B^2 = 15$ (still subject to $9 \geq p_B^2$, $p_A^1 \geq 6$ and $9 \geq p_B^2$, $p_B^2 \geq 6$).

Between them, Bidder 1 and Bidder 2 must therefore pay an additional €3 on top of the sum of their individual joint opportunity cost.

The Vickrey-nearest rule selects the minimum revenue core price vector that is closest to Vickrey prices (i.e. with the smallest sum of squared differences between the prices chosen and the Vickrey prices). In this example the Vickrey-nearest minimum revenue core prices are determined by splitting the additional €3 above individual opportunity cost equally between the two winning bidders i.e. $p_A^1 \geq 7.5$ and $p_B^2 = 7.5$

³⁴ Note: the auction literature refers to the rule as either "nearest-Vickrey" or "Vickrey-nearest". We choose the name "Vickrey-nearest" whenever we can – we believe it explains the rule better, since we are searching for prices that are nearest to the Vickrey prices, instead of searching for the nearest (relative to some vector) Vickrey prices (which is not a good objective, since Vickrey prices are unique).



Weighted Vickrey-nearest

The simple minimum-squares approach may be considered unfair when bidders with disparate winnings (such that some winners' winnings are strictly greater or may be reasonably judged to be greater than others') are made to incur a similar core adjustment. For this reason, some of the recent CCAs use a 'weighted Vickrey-nearest' approach, minimising the *weighted* sum of squares, where the weight is the size of the corresponding winner's winnings, which may be defined in many ways. For example, in the case of the Canadian 600 MHz auction, it was the value of the lots in the winning package at reserve prices.

This approach matters especially in spectrum auctions with regional licences, where regional operators may win spectrum that is orders of magnitude less valuable than that of national players.

Example 6: Weighted Vickrey-nearest minimum-revenue core pricing

Consider an auction where there are three heterogeneous items. Bidders submit (potentially multiple) sealed combinatorial bids and the auctioneer determines the Vickrey-nearest minimum-revenue core prices.

The weights reflect the auctioneer's prior assumptions over which items are more valuable than others and are equal to 12, 3 and 1 for X, Y and Z respectively. The reserve prices are €120, €30 and €10 for X, Y and Z respectively. Bidders submit the following bids:

Bidder	Item X	Item Y	Item Z	Price
A	Yes	Yes	Yes	€1,000
A	Yes	No	No	€200
A	No	Yes	No	€100
A	No	No	Yes	€20
B	Yes	No	No	€800

C	No	Yes	No	€300
D	No	No	Yes	€30
Reserve	Yes	No	No	€120
Reserve	No	Yes	No	€30
Reserve	No	No	Yes	€10

In the optimal allocation, B, C and D are awarded their bids for X, Y and Z respectively and the value achieved in the auction is €1,130.

D's opportunity cost is calculated by calculating the difference between the following two values:

- the value achieved by bidders other than D; and
- the value achieved in a hypothetical winner determination problem where D's bids are excluded,

where the first value is subtracted from the second one.

The first value is €1,100. The second value is €1,120 as, without D's bids, item Z goes to A due to A's €20 bid and items X and Y still go to B and C respectively. That means that D's opportunity cost is €20 (intuitively, D has denied €20 of value to other bidders – in this case, A, who loses out on the value it would get from winning item Z).

Similarly, C's opportunity cost is €1,000 - €830 = €170, and B's opportunity cost is €1,000 - €330 = €670, driven by A's losing bid of €1,000 for all three items.

The sum of these three opportunity costs is €860. The bidders paying their opportunity cost is not in the core since A was prepared to pay €1,000 for all three items and B, C and D would only pay €860 for them.

The auctioneer determines the prices by solving the following problem:

$$\min_{p_B, p_C, p_D} 12 * (p_B - 670)^2 + 3 * (p_C - 170)^2 + (p_D - 20)^2 \text{ subject to:}$$

$$p_B \leq €800, p_C \leq €300, p_D \leq €30, p_B + p_C + p_D \geq 1000$$

(Note: every group of bidders must pay at least their joint opportunity cost, but for clarity purposes the group opportunity cost constraints for each pair of bidders have been omitted here).

Intuitively, this means that the auctioneer starts at Vickrey prices (with a sum of €860) and tries to split the remaining €140 that the three bidders have to pay in 12-3-1 proportions between B, C and D respectively. This means that B pays its opportunity cost (€670) plus €140 × (12/16) = €105, a total of €775. C pays its opportunity (€170) plus €140 × 3/16 = €26.25, a total of €197 (rounding up). D pays its opportunity cost (€20) plus €140/16 = €8.75, a total of €29 (rounding up).

As B and C have won items of substantially different value (according to the reserve prices), they have borne a substantially different share of the core adjustment. However, the perceived fairness of this outcome relies on the auctioneer being able to accurately assess the relative value of the three items.

If the auctioneer had decided instead to distribute the core adjustment equally across the bidders (but still respecting the constraint where a bidder's price cannot be higher than its bid), D would have paid €30 (its bid amount), but B and C would have paid €735 and €235 respectively.

3.4.3 Incentive consequences of MRC pricing

Incentives to shade bids

MRC pricing has become the predominant methodology for setting prices in CCAs. This creates incentives to bid broadly in line with valuations, as winning prices are determined by competition from other bidders (although this can be complicated by budget constraints or situations in which bidders have sufficient knowledge about the likely bids of competitors they might be able to affect the prices they pay themselves). These incentives are not perfect however, as MRC pricing deviates from Vickrey pricing and only Vickrey pricing creates perfect incentives to bid at valuation. MRC prices may strictly exceed Vickrey prices for some winners in some cases where other bidders' valuations have complementarities.

As a result, MRC prices can create some incentives for bidders to bid below valuation to reduce the price they pay. However, Vickrey pricing is not a feasible option for any practical combinatorial auction as it could result in losing bidders being unhappy with the outcome. This means that we must accept some degree of incentive distortion in any practical combinatorial auction.

Minimising incentive distortions

If we adopt the constraint that losers should be content with the result and, subject to this constraint, try to minimise the incentives for bidders to deviate from straightforward bidding at valuation, then MRC pricing is the best that we can do without having more specific knowledge of how bidders might bid. MRC pricing involves the minimum possible increase in prices above the level of Vickrey prices in order for losers to be content, and because prices are as low as possible subject to floors set by joint opportunity cost, the incentives to deviate from straightforward bidding at value are minimised.³⁵ This is a strong theoretical argument for the use of MRC pricing.

In general, auction designers should not be making too many assumptions about the structure of bidders' valuations and how they might bid, as this information is typically not available. This is sometimes called the "Wilson doctrine", after the original designer of the Simultaneous Multiple Round Ascending auction (SMRA). According to this view, it is appropriate to minimise the overall incentive across all bidders for deviating from truthful bidding in an anonymous manner, rather than tailoring the auction design to the specifics of certain bidders.

³⁵ This can be formalised. MRC pricing minimises the total incentive to deviate from bidding at value across all bidders. See Milgrom and Day (2007), "Core-selecting package auctions", *International Journal of Game Theory*. DOI 10.1007/s00182-007-0100-7

4 Advantages and disadvantages of the CCA

In this section, we explore the advantages of using the CCA compared to other auction formats and explain the theoretical and practical problems that may arise in a CCA.

- Section 4.1 deals with how the CCA facilitates bidders' expression of their valuations, assuming broadly straightforward bidders whose only motivation is to maximise their surplus.
- Section 4.2 introduces bidders' incentives to "game" the auction by bidding untruthfully in order to affect their or their rivals' outcome.
- Section 4.3 looks at the multi-layered decision process within individual firms participating as bidders, considering how the rules of the CCA interact with financial markets and corporate hierarchies distorting the truthful bidding incentives.

When providing commentary on the properties of particular auction formats, it is important to assess them in situations where they are the appropriate choice. Specifically, the CCA is usually not needed for simpler situations, e.g. where there are few lots or where bidders' valuations of lots in different categories are practically independent of each other.

Additionally, bidders in CCAs will typically have limited knowledge of each other's demand structures. Theoretical results based on a convenient assumption that each bidders' demand structure is common knowledge may be often irrelevant in practice if bidders are not sure what rivals will do.

4.1 Expressing valuations

In this sub-section, we will analyse how well bidders can express their valuations in the CCA, noting all practical difficulties present in the CCA but emphasizing the differences between the CCA and simpler auction formats such as the SMRA and the clock auction.

4.1.1 Local complementarities and supplementary bids

The presence of complementarities poses an inefficiency-complexity trade-off for the auction designer. Simpler formats such a clock auctions and SMRAs perform best when there are no complementarities. Indeed, in this case, these formats would lead to an efficient allocation if bidders bid straightforwardly (though in

practice there are often incentives to deviate from straightforward bidding, such as strategic demand reduction). Where complementarities are weak and take simple forms, these simple formats may also perform reasonably well. However, as complementarities become more complex, and have more impact on the efficient outcome, these formats perform less well and there may be benefit from more complex formats, such as CCAs.

The following example demonstrates how a clock auction or SMRA can lead to inefficient outcomes where some bidders have complementarities.

Example 7: Aggregation risks in clock auctions and SMRAs

Consider two lots in single category and two bidders (X and Y). These are their cumulative valuations:

Quantity	X's valuation	Y's valuation
1	€80	€120
2	€200	€200

Bidder X's marginal valuations are increasing and bidder Y's – decreasing. As usual, winning no lots at all yields a value of €0.

There are multiple optimal allocations. Regardless of whether one of the bidders gets both lots or they both get one each, the total achieved value will be €200.

However, a simple clock auction with linear pricing and with bidder X and Y making surplus-maximising bids would not arrive at any of these outcomes. If the reserve price is €10 and the price increment is also €10, the following bids would have been submitted from round 7 onwards:

Price	X's bid	Y's bid
€70	2	2
€80	2	2 (or 1 tied)
€90	2	1
€100	2 (or 0 tied)	1
€110	0	1

The auction would end with price equal to €100 or €110 when X reduces demand to zero (at €100, it is indifferent between bidding 0 and 2). As Y is bidding for one lot, this would leave one unsold lot and would not be an efficient allocation. This arises because of X's non-decreasing valuations.

An SMRA has a similar inefficiency. Take a different example, now with two different lots. Assume that the demand structure is:

Lots	X's valuation	Y's valuation
A	€80	€155
B	€80	€85
A and B	€200	€240

Both lots had a reserve price of €10 and a price increment equal to €10. X's demand structure includes a complementarity, whereas Y's valuations are linear.

Both bidders would be submitting bids for both lots at any price lower than €80. However, at €90, X would not know whether it is best to bid for both lots or for none. If X keeps bidding for both lots, it can make either profit or loss depending on what X thinks might happen subsequently:

- if Y were to drop out from both lots in this round, then X wins both lots profitably;
- if Y were to drop out of one of the lots in the current round but continue bidding on the other lot to a price of at least €110 (which is what would happen here given Y's valuation, though X does not know this), then X cannot win two lots profitably should drop out now (though may now be stuck as highest standing bidder); and
- conversely, if Y were to drop one lot in the current round, but X expects Y to drop the other one at a price below €110, then Y should keep bidding for both lots.

Here the complementarity requires X to make forecasts about Y is likely to do in order to decide itself how best to bid. This occurs even though X is a straightforward bidder, focussed on maximising its own surplus.

CCA offers a solution to this problem by first running a clock stage but then offering a supplementary stage where bidders can specify a more detailed demand structure, including an opportunity to bid for lots that constituted excess supply at the end of the clock stage due to bidders lowering demand too fast, be it because of complementarities or too steep price increments.

Example 8: Handling of aggregation risks by the CCA

Consider the same valuation profile that we examined when showing aggregation risks in the clock auction. There are two lots in the same category and two bidders (X and Y). These are their cumulative valuations:

Quantity	X's valuation	Y's valuation
1	€80	€120
2	€200	€200

Bidder X's marginal valuations are increasing and bidder Y's – decreasing.

There are multiple optimal allocations. Regardless of whether one of the bidders gets both lots or they both get one each, the total achieved value will be €200.

Price	X's bid	Y's bid
€70	2	2
€80	2	2 (or 1 tied)
€90	2	1
€100	2 (or 0 tied)	1
€110	0	1

The clock stage of the CCA will progress in the same way as the clock auction detailed in the example above, ending with one unsold lot.

However, now X and Y will participate in a supplementary stage where they will be able to submit bids for one and for two lots subject to preferences they revealed in the clock stage. Assuming that X reduced demand at €100 and Y at €80:

- X will be able to bid for one lot up to €100 and for two lots up to €200; and
- Y compared to the exact amount Y choose to bid for one lot (which will need to be Y's final clock bid for a single lot, and could be increased to 120), Y will be able to bid at most €80 more for two lots.

They are thus able to express their exact valuations. Assuming they do, the final allocation will be one of the three efficient ones.

In this simple example it was not possible to claim any features of the final allocation with 100% certainty at the end of the clock stage (and before the supplementary stage). However, this is only due to the simplicity of the setting and the comparable strengths of the bidders (which in real auctions may or may not be related to common values).

However, the CCA is recommended in situations where there are far too many lots for the bidders to express their full valuations for, in which case the CCA offers a mechanism to reduce the competition in the sealed-bid stage to just the lots that constitute excess supply after the clock stage – in addition to the price-setting function of the supplementary stage.

In section 4.2.1 we outline how the choice of pricing mechanisms affects bidding incentives if some bidders express complementarities between lots.

4.1.2 Package discovery

An important feature of iterative auctions is that bidders do not have to form valuations for every possible combination of the lots on auction. The ascending price mechanism allows them to focus their efforts on calculating their demand for the marginal lots that they may add or subtract from their current package.

In CCAs, this mechanism is facilitated with relaxed activity rules which enable bidders to safely reduce their eligibility if they bid straightforwardly, since the revealed preference-based rules will allow them to bid above eligibility if that is consistent with earlier bids. In SMRAs and clock auctions, bidders often have to bid for oversized packages to store eligibility in anticipation that they may need it to bid straightforwardly in future rounds. This reduces transparency with regards to what the efficiency-relevant packages are and, if a late switch from eligibility storing to straightforward bidding involves a sharp demand reduction, may generate significant undersell.

Clock auctions may be enriched by relaxed activity rules, as opposed to SMRAs. This would improve package discovery in clock auctions, but other problems, such as aggregation risks, would still persist.

4.1.3 Budget-constrained bidders

Budget-constrained bidders face difficulties in most auction formats. As a broad feature, within multiple lot auctions, it becomes necessary for a budget-constrained bidder to anticipate whether or not it is likely to win a particular outcome before deciding to compete for it.

Within a simple clock auction with multiple lots in a single category, if a bidder has a budget constraint that prevents it bidding its full value for a larger number of lots, this may lead to increased incentives for strategic demand reduction. The bidder compromises for a (possibly inefficiently) small number of lots because it does not expect that its bids for larger amounts to be competitive. Therefore, there is likely to be some bias towards a budget-constrained bidder winning smaller packages; it is possible the budget constraint could be low enough that the bidder prefers not to exhaust its budget constraint bidding for a larger package, but rather to switch to a smaller package and try to moderate the price paid. SMRAs are likely to see similar issues, though may be to be played out with bidders switching between substitutable lots.

Within second-price auctions, there is a trade-off to be struck for bidders between expressing their relative valuations between larger and smaller packages, and ensuring that bids for small packages are high enough to be competitive. What typically happens is that a budget-constrained bidder does not fully express the value difference between small and large packages for this reason (as seen in the example below), as bids for larger packages are constrained by budget, and bidding below value for smaller packages risks winning nothing. Therefore, we also have some potential bias towards bidding for smaller packages. However, unlike the simple clock auction, we would still expect budget constrained bidders to make full use of whatever budget they do have to bid for large packages.

The example below shows how, in a sealed-bid second-price auction, an inefficient allocation may occur if a bidder has to shade some bids due to its budget constraint.

Example 9: Budget-constrained bidding in a sealed-bid second-price auction

Consider two items (A and B) and two bidders (X and Y). They will submit three sealed bids each (for A, for B, and for A and B together). The final allocation will be the revenue-maximising one (with ties broken at random) and the price will be based on opportunity cost. These are their valuations:

Item	X's valuation	Y's valuation
A	€30	€20
B	€20	€12
A and B	€50	€30

Both bidders face a budget constraint of €30.

Straightforward bidding would lead to the optimal allocation, where X gets both A and B and pays €30. However, while bidder Y can bid straightforwardly (and does so), bidder X cannot express its full valuation for A and B together because it fears it may pay more than its budget constraint, even though in reality it would not.

If X trims its bids to the budget (bidding €30 for A, €20 for B and €30 for A and B together), it will only win A while Y will win B.

If X reduces all its bids to preserve the differences between their values while fitting all of them within the budget constraint (bidding €10 for A, €0 for B and €30 for A and B together), each bidder has a 50% chance of winning A and B and 50% chance of winning nothing.

These two strategies produce an expected deadweight loss of €8 or €10 respectively when compared to the optimal allocation, even though X would end up paying a price within its budget constraint if it bid straightforwardly.

However, if X knew that Y is not going to submit a bid higher than €30, it could bid up to its valuations.

Similar issues may appear in the CCA, as shown below. Having clock rounds can provide additional information to budget-constrained bidders to allow them to assess what they might win, but such bidders will face the same difficulty that they may not be able to express the full amount of their valuation differential between smaller and larger packages.

Example 10: Budget-constrained bidding in a CCA

Consider two items (A and B) and two bidders (X and Y). These are their valuations:

Item	X's valuation	Y's valuation
A	€25	€18
B	€25	€18
A and B	€50	€36

Additionally, X faces a budget constraint of €30.

They bid in a CCA where the reserve price for each item is €10. When both bidders bid for an item, its price rises by €1.

In an optimal allocation, X will get both items.

If they try to bid straightforwardly, the following bids will be placed:

Prices	X's demand	Y's demand
€10, €10	A and B	A and B
€11, €11	A and B	A and B
€12, €12	A and B	A and B
€13, €13	A and B	A and B

€14, €14	A and B	A and B
€15, €15	A and B	A and B
€16, €16	?	A and B

At price of €16 for each item, X will face a dilemma where it can only bid for one item due to the budget constraint. Without loss of generality, let us assume it chooses A.

Prices	X's demand	Y's demand
€15, €15	A and B	A and B
€16, €16	A	A and B
€17, €17	A	A and B
€18, €18	A	A and B
€19, €19	A	Nothing

In the supplementary round, the rules allow X to place an arbitrarily large bid for A but its bid for A and B together can be only €15 greater than its bid for A and its separate bid for B can only be up to €15. As a result, X cannot win B whatever it does, resulting in an inefficient allocation.

4.1.4 The 'missing' supplementary bids problem

Constraints on the number of supplementary bids imposed for technical reasons or bidders not being sophisticated enough can lead to what might be called 'missing' bids in CCAs, due to bidders not making a sufficient number and variety of supplementary bids.

Under the MRC approach, this may make different bidders pay different amounts for similar packages. This appears to have happened in the Swiss 3G auction in 2000 (though the bid data was not made public). Under this scenario, one winner competes strongly to add spectrum to its winning package through supplementary bids, thereby setting the prices paid by other winners, but another winner fails to make such bids for such additional lots, leading to lower prices for its rivals. Whilst such an outcome might well attract the complaint that one winner has paid too much relative to the other, it would be more accurate to describe this as one winner paying less because of lack of competition from rivals.

It is not clear that such price disparities should be a policy concern as such, as in the context of spectrum auctions it is unlikely that there would be any material long-run impact on downstream markets. Also, to the extent that was indeed the reason behind the Swiss outcome, it may have arisen due to this being an early CCA and bidders not fully understanding the consequences of the rules; this is much less likely now given a good understanding of CCAs by most spectrum auction participants.

Nevertheless, if bidders limit the number and range of the supplementary bids they make, this can also raise efficiency concerns; lots may be awarded to a bidder who does not value them the most, because the bidder with the strongest valuation has not submitted bids for them.

Furthermore, missing bids may exacerbate gaming opportunities which we outline in section 4.2. In particular, Levin and Skrzypacz (2013) note that *"if bidders do not increase their bids in the supplementary round to levels consistent with their expressed demand in the clock round (and they have no strict incentive to do so), this leads to price discounts and incentives for demand expansion in the initial clock round"*. Put simply, if a bidder expects to face little competition from rivals in the supplementary round, it might bid for more lots than would choose if it paid its bid price, in effect anticipating that its winning price will be a discount on its bid price.

The problem of missing bids is more likely to arise when there is a large number of unsold lots at the end of the clock stage. Whilst the problem typically does not compromise efficiency and has diminished as bidders have become more knowledgeable about the properties of CCAs, such price disparities have been suggested as a reason to favour alternative auction formats.

Section 4.1.5 below outlines one method of alleviating the problem by making it easier for bidders to express a large number of supplementary bids for various alternatives. However, in highly complex situations where we expect bidders to need to make a large number (and wide range) of different package bids for a combinatorial auction to deliver an efficient outcome, other solutions may need to be considered (such as iterated combinatorial auctions where bidders can make multiple bids each round).

4.1.5 Bidding languages for the supplementary stage

The initial CCA proposal assumed that bidders will submit a number of all-or-nothing bids (called *XOR bids*) in the supplementary round. This has been the case in almost all CCA implementations to date. However, it is not the only way of allowing bidders to express their preferences.

As Ausubel and Baranov (2014) note, when CCAs started being used to sell a large number of spectrum licences, usually divided by regions of the relevant country, more attention has been devoted to the differences in how efficient different bidding languages are in specific scenarios. This is because a large number of items on auction gives rise to the missing bids problem described above and to constraints being imposed on bidders regarding how many bids they can submit, in order to prevent computational problems in winner determination.

Generally, different languages will be more efficient than XOR at expressing some valuation structures but will make it harder, or even impossible, to express others. Efficient ways to represent preferences will necessarily involve some loss of flexibility.

The most popular alternative is to make bids non-exclusive (called *OR bids*). OR bids allow for a more compact expression of linear demand. In an extreme case where a bidder bids for n different goods and its valuation structure is perfectly linear, it needs to submit only n bids under the OR language but 2^n bids under the XOR language to perfectly express its valuations. Where there are only complementarities and no linearities, both languages need 2^n bids. However, when some goods are substitutes, it is impossible to express the valuations using OR bids.

Ausubel and Baranov (2014) note that the most important challenge that may arise from implementing the OR language is probably related to devising appropriate formulations of activity rules. Additionally, Ausubel and Baranov (2014 and 2017) note that a successful implementation of OR bids may rather depend on whether bidders have linearly additive valuations for incremental lots on top of their final clock package, rather than on their general valuation structure.

To this date, there has been only one implementation of the OR language in a CCA: the Canadian 2.5 GHz auction. This allowed bidders to specify a number of incremental bids that would be added to their final clock bids to create a supplementary bid. If n such incremental bids were specified, then this implied up to $2^n - 1$ supplementary bids formed by taking the possible subsets of those incremental bids. Bidders could optionally set quantity caps to exclude some of these combinations of incremental bids. This system was adopted because of the large number of lots involved given the regional structure of the auction.

Another alternative (noted by Ausubel and Baranov, 2014) which alleviates the problem of OR bids not being able to express substitutability but retains high efficiency for highly linear demand structures is a combination of the XOR and OR languages, for example one where bidders can submit many exclusive sets of non-exclusive bids (i.e. the auctioneer will accept potentially any bids, but only from one set). This may prove ideal for piecewise-linear demand structures.

4.2 Gaming opportunities

In the subsections below we outline the research on bidding incentives under the currently used as well as proposed core pricing mechanisms relevant to CCAs. Further, we point out other incentives

to deviate from truthful bidding and some solutions for resolving them.

4.2.1 Bidding incentives under MRC pricing

In a multi-item second-price sealed-bid auction, Vickrey prices make truthful bidding a dominant strategy. However, Vickrey prices have several disadvantages, as we have seen in Section 3.

Day and Milgrom (2007) prove that there is an identity between auctions which provide optimal incentives (one cannot improve a bidder's truthful reporting incentives without worsening other bidder's incentives) and auctions which choose a bidder-optimal allocation (no bidder's payoff can be improved without worsening another bidder's payoff). In effect, this result generalises the observation that if the auction mechanism tries to achieve an outcome that is optimal for a bidder given the bids made by that bidder, then the bidder has an incentive to state what it wants truthfully; however, in practice this principle can only be applied up to the point that bidders' interests conflict.

This result gives strong theoretical support for the use of bidder optimal core pricing. However, the broad principle does not uniquely define the payment mechanism. Out of all bidder-optimal core-selecting mechanisms, Day and Milgrom suggest using the one that minimises the auctioneer's payoff – what is now known as the minimum-revenue core pricing (MRC). This is because MRC has an additional advantage: its revenues never decrease in response to an increase in bids. Day and Raghavan (2007) extend the analysis of minimum-revenue core pricing by showing that it minimises the aggregate incentives to deviate from truthful bidding, which provides strong reasons to use this class of pricing mechanisms in auction formats such as the CCA.

MRC pricing is formally equivalent to bidders paying the least amount that, if they had bid this amount instead for their winning package (and reduced their other bids by a similar amount), then they would have still won. Therefore, it ensures that winners pay enough for the losers to be content with the auction outcome, but subject to this requirement, the winners pay the least amount possible.

Vickrey pricing makes truthful bidding a dominant strategy but prices may be distant from the core. Core pricing selects prices that are in the core but only with respect to bidders' reported valuations (bids). It is a different challenge for a pricing mechanism to yield prices that are close to the core with respect to bidders' true valuations. Ausubel and Baranov (2019) investigate the properties of several pricing mechanisms in sealed-bid combinatorial auctions in an environment where bidders' valuations may be correlated.

Specifically, they investigate the local-local-global model, where there are two items, each of the two 'local' bidders desires one of them and one 'global' bidder views them as perfectly complementary. In this scenario, Vickrey prices are outside the core when local bidders bid individually less but collectively more than the global one. They calculate the seller revenue, efficiency of the allocation and distance to the *true core* of the allocation under four different pricing mechanisms:

- proxy;
- Vickrey;
- unweighted Vickrey-nearest; and
- nearest-bid

and different values of parameters controlling:

- the correlation of the valuations of the local bidders; and
- the shape of the distribution of the valuations of the local bidders.

They find that "*while the VCG rule is always efficient, any of the considered core-selecting rules can generate higher revenues under certain assumptions and, as a result, can produce outcomes that are closer to the true core. The lack of general rankings [regarding which auction mechanism produces outcomes closer to the true core] can be observed even when local bidders' values are fully independent*".

4.2.2 Implications of tie-break rules for prices

Often, MRC pricing does not yet pin down a unique price vector in an auction – there is a one-to-one trade-off between two or more bidders' share of the core burden.

There are several options for determining how ties are broken. In section 3.4 above we describe the Vickrey-nearest rule (or its weighted version), which has been always used in CCAs.

As Erdil and Klemperer (2009a) show, under some conditions, the Vickrey-nearest rule "*is the ex-ante welfare-maximising MRC-selecting rule*". However, as Erdil and Klemperer (2009b) point out, these conditions are very strict and unrealistic.

Additionally, they point out practical considerations which question MRC pricing as a mechanism that is always most desirable. They propose an alternative pricing mechanism, which we describe in section 5.2.

4.2.3 Price driving

There are possible reasons why a telecoms operator might prefer to raise rival's cost in a spectrum auction.

- First, there is a principal-agent problem present in telecom companies, where shareholders and, to some extent, senior management may not be able to assess perfectly the performance of the team which submits bids in an auction. In the absence of a reliable way to rate the surplus achieved through the purchase of spectrum in the auction, they turn to comparing the cost paid by them versus that paid by competition.
- Second, if a competitor has to bear a higher cost in a spectrum auction and they face limited liquidity / imperfect capital markets, they may find themselves cash-strapped and unable to invest in infrastructure, which lessens competition.

It is difficult to know how significant these issues might be in practice. In particular, it is implausible that large telecoms operators would be subject to sufficiently strong capital constraints that their ability compete in downstream markets might be limited by paying more for spectrum. Equally if shareholders find it difficult to assess the success (or otherwise) of spectrum auction outcomes, there are broader issues at play than just auction design. In particular this suggests that spectrum licences may be being awarded when their use and value is highly uncertain.

If bidders' objectives are distorted by such concerns, then bidding behaviour in any auction is likely to be affected. However, we note that this issue is not limited to CCA and there would be impacts regardless of the auction format used. A bidder wanting to drive up a rival's price would, regardless of the format, also face risks of winning unwanted lots and paying in excess of valuation. Therefore, we do not see concerns about price driving as being in any way specific to the CCA. Nevertheless, the potential for non-straightforward bidding in a CCA due to price driving objectives has been noted, for example by Janssen and Karamychev (2016).

Sometimes bidders will submit supplementary bids for packages of rivals' interest at the maximum possible amount subject to not winning them. However, this requires knowledge about the likely bid amount of the rival. Therefore, it is more plausible that they will find that the maximum amount carries a high risk of winning that package, in which case they will have to trade off increasing rivals' cost with the risk of winning something they do not want.

Here, the bidders may be encouraged in favour of higher bid amounts by the fact that winning the price-driving bid would drive a rival out of winning anything in the auction, which brings extra profit from lessened competition. The anti-competitive incentive to knock rivals out is not specific to CCAs, but theoretically might be exacerbated by the strong incentives to compete for additional lots present in a CCA (in contrast to SMRAs or clock auctions, where there are usually incentives to moderate the quantity sought to get a lower price). However, the underlying problem in such cases is not

the auction format, but rather that bidders may be permitted to make bids for packages of spectrum whose valuations are inflated by an expectation of gaining market power. If appropriate safeguards were in place to protect downstream competition (such as caps or reservations) then such bids should not be possible.

Furthermore, a bidder's anticipation that they would like to submit untruthful bids in the supplementary stage may lead them to change their behaviour in the clock rounds in order to create more favourable bidding constraints in the supplementary round. The more aggressive a bidder's clock bids are, the more relaxed its supplementary round constraints will be. Additionally, undersell may be leveraged to extract money from rivals.

Levin and Skrzypacz (2013) examine the inefficient equilibria that might arise due to the price-driving incentives. They show that even in a setting where bidders have linear demand curves, there are many qualitatively different equilibria.

- In one of these examples, there is a predatory bidder who submits its maximum allowed demand throughout the clock phase and then drops demand instantaneously to a market-clearing level. That creates very relaxed constraints for the predatory bidder in the supplementary stage and allows it to force clock prices upon the entirety of its rival's winnings. The weaker rival may anticipate the predatory strategy and, at some point, submit lower demand than its valuation model would recommend, in order to limit the final clock prices, which will determine its cost.
- In another scenario, an equilibrium entails bidders tacitly colluding by giving up their pricing power in return for their rivals doing the same. This could lead prices being lower than they might otherwise be, contrary to price driving.

We should not be surprised that a range of equilibria can be supported in the context of a dynamic game between bidders. For instance, to the extent that bidders find a way to drop pricing power progressively (which may be possible in a regional spectrum auction by dropping demand region by region), there is a similarity to tacit collusion sustained between oligopolists competing over price over time. Analogous behaviour in a clock auction or SMRA would involve 'market sharing', i.e. a tacit agreement between winners to take certain lots and limit competition. Therefore, we need to be careful not to misinterpret such examples as specific criticisms of the CCA given similar phenomena can occur in other formats.

Concerns about pricing driving behaviour with the CCA rely on a credible theory of benefit for bidders. Whilst it is possible to imagine reasons why a bidder might prefer its rivals to pay more, bidding above valuation also entails significant risk if rivals' valuations are unknown, as inflating bids for larger packages could lead to those packages being actually won. In practice, this is likely to be a

significant brake on such behaviour. Arguments that making rivals pay more lead to significant commercial benefit for bidders are not plausible, given that spectrum costs are largely sunk and form only a minority of the overall cost base of mobile operators.

Levin and Skrzypacz's argument that maintaining excess eligibility in a CCA could be used as a predatory strategy provides a more credible argument. In this case, the benefit of overbidding for large packages is to force a weak bidder to drop demand to prevent clock prices rising further. Potentially this could lead to a predatory bidding winning more than it might otherwise have done. However, this can only work in situations in which the weaker bidder could influence the evolution of the clock price (i.e. end excess demand by reducing demand); this is likely to be limited to the very end of the clock rounds (if at all).

Furthermore, even if a bidder maintains clock bids for larger packages for longer, this does not entail any commitment to bid an inflated differential for larger packages in the clock round, as it is possible for the bidder to reduce the differential by increasing its final clock bid (which the bidder may wish to do for reasons such as making a knock-out bid for its final primary package). Therefore, even if faced by strong demand from a rival during the clock rounds, this might not entail facing price driving supplementary bids.

The authors also examine real-world examples of price-driving behaviour. They claim it is widespread, citing one example (from the Austrian 4G auction in 2013) where bidders paid €2.01 billion collectively, which was close to the value of all the licences at clock prices (€2.07 billion) and much more than what they would have paid had they submitted no supplementary bids (€765 million). However, it is not clear how such bidding behaviour can be differentiated from bidders simply having value for larger packages of spectrum and competing for those. Therefore, these supposed examples of price driving behaviour are largely indistinguishable from bidders competing for additional spectrum. Within the CCA there are stronger incentives to compete for additional spectrum than in uniform priced auctions (such as clock auctions, and in practice SMRAs as similar lots will be sold for similar prices), because in a CCA there is no concern that unsuccessfully competing for a larger amount of spectrum will raise the price for a smaller amount of spectrum eventually won.

One reasonable concern is that spectrum auction with slack caps may involve some bidders having valuations that are driven in part by an anticipation of rents from downstream service competition being weakened. Within a CCA, this could mean that, even if no bidder eventually won enough spectrum to gain market power, prices paid were nevertheless affected by the anti-competitive valuations. This is a reasonable concern, but reflects that caps need to be set to prevent anti-competitive outcomes; this is a matter of policy rather than a specific concern for the choice of auction design.

This said, price-driving behaviour may be curbed by spectrum competition caps. This is because the untruthful price-driving bids are likely to be much larger than any of the sincere bids. If auctioneers can anticipate the likely limits to bidders' sincere demand under the clock prices that will likely materialise in the clock stage, they can cut off bids for larger packages. However, spectrum competition caps have more than one function and have to fit into a coherent overall framework. Therefore, auctioneers may find it difficult to specifically use caps against price-driving, but caps set to prevent anti-competitive behaviour will have a by-product of reducing price-driving behaviour.

4.2.4 No unsold lots in the final clock round

If there are no unallocated lots at the end of the clock stage, then the final allocation of the auction cannot be subsequently affected by the supplementary bids made (under certain caveats set out below). This property arises because of the final price cap.

Bidders with non-zero final clock packages have bid for that package at final clock prices. Bidders may make supplementary bids for other packages and may have other clock bids made at lower clock prices; the incremental value that can be expressed by any of these other bids for adding lots to final clock packages is always limited to the final price cap. Therefore, a bidder wanting to gain additional lots in excess of its final clock package in the supplementary bids round cannot express a sufficiently large incremental value to reduce other bidders' final clock allocations. This is true even if a rival has made supplementary bids for packages that are subsets of their final clock package and so offered to 'give up' lots from its final clock package; the final price cap limits these bids for smaller packages, with the result that the bidder must express an incremental value for retaining these dropped lots at least equal to final clock prices.

Two caveats apply to these conclusions. The first is the potential for ties within the determination of winners. It is possible that, even within the constraints imposed by the final price cap, there could be an alternative tied outcome that differs from the situation at the end of final clock round but has the same total value of winning bids. However, it is common for tie-breaking rules to favour tied outcomes that are more similar to the situation in the final clock round (for example, minimising the number of lots that bidders lose relative to their final clock packages). However, even without such a tie-break rule, any bidder can guarantee that their final clock package is won by increasing their final clock bid by the minimum amount possible whilst not increasing bids for other packages. Therefore, it is possible for bidders to lock in their final clock package at little additional cost regardless of the tie-breaking rules.

The second caveat is that under some activity rules – including those used by ComReg in the 2012 MBSA and the 3.6 GHz auction, and proposed for the MBSA2 – it is possible that an increase cannot be made in a bidder's supplementary bid for its final clock package without having to increase a bid for some other package as well. This may occur if a bidder's final clock bid is a relaxed bid and constrained by a bid for some other package. In the case that the tie-break rules for winner determination favour the clock outcome, this makes no difference and the final clock outcome will become the winning outcome. However, if such tie-break rules are not used and the bidder needs to increase its bid for its final clock package somewhat, it may need to also increase its bid for some other package. There is then a chance that (depending on compatible bids by other bidders) that that other package might feature in a tied winning outcome that was selected (say at random) when determining winners.

Therefore, in the situation where there are no unallocated lots, the role of the supplementary bids is (subject to the caveats above) to set the prices paid by winning bidders, rather than to affect the winning outcome. This conclusion applies regardless of the detailed activity rules, provided that there is a final price cap applied to supplementary bids. This feature of the CCA raises a potential concern that bidders might then bid in excess of their true valuations for packages larger than their final clock packages in order to increase rivals' prices, knowing that these bids for large packages will not win.

There are two potential responses to this issue. The first is to create incentives for bidders to bid in line with valuations by creating some uncertainty about the final clock round allocation and with this some risk that supplementary bids could become winning bids. The second is to shift to an alternative methodology not based on second price, such as the ECCA. We consider each in turn below.

Some CCAs, for example the Canadian 600 MHz auction, have limited information provided in the final clock round, providing aggregate demand information at the end of each clock round except the final clock round. This means that bidders do not know how many unallocated lots there might be at the end of the clock stage. This creates incentives for supplementary bids to be made in line with valuations, as the final outcome is uncertain and if a bidder bids in excess of its valuation for a larger package, there is some risk that it could win this and pay in excess of its valuation.

This approach of limiting information in the final clock round does not appear to have been very successful where used, as it is possible for bidders to work around the limitation by bidding for additional lots in a relatively low value lot category to prevent the clock rounds from closing and maintain this until excess demand is eliminated in other lot categories; the clock rounds are then closed by dropping these low value lots. In the Canadian CCAs using this restriction on final clock round information, such a strategy was easy to implement

as they had a regional structure with some lot categories having very low relative value.

A better approach is that used by ComReg in both the MBSA and 3.6 GHz auctions. In these auctions, ComReg maintained the right to make a deposit call after the supplementary bids round, but before determining winning bids. This meant that bidders did not know whether rivals might have all or some bids eliminated due to failure to meet a deposit call. Whilst this was a small risk, it provided some control on supplementary bids, as there was some risk that a significant number of lots could come into play if a bidder was eliminated, leading to the potential for additional lots being won.

The second possible response is to give up on the second price rule. Under the ECCA approach, if there are no unsold lots at the end of the clock stage, bidders will pay the amount of their bids. In effect, this is as if rivals had made bids within a second price auction to the maximum levels possible to increase rivals' bids. Notice that even within a conventional CCA we could have a similar situation if (i) it was common knowledge that bidders knew that other bidders had a diminishing returns structure to their valuations, so unsold lots would not occur and (ii) bidders made full use of opportunities to increase other winners' prices, as this would lead to bidders paying the full amount of their winning bids.

Overall, this second approach means moving to a mechanism that has an implicit first-price aspect, which comes with potential impacts on bidding incentives. In particular, this creates incentives to moderate competition and compromise for smaller quantities. In contrast, the first approach, ensuring that there is some risk that supplementary bids may affect the outcome even if the final clock round finishes with no unsold lots, provides an incentive not to overstate bids without introducing this first price aspect.

4.2.5 Demand reduction in regional auctions

In many auction formats, bidders face incentives to reduce demand unnaturally early in order to stop the price of the lots increasing. However, the nature of these incentives varies between the formats.

Let us imagine a pay-as-you-bid clock auction with one lot category, two lots and two bidders (A and B) with decreasing marginal valuations. At the beginning of round t , A is bidding for one lot and B is bidding for two lots at a price of $p_t < v_{A1}, v_{B2}$. Under straightforward bidding, B will continue to bid for two lots. However, B will note that allowing the price to increase further will make the surplus derived from the first lot smaller. If $v_{A1} \geq \frac{p_t + v_{B2}}{2}$, it will be profitable for B to immediately decrease its demand to one. This may result in an inefficient allocation where both A and B get one lot even though $v_{B2} > v_{A1}$.

In a CCA, such inefficiency will not occur. If A is currently not competing for the second lot, it has already set a hard limit on the possible valuation it may express for the second lot and, therefore, the possible price B can pay for its first lot.

List and Lucking-Reiley (2000) test the differences between uniform-price auction and Vickrey auction by running a field experiment where they auction dozens of sports cards, with two bidders and two cards in each of the auctions. Some auctions are uniform-price (*"For each card won, the purchase price is equal to the amount of the third-highest bid (that is, the highest losing bid)"*) and some are Vickrey (*"For each card won, the purchase price will be determined as follows. For the first unit you win, you pay an amount equal to the highest rejected bid which was not your own. For the second unit you win, you pay an amount equal to the second-highest rejected bid which was not your own"*). Consistent with theoretical predictions, they find that uniform-price auctions yield lower bids for the second unit and higher likelihood of split allocations. However, contrary to theory, they find that uniform-price auctions yield higher bids for the first unit in such a way that the paper's authors cannot find a statistically significant difference in total revenue for the two cards between those two auction types.

4.3 Governance issues

The multi-layered decision process where bid teams within bidding firms need to seek approval from management and shareholders for their budget and bid strategy and the firm may have to seek funds on financial markets, for either auction expenditures or further activity, may generate inefficiencies and practical difficulties.

4.3.1 Second prices and exposure

The second price rule results in bidders not knowing how much they will pay for their chosen packages, both during the clock rounds and in the sealed-bid supplementary round.

When a bidder places a clock bid, it has to acknowledge that, if the auction ends after the current round, the final (supplementary round) price of its current clock package may be either higher or lower than the clock price.

On one hand, bidders' bid histories impose caps on the valuations they can express for the goods on auction. Since bidder X's competitors may not be able to express valuations for all packages at the final clock price, bidder X could calculate a resulting *discount* – a minimum amount by which its allocation price will be lower than the clock price of its package thanks to the caps – which is never negative. However, calculating the discount requires knowledge

about competitors' bid histories. Since usually auctioneers restrict knowledge about rivals' bids to prevent undesirable incentives such as collusion, a bidder may not be able to precisely calculate its discount.

The reason why bidders may pay more than the clock price for their winnings is that, whenever there are unsold lots, bidders can leverage them in order to inflate a rival's prices or knock the rival out. While discounts are specific to bidders (broadly, larger bidders will enjoy larger absolute discounts), the leverage potential, as a result of how it is defined in complementarity to the discount, will be the same for most bidders. We provide a full description of how the discount might be calculated in Annex A.

One way in which auctioneers deal with these problems is by running pay-as-bid auctions. However, pay-as-bid rules bring a host of suboptimal incentives to the auction, as bidders need to anticipate how much competition they face and accordingly bid at some amount less than valuation. Within combinatorial auctions, this could lead to highly inefficient outcomes if bidders have different expectations about competition. Therefore, one may prefer to find ways of bringing more price certainty to existing second-price formats such as the CCA. We discuss such solutions in the section 5 below.

4.3.2 Budget constraints as a strategy tool

Often, in large firms who act as bidders in an auction, there is a two-layered decision process where senior executives set budget constraints and, subject to these constraints, a bid team chooses the best strategy for the auction. There is limited information and these two types of agents have different incentives (in particular, either of their incentives will rarely coincide with surplus maximisation). Therefore, the senior executives may set budget constraints that do not exhaust the available cash and credit for the firm.

Janssen and Karamychev (2016) look at these endogenous budget constraints and show that the budget decisions can lead the auction to a Hawk-Dove type game with multiple equilibria where, in an example with two bidders, it may be an equilibrium for *either* bidder to set an aggressive budget constraint and for the *other* bidder to set a defensive one, whereas it is not an equilibrium for both bidders to set the same kind of budget constraint. The aggressive bidder's bid team will threaten to apply large pricing power to the more defensive bidder and the defensive bidder's bid team, due to their budget constraint, is prevented from bidding for a large package. Instead, the defensive bidder will make smaller clock bids (than surplus maximising), which will lower clock prices and thus the overall allocation prices, which in turn will justify the defensive budget constraint.

4.4 Assessment

Some papers provide general assessments of the CCA. For example, Levin and Skrzypacz (2013) and Knapek and Wambach (2012) note the complexity of the CCA, with the latter authors striking a sceptical tone regarding this auction format. Some papers point out specific inefficiencies present in the CCA, sometimes related to the bidders not being able to fully express their valuations and sometimes related to bidders being able to bid untruthfully to improve their outcome. In this section, we have aimed to describe all such criticisms.

Overall, however, we find the relevant literature lacking regarding the comparison of the CCA with other auction formats, such as the SMRA or the clock auction. It would have been very valuable for more studies to explore the range of scenarios in which specific auction formats fare best. This is because a large share, if not most, of the criticisms that are applicable to the CCA are also applicable to most other designs used in spectrum auctions. In fact, through examples, we have shown how e.g. the degree to which bidders can express their valuations in the CCA is not perfect, but nevertheless superior to that in the SMRA and the clock auction.

5 Alternative pricing methodologies

The purpose of this section is to assess whether alternative pricing methodologies could deal with some of the issues assessed above and, in particular, by providing bidders more comfort about what prices that might pay if they ultimately win certain packages.

Linear, uniform clock prices vs. bidder-specific winning prices

In our standard specification of the CCA, the prices announced in each clock round are linear (the price of a bundle is the sum of the prices of the items included in the bundle) and, barring set-asides, uniform (for each specific bundle, each bidder faces the same price, so the pricing scheme is anonymous). However, the final allocation prices are determined by the Vickrey nearest minimum revenue core (VN-MRC) pricing algorithm after the supplementary stage and so may deviate from either or both of these properties. Winning prices are ultimately for packages of lots and set for each bidder.

Modifications to align the clock stage with the eventual outcome

Of course, clock prices need not be linear or anonymous and the supplementary stage does not have to entail MRC pricing. These are just chosen features of the auction design. In this section, we will discuss some ideas for alternative pricing methodologies to better align the clock stage with the eventual outcome of the auction.

Section 5.1 presents possible modifications of the clock stage rules. Section 5.2 considers a modification of the core pricing algorithm applied after the supplementary stage³⁶. Section 5.3 presents how revealed preferences combined with activity rules can be used to inform bidders of their financial exposure. Section 5.4 explains how to use that exposure calculation as an alternative pricing mechanism, reducing or removing the need for soliciting price-setting bids in the supplementary stage.

5.1 Modified pricing in the clock stage

In section 3, we noted the problems resulting from complementarities in auctions with uniform linear prices, such as SMRA or the clock auction³⁷, and how the CCA deals with them, enabling efficient allocation. We also noted that under particular forms of complementarity, even the CCA may not arrive at an

³⁶ We note that Parkes et al. (2001) suggest alternatives to Vickrey pricing mechanisms in exchanges, aiming to introduce a budget-balance constraint (that the exchange does not run at a loss) while achieving incentives that are closest to the truthful ones. We do not consider their findings relevant to the topic at hand.

³⁷ If identical lots are offered as separate lots within an SMRA, substitution between those lots will typically keep prices within one bid increment. Therefore, prices for identical lots will be approximately equal as an outcome. For clock auctions, this is imposed as a feature of the auction, as a common price per lot is set for a category of lots.

approximately efficient outcome. Finally, we noted that non-decreasing, but anonymous prices (i.e. non-linear prices with discounts for smaller packages, but applying uniformly to all bidders) can solve the problem of allocating with complementarities in some cases, but not in others.

In this section, we will focus on the differences between linear and non-linear non-decreasing pricing. We will describe most natural implementations of such mechanisms in the clock stage of the CCA, assess to what extent they yield any benefits. We also outline how they affect other properties of the auction, including truthful bidding incentives and complexity.

Pricing different numbers of lots differently

In auctions with homogeneous goods (e.g. spectrum auctions with multiple lots in each of many categories) the auctioneer can conduct a clock stage in which lots in a category are priced at a different amount per lot depending on the quantity sought. For example, one lot in a specific category would be priced at €100 and two lots in the same category could be priced at €300, reflecting stronger demand for pairs. These prices are available to all bidders, depending on how many lots they wanted, and so apply uniformly and anonymously across bidders.

Non-linear prices within categories

We can think of this as different quantities of lots (within a category) as functioning like different products. For example, suppose that a category of identical lots was offered as pairs and as singletons, with one price for pairs and another for singletons. The price of pairs would need to be at least twice that of singletons. If a bidder wanted a certain number of lots, this would be met by pairs, unless the bid wanted an odd number, in which case a singleton would be added. Therefore, a bidder could include at most one singleton. Excess demand for pairs and singletons can be assessed in the usual manner. However, when increasing prices for categories in excess demand, if the price of singleton needed to be increased, but pairs were not subject to excess demand, then the price of pairs might need to be increased in order for pairs to be at least twice the price of singletons. The price of singletons can close at less than half of the price of pairs to avoid inefficiently unsold singletons.

Cross-category synergies

The same approach could, at least in principle, be applied across lot categories, where a combination of lots from different categories could be priced above the sum of the prices of the component lots. This would need to be applied selectively where there are particular combinations of lots with strong complementarities, otherwise it would rapidly become unmanageable.

Implications for activity rules

The general structure of activity rules is not changed by using more complex pricing rules. In particular, relative caps are based on the price differences between different packages of lots. Even if we do not use a linear price system (i.e. a per lot price), these price differences are still well-defined. The logic of revealed preference,

capping bids for packages not chosen relative to packages chosen still holds.

Complexity and specificity to particular synergies

The problem with this non-linear pricing approach is we are in effect introducing new categories of lots by treating lots within certain combinations differently for pricing purposes. If the number of such products becomes too high, bidders would struggle with the complexity involved. Therefore, at best we can hope to capture a very limited number of specific synergies between lots within or across categories where these are particularly strong. This might be useful in certain applications, for example if some bidders only have synergies of particular forms and are competing with other bidders without synergies. However, often the auction designer cannot assume that synergies have particular forms. Therefore, moving from linear pricing in the clock stage is not a viable approach in general.

5.2 Reference pricing

Deviations under MRC pricing

MRC pricing minimises the sum of bidders' *total incentives to deviate* (from the truthful bidding strategy) understood as the maximum gain they can achieve by deviating. However, the deviations that achieve the maximum price reduction for a package for a bidder tend to be the biggest ones, but which also run the risk of changing the allocation and the bidding winning something else (or possibly losing altogether). Therefore, if a bidder does not have perfect information and is risk-averse, they will prefer to make smaller (safer) deviations instead. Therefore, if an auctioneer wants to limit how much bidders misreport their valuations in order to reduce their prices, instead of total incentives to deviate, they may want to look at bidders' *marginal incentives to deviate* from their true values.

Marginal deviation incentives

This observation has been made by Erdil and Klemperer (2009b). They point out that by lowering its bid for its winning package slightly, a bidder may be able to increase the Vickrey price paid by rivals. This is because the difference between that bidder's winning bid and its bid for larger packages may enter the opportunity cost of rivals, and this difference is increased by lowering its winning bid. In turn, increasing rivals' Vickrey prices may lead to rivals bearing a larger part of any joint opportunity cost correction shared with winner under the Vickrey-nearest MRC pricing rule when there are multiple MRC prices. The example below shows how this situation can arise naturally in a three bidder and two lot category case.

Reference pricing

Given this, Erdil and Klemperer propose an alternative core pricing mechanism, which they call *reference pricing*. It selects a vector of core prices which is closest to a vector of "reference prices", which are dependent on the bids in the auction, but in such a way that, *on the margin*, a bidder's payment does not depend on its own bid. An example of such rule is presented below.

Example 11: A reference pricing rule

Consider a combinatorial sealed-bid auction with two items (A and B) and three bidders (X, Y and Z). These are their valuations:

Item	X's value	Y's value	Z's value
A	€20	€0	€0
B	€0	€20	€0
A and B	€0	€0	€30

If all bidders bid straightforwardly, they achieve the optimal allocation where X gets A and Y gets B. The opportunity cost for each of these bidders is equal to €10, which implies that Vickrey prices would sum up to a total of €20 for X and Y. However, Z was prepared to buy A and B together for €30. Vickrey prices are not in the core.

The Vickrey-nearest rule (in a variant which treats item A and B with equal weight) tells us to split the *core adjustment* of €10 equally between bidders, which end up paying €15 each.

However, this introduces gaming incentives. Let us imagine that X knows what packages other bidders are interested in, expects the difference between Y's and Z's bid to be less than €15 and places the following bids:

Item	X's bid	Y's bid	Z's bid
A	€15	€0	€0
B	€0	€20	€0
A and B	€0	€0	€30

The opportunity cost here is €10 for X but €15 for Y and the Vickrey-nearest rule would redistribute the core adjustment of €5 equally making X pay €12.5 and Y – €17.5. X has lowered its price by changing its bids unilaterally. In general, if X manipulates its bid between €10 and €30, it will pay a price between €10 and €20 respectively.

In this case, an example of a reference pricing rule would be: *"If Vickrey prices are in the core, bidders pay Vickrey prices. Otherwise, the bidder who wins A and the bidder who wins B will each pay half of the losing bid for A and B together, but no more than their winning bid amount"*. In this example, it would mean that until X and Y bid together more than Z and each of X and Y bids at least €15, they will pay €15 each. In the bidding example above, X and Y will still share the opportunity cost equally.

The Vickrey-nearest rule rewards X with €0.5 for every €1 of decrease in the bid amount between €20 and €10. The reference pricing rule rewards X with €1 for every €1 of decrease in the bid amount between €15 and €10. If X knows exact amounts of the bids that Y and Z will be submitting, it can manipulate the price to the same extent under either rule – the lowest it can pay for A is €10.

However, if X knows that the difference between Y's and Z's bid will be smaller than €20 but is very uncertain whether that difference is smaller than €15 and is risk-averse, the reference pricing rule will be better at disincentivising X from gaming.

On the margin (relative to truthful bidding), reference pricing makes X's price independent of changes to its bid, even if, in the extreme, both pricing rules allow X to derive the same gains from gaming.

The example above shows one scenario where the reference pricing rule is clearly desirable. In general, Erdil and Klemperer show that the Vickrey-nearest rule is dominated (regarding the sum of bidders' *marginal* incentives to deviate) by an appropriate reference pricing rule.

Benefits of reference pricing in practice

Whilst the reference pricing approach is theoretically attractive, in the typical situations within spectrum auctions where a CCA would be used (which tend to be multiple band auctions), its benefits are likely to be limited. The first problem is that the auctioneer has to pick an appropriate reference pricing rule, keeping in mind that product categories may have very divergent values (whose ratio may not be entirely predictable by the auctioneer at the point of laying out the rules). Second, the auctioneer has to consider examples where a core adjustment arises by more complicated scenarios than two bidders bidding for the package of one other bidder. Third, reference pricing will not be very relevant in auctions where bidders cannot reasonably predict which packages' prices will be subject to core adjustment, which is the usual situation in auctions with several bidders and tens of items.

5.3 Providing information on price exposure

A common complaint about CCAs is that bidders do not know what they are likely to pay when they bid, as a result of the MRC pricing methodology determining winning prices after the supplementary bids round in the light of all bids received in the course of the auction. Whilst there is competition during the clock rounds, it is possible that competition affecting final prices could also occur during the supplementary round, for example because of unsold lots at the end of clock stage. Therefore, prices may be uncertain during the clocks to the extent that competition is not fully played out and deferred into the supplementary round.

However, in many cases the competition yet to occur within the supplementary round is quite limited. In this case, there may be implied caps on the most that a bidder would need to pay if the clock rounds ceased – and there were no unsold lots – the bidder eventually won its final clock package. This implication of the activity rules can be used to provide additional information to bidders over the prices they might pay eventually (under certain assumptions).

5.3.1 Upper bounds on winning prices

Discounts with anonymous bidding

In a CCA, there are caps on supplementary bids set by the history of the clock rounds. These limit the additional amount that can bid for packages larger than a bidder's final clock bid depending on how it has bid in the clock rounds. In turn, this limits the opportunity cost

that a bidder can impose on rivals. The implication is that if the clock round were to end, there is a maximum opportunity cost that a winner can possibly face. In some cases, it is possible that the clock history will imply that the maximum winning price a bidder would have to pay could be less than its clock bid. We call such an upper bound on price the bidder's '*exposure*'.

We explain in detail how such discounts can be calculated in Annex B. As clock prices increase, bidders reduce demand. This has the effect of setting constraints on supplementary bids for larger packages; the details depend on how the supplementary bids rules are setup. As the clock rounds progress, these constraints cumulate, which tends to limit supplementary bids. However, there are typically also constraints on supplementary bids that depend on the clock price (specifically, the final price cap, which limits supplementary bid for packages other than the final clock package relative to the bid for the final clock package). These constraints will become looser as the clock prices increase.

Therefore, there are conflicting factors that affect a bidder's exposure. Constraints cumulate as the clock rounds progress, but clock prices increase. As a result, the difference between clock prices and a bidder's exposure can increase or decrease in the course of clock rounds.

5.3.2 Importance of unsold lots

It is important to keep in mind that if there are unsold lots at the end of clock rounds in a CCA, these lots might be of significant value to a bidder, who then might make a strong bid including these lots and its final package bid. This will have implications for what its rivals need to pay.

This issue is closely associated with that of so-called knock-out bids. If a bidder wishes to guarantee winning its final clock package, then it needs to increase its final clock bid in the supplementary bids round by the value of unsold lots at the final clock price (and not increase its bids for other lots too much or it may win one of those instead). However, it is always possible that the bidder might face a rival who makes a bid for those unsold lots, which may contribute to the opportunity cost that the bidder needs to pay to win its final clock package.

Therefore, an exposure price for a package represents what the bidder would have to pay *at most* in the current clock round if:

- the current clock round were the last clock round;
- there were no unsold lots at the end of the clock round; and
- the bidder eventually won the package it has bid for.

5.3.3 Risks of gaming

Finally, one has to consider the impact of providing discount information on the conduct of the auction. Since different rivals' bid histories provide different discounts for a bidder, telling a bidder its discount might, at least in theory, make it possible for them to infer additional information about rivals' bid histories. Therefore, there is a potential concern that this could undermine measures such as limited transparency during clock rounds (e.g. reporting only aggregate demand information, rather details of individual bids made).

We consider that this risk is low. In complex spectrum auctions, the only sure-fire way of inferring information about rivals' bid histories from the discount information would be to simulate all possible histories and look at those that provide the observed discount. First, it is not practically possible to simulate all these bid histories in auctions where there are at least several bidders, several lot categories and the bid history consists of at least several rounds. Second, many histories may result in the observable discount may not have much in common, making the inferred information devoid of value. Due to the uncertainties involved, we will use experimental evidence to provide an assessment of this information policy in section 6.

5.4 Bidders paying their exposure

Paying the exposure price

It is possible to institute a second price-like mechanism based on the exposure prices. This has been proposed before in the consultation for the Canadian 600 MHz auction (ISED 2017) under the name of an ECCA (enhanced combinatorial clock auction). In short, it suggested that bidders pay their knock-out bid minus the sum of value gained by other bidders in the supplementary stage relative to their FCPs, subject to the final allocation price being not smaller than reserve price and not greater than the bidder's bid.

This approach goes further, as rather than just giving bidders better information about what they might eventually need to pay, it takes the idea of a bidder's maximum exposure to rival bids and computes the winning price on this basis.

5.4.1 ECCA rules

Here, we will explicitly detail the differences between the ECCA, as defined by ISED, and the CCA, discuss the impact of ECCA's rules on efficiency and fairness and provide an assessment of whether there can be an alternative implementation of exposure pricing rules.

Information policy

In the clock stage of the ECCA, the only change is to do with the information policy. After each clock round, the auctioneer calculates a discount for each bidder according to the methodology detailed in Annex A. The auctioneer then reveals this discount (each bidder only gets to know their own discount) before the next clock round. As discussed in Annex A, the way the discount is defined, it can be communicated as a single number.

After the clock stage, the final demand is revealed to all bidders. In the standard CCA, the withholding of final demand information is necessary in order to incentivise various price-setting bids which bidders would not submit if they knew they had no chance of winning. In the ECCA, prices are set largely independently of supplementary bids, therefore the same policy is not warranted.

For the same reason, if, in the ECCA, the clock stage finishes without excess supply, there is no supplementary stage. The base price (the total price of spectrum excluding the assignment stage price) for bidder X is the higher of (i) X's final clock bid minus X's discount and (ii) the reserve price for X's FCP.

If the auction does proceed to the supplementary stage, each bidder is informed of their own knock-out bid (*KO bid*). Bidders submit supplementary bids in the same way as they do in the standard CCA.

Tentative base price

The base price is calculated in a significantly different way compared to the standard CCA. The tentative base price for bidder j is calculated as follows:

$$\widehat{P}^j = KO^j - \sum_{l \neq j} (B^l - B_T^l) - \sum_{i=1}^m P_{1,i} * (U_i - U_{T,i}),$$

where:

- i indexes lot categories;
- l indexes bidders;
- KO^j is bidder j 's knock-out bid;
- U_i is the number of unsold lots in category i after the supplementary stage;
- $U_{T,i}$ is the number of unsold lots after the clock stage;
- $P_{k,i}$ is the price of the i^{th} product in round k ;
- B^l is the bid amount of bidder l for its winning package; and
- B_T^l is the bid amount of bidder l for its final clock package.

The leverage price (the price of undersell at final clock prices minus reserve prices) in the KO bid comes from a worst-case opportunity cost simulation where X's rivals only value unsold lots when they are coupled with lots in X's FCP. By winning unsold lots and improving their value without displacing X, the rivals are showing that this is

not the case. Specifically, for every €1 that rivals have shown they can gain without displacing X, X's leverage price (and thus the KO bid) should be reduced by €1. This is implemented in the equation above, which says that the provisional base price is equal to the KO bid minus the value gained by other bidders in the supplementary stage. The first subtracted term concerns real bidders, and the second one – the reserve bidder, effectively ensuring that bidders cannot add unsold lots to their packages without paying at least the reserve price for them.

Note that the formula does not explicitly mention that a bidder should pay a price for the lots they win in the supplementary stage. However, it effectively implements Vickrey pricing. For example, if bidder X wins a packet of unsold lots with a €20 bid displacing a €10 for the same lots by X's rivals, X will forgo a €10 reduction in payment (which effectively means that X is paying €10 for the lots). If X places a €20 bid which, together with another €20 bid from one rival, displaced a €30 bid from another rival, X's price will be €10 higher.

In the standard CCA, if a bidder has price-driving incentives, it should focus on the lots it *does not* want to win and bids for them at the highest price at which it will not win them. In the ECCA, if a bidder has price-driving incentives, it bids for lots it should focus on the lots it *does* want to win and bids for them at the lowest price at which it will not win them, since every €1 by which a bidder raises its winning bid for unsold lots becomes €1 of price reduction for its rivals.

Final base price

If we denote X's bid for X's winning package as B^x and the reserve price for X's winning package as R^x , the final base price is calculated as follows:

$$BP^x = \max\{\min\{\widehat{BP}^x, B^x\}, R^x\}.$$

In other words, BP^x is obtained by taking \widehat{BP}^x and adjusting it to be at most B^x and to be at least R^x .

5.4.2 The first-price gamble

However, under certain conditions, there is a first-price element to the ECCA which is not present in the standard CCA. Suppose, for the sake of clarity, that bidder X is just bidding for its FCP in the supplementary stage. Its rivals' revealed preference constraints are such that X's knock-out bid is higher than the final clock bid.

However, X does not raise its final clock bid and the rivals do not submit bids that could knock X out. They also do not bid for unsold lots. As ECCA's rules state that a bidder cannot be made to pay more

than its bid, the auctioneer will assign X its FCP, making it pay the final clock prices, instead of the knock-out bid. Note that, in this scenario, X gets the same package regardless of whether it bids the knock-out bid or not, but is priced differently. This contradicts the principle of second price mechanisms, which is that a bidder's price for a package should not depend on its own bids and so has incentive consequences.

In other words, in a scenario where a bidder bids solely for their FCP, the *first-price gamble* (the situation in which a bidder can affect its price by changing its own bids, trading off the chance of being knocked out against the price if it does not get knocked out) arises when the provisional base price of the FCP is higher than the price of the final clock bid. This occurs when the *leverage price* (the one factor that raises the knock-out bid above the final clock bid) is higher than the sum of the discount and the value gained by rivals through winning undersell (the two factors that dampen the knock-out bid below the final clock bid).

Up until now we have skipped the impact of unsold lots on the gamble. If bidder X's rivals compete for unsold lots, X's provisional base price is reduced and therefore the gamble loses its impact on pricing. In the extreme case, X's rivals will submit bids that clean up all unsold spectrum at final clock prices (and X does not). In that case, it is impossible to knock X out, X's provisional base price will be equal to the final clock bid and X's gamble will have no effect.

On the other hand, if it is just X who competes for unsold lots, its provisional base price will not be affected but X's minimum bid amount will rise, limiting the gamble available to X. In the extreme case where X bids for all unsold lots at final clock price, X's minimum bid amount for such bid is equal or higher to their knock-out bid. Again, it is impossible to knock X out and X faces no gamble.

A bidder will, therefore, adjust their bid amount for their FCP keeping in mind that this amount will only have an impact on allocation or price if the competition for unsold lots is not high enough.

As every bidder has the same *leverage price* added towards their knock-out bid but smaller bidders will have smaller discounts, the first-price gamble will occur more often for small bidders. As a result, there might be situations in which bidder X's rivals will have the power and the desire to knock X out but they do not express such preferences and X will win a package, paying reduced prices. Such misallocation may arise if the rivals overestimate ECCA's ability to limit the impact of the supplementary stage.

Therefore, ECCA supplementary stage behaviour is such that in comparison with the CCA, there is no use in placing (price-setting) bids that cannot affect allocation, but bidders should still place those bids that have a chance of affecting allocation.

Example 12: Effects of undersell on allocation prices and the first-price gamble

Consider a CCA with exposure pricing with 10 lots in one category and 2 bidders (X and Y). The reserve price for a lot is €1 and in each round the price increases by €1. This is the bid history:

Round	Price	Demand	
		X	Y
1	€1	10	5
2	€2	10	5
3	€3	10	5
4	€4	10	5
5	€5	1	5

At the start of rounds 2-5, Y has no discount, since X is bidding for the whole supply in rounds 1-4. Round 5 is the final clock round and the value of Y's FCP at the final clock prices is €25. However, Y is informed that, as its discount is €0 and the value of undersell at final clock prices minus reserve prices is €16, its knock-out bid is €41.

If the price of the winning package is **not** constrained by the bid amount for that package, Y will have to pay €41 for its winning package even though its clock price never exceeded €25. X, knowing that, might have been submitting excessive bids just to drive up Y's price, which Y can now do nothing to limit. If the price of the winning package is constrained by the bid amount for that package, there are incentives for the bidders to gamble by reducing their bid amount for their FCP.

Since Y cannot compete for 5 of the lots at more than reserve price, if X wants to win them, it should bid for them at either reserve price or reserve price plus €1. In case X competes for unsold lots at reserve price and wins them, its base price will be €5, obtained by starting from the bid amount ($5 * €1 = €5$), subtracting the discount (€20), adding the value of undersell at final clock prices minus reserve prices ($€20 - €4 = €16$) and adding the value lost by the reserve bidder in the supplementary stage ($4 * €1 = €4$). It is the same price X would pay if the supplementary stage was conducted using standard CCA rules.

Y knows its knock-out bid is equal to €41 (intuitively, the difference between the scenario where X wins its final clock bid at €5 and the reserve bidder leaves with €4 of value and the scenario where X bids for 10 lots at €50). However, if it can predict that X will not bid for 10 lots more than the €40 it already bid in the fourth round (X cannot reduce this bid), Y can lower its price by €10, to €31. Y's tentative base price does not move when X wins unsold lots at reserve price.

An interesting fact is that if Y tries to defend itself against such potential attack by raising its FCP bid above €31 but X does not in fact submit a bid of more than €40 for at least 6, Y will still pay its full bid. If X can anticipate risk-averse play on part of Y, X can raise Y's price by submitting untruthfully aggressive bids in the clock stage and then focussing on its actual packages of interest in the supplementary stage. However, a risk is that if Y does not defend its FCP, X will win a package it did not want.

Let us assume that X did not desire 10 lots for €40 but only bid for 10 lots at the price of €4 each to drive up Y's price. Depending on specific valuations and beliefs, this behaviour can be effective in increasing the price of rivals. Just like in the standard CCA, X runs some risk of winning a package it does not desire in return for an increase in Y's prices. However, in the ECCA, the return on the risk is higher, as Y can be tricked into paying more than €31 if it thinks X is likely to

compete for 10 lots at more than €40, without X having to actually submit such bid.

The example above shows that the first-price gamble can be exploited by 'attacker' rivals who can trick a 'defender' into believing it has a chance of being knocked out and paying more for their winnings, while the 'attacker' is not committing to knock the defender out if the defender does not raise its bid. In fact, the attacker might be instead competing for unsold lots, which it wants to compete for at low prices, not to deplete the leverage price that enables the attack. Therefore, the ECCA is not immune from gaming opportunities.

In section 6, we will investigate how often and under what circumstances bidders can expect to face the first-price gamble. It can be argued that, subject to this caveat, the ECCA introduces some benefits relative to the CCA, especially that the supplementary bids that can affect allocation (the ones that remain in the ECCA) are those that are more likely to be placed with truthful amounts than the pure price-setting bids. If bidders follow the approach of submitting all bids that affect allocation) is followed, the bidders who use the first-price gamble will have as much potential to be knocked out as in the standard CCA (where the same bids are submitted) and, if they do not get knocked out, will pay for their package as much or more than in a standard CCA.

5.4.3 Assessment

It is certainly possible to augment the information provided to bidders within a CCA to give a better indication of what the bidder may pay *at most* but under certain optimistic assumptions (in particular the lack of unsold lots in the final clock round). We investigate this approach through simulations in Section 6. This information is potentially useful for bidders to understand their financial exposure, but it needs to be kept in mind that the potential for competition to incur within the supplementary round will change in the course of the clock rounds and it is possible for the clock rounds to finish with significant competition yet to occur within the auction. Therefore, this additional information needs to be carefully interpreted by bidders and does not amount to an absolute guarantee on the maximum price they might need to pay.

It is possible to go a step further and to use this approach of calculating the maximum opportunity cost that bidders might face given rival bids and implements this as the amount the bidder will pay if it wins. This is the essential idea in the ECCA, which was proposed by not used in Canada. Whilst this approach has some merit in providing more price certainty for bidders, it tends to result in bidders paying more and having stronger incentives to bid at less

than valuation as there are elements of a first-price auction within bidding decisions in an ECCA.

The ECCA addresses any problem of price disparities due to missing supplementary bids. It effectively applies on a bidder the maximum pricing pressure that other bidders could ever apply to the bidder in an ordinary CCA. Therefore, there is no need to put price-setting bids. This saves a lot of effort for bidders who do not pay different prices for the same packages just by the virtue of being able to craft a better price-setting strategy in the supplementary stage of the relatively complex CCA. Additionally, budget constraints will have less bearing on the relative pricing power of differently sized bidders in the supplementary stage. This is the reason why the ECCA does not include a supplementary round if clock stage ended with no excess supply – the supplementary round would neither change the allocation, nor pricing (whereas it can change the latter in the standard CCA).

It is reasonable to expect the ECCA to produce higher revenues than the CCA. The question of whether a higher expected auction revenue is a positive or a negative change is outside the scope of this study.³⁸

Under some circumstances, the ECCA introduces a new gaming incentive in the form of the first-price gamble. However, the gamble requires substantial amount of undersell to be available to bidders and for the bidders to take it up (risk being knocked out in return for lower price) requires a substantial appetite for risk on their part.

Overall, we consider the main benefits of the ECCA come from the reduction of the uncertainty faced by the bidders during the auction over the price they might eventually pay. However, an equivalent benefit can be brought about in a CCA simply by the introduction of a new information policy which informs bidders of their discounts and knock-out bids, without implementing the exposure pricing mechanism.

³⁸ However, we note that ComReg does not seek to maximise revenue rather, its objective in assigning rights of use of spectrum is *"to derive the maximum benefit for society and contribute to the development of the internal market, while promoting the interests of users within the Community."* ComReg Document 18/118 Radio Spectrum Management Strategy Statement 2019 to 2021 at paragraph 3.33.

6 Simulations of exposure pricing

In this section we present, as a proof-of-concept, evaluations of exposure pricing using both some bid data from real-world auctions and using simulated bid data.

6.1 Real bid data analysis

6.1.1 Canada 600 MHz exposure calculation

The Canadian 600 MHz auction, completed in March and April 2019, is the most relevant case we can examine. Unlike the UK 4G auction, it did not include complications in the price incrementation algorithm and the winner determination algorithm caused by a bundle being reserved for specific bidders. Instead, the only pro-competitive measure was a set-aside which was treated as a separate product, allowing for more reliable exposure calculations. The auction included relaxed bidding constrained by GARP-based activity rules. These activity rules, based on the generalised axiom of revealed preference (GARP) which imposes preference consistency amongst groups of bids, is somewhat different to the activity rules that ComReg has used within its CCAs. (Certain aspects are significantly more restricting than ComReg's rules, but other aspects are looser, so there is no simple comparison.)

GARP discounts

For each clock round (except for round 1), for each bidder, we have calculated the discount associated with that bidder in that round. Then, we have calculated the knock-out bid that each bidder faced in the supplementary round. Both of these measures were calculated using the detailed bid history available only to the auctioneer (and released to the public after the auction).

Only one bidder, Freedom Mobile Inc. (hereafter Freedom), had a discount before any clock round. It might not be surprising that the biggest set-aside bidder was the most likely one to get a discount, since the competition for set-aside lots was relatively faint due to the size of the set-aside on one hand and the restrictions on who could compete for it on the other hand.

In none of the rounds did any of the three national bidders (Rogers Communications Canada Inc. – hereafter Rogers, TELUS Communications Inc. – hereafter TELUS, and Bell Mobility Inc. – hereafter Bell) face a discount. We explain the intuition behind these results in Annex B.

WARP discounts

We have also calculated the discounts that bidders would have faced before each round in the 600 MHz auction if supplementary bids were constrained using WARP-based rules similar to those used in ComReg's CCA's for the supplementary bids round. Note that, if WARP-based rules were in place for the auction, bidders would have probably made different decisions in the clock stage, therefore this exercise is more speculative.

Specifically, a bidder's maximum implied valuation for a clock package which is not the bidder's smallest package is determined by only one other clock package (though constraints can form a chain). Similarly, the bid amount for a package which is not among the bidder's clock packages is directly constrained only by one clock package.

Since those WARP constraints are a subset of the GARP constraints, bidders' maximum implied valuations can only be higher under WARP. Therefore, discounts can only be lower.

As a result, we have calculated that Freedom enjoys smaller discounts under WARP than under GARP. For example, starting from round 30, Freedom enjoys no discount.

6.1.2 Simulated clock stage and discounts

This simulation involved taking bidders' supplementary bid list as their complete valuations (that is, for each bid submitted in the supplementary stage, the bid amount would signify the value of the particular package for the bidder. Additionally, all packages not included in the list would be assumed to be worth nothing to the bidder) and simulating a clock stage where, in each round, each bidder would pick the package that generates the highest surplus. This clock stage behaviour is by construction compliant with both the GARP-based and WARP-based activity rules.

The simulation yielded a 51-round clock stage. We then calculated the discounts before each round for each bidder in this simulation. The discounts were more prevalent than the ones based on the real bid history, regardless of the activity rules variant chosen. Specifically, if we say that a bidder faced a 'persistent' discount if it was non-zero in the final clock round:

- In the WARP variant, Freedom and Videotron faced persistent discounts, while Rogers faced a non-persistent one. This is to be contrasted with the WARP discounts for the real bid history, where only Freedom faced a discount and it was non-persistent; and
- In the GARP variant, Freedom, Rogers and Videotron faced persistent discounts. This is to be contrasted with the GARP

discounts for the real bid history, where only Freedom faced a persistent discount and no other bidder faced any discount.

However, regardless of the activity rules (WARP-based or GARP-based) or the bid history (real or simulated) used, the discount were not monotonic – at least one bidder’s discount declined from one round to the next one.

This is because a bidder’s revealed-preference constraints do not necessarily tighten as the clock stage progresses. The rationale behind this is explained in Annex A .

6.2 Simulated bid data analysis

Given the limited availability of actual action data that can be used to investigate exposure pricing, in this section we report the results of a simulation exercise. We have created a reasonable probability model for bidder valuations, reflecting typical structure of a multiple band spectrum auction in which a CCA might be used. We then used a Monte Carlo approach, drawing sets of valuations and creating clock round histories on the assumption of straightforward bidding. We then compute exposure prices for each round history. We can then summarise some of the broad features of exposure prices by computing various summary statistics for all the various auction histories we have created.

6.2.1 Auction setup and valuation scenarios

We generate random auction setups using a parameterised model. The key assumptions for generating a random setup are as follows:

- The number of bidders will be equal to 3, 5 or 8 with equal probability;
- The number of categories will be equal to 1, 4 or 12 with equal probability;
- Each category always contains 10 lots;
- The reserve price for each category r will be equal to $100 * e^{M_r}$ rounded upwards to the nearest unit, where M_r is a draw from a normal distribution with a mean of 0 and a standard deviation of σ_1 , where σ_1 has a value of 0, 0.5 or 1 equiprobably. The eligibility points associated with the category will be equal to $10 * e^{M_r}$ rounded upwards to the nearest unit. The M_r multiplier represents the fact that lots in some categories are more important than in others;
- Each bidder’s valuations will consist of a table of marginal valuations (one value for each lot in each category) and a list of synergies. Each synergy specifies a package that needs to be attained to fulfil the synergy and the value that the bidder will

- gain on top of the sum of its marginal valuations if the bidder does fulfil it;
- the maximal marginal valuation a bidder will hold for a specific category will be equal to $200 * e^{M_r} * e^{M_{b,r}}$, where $M_{b,r}$ is a draw from a normal distribution with a mean of 0 and a standard deviation of σ_2 , where σ_2 has a value of 0.1, 0.25 or 0.5 equiprobably. The $M_{b,r}$ multiplier represents the fact that some bidders are interested in particular categories more than other bidders are. We only consider positive values of σ_2 because if σ_2 was equal to 0 (and therefore $M_{b,r}$ was constant across bidders), there could be multiple bidders with exactly the same valuations, which would introduce unnatural behaviour into the auction (such as every bidder dropping demand to zero in the same round);
 - bidder's marginal valuations for lots will sometimes exhibit 'lumpy' demand, where a specific lot is has a lower marginal value attached to it than the next lot in the same category. The likelihood of a specific bidder exhibiting this tendency will be equal to either 0%, 50% or 100%. In the event of the likelihood being 50%, each bidder's 'type' will be determined independently from other bidders.
 - if a bidder does exhibit lumpy demand, the bidder will hold the maximal marginal valuation (described above) for the k -th lot, where k is another random parameter with value equal to 2, 3 or 4 and drawn only once for each auction (i.e. the same value applicable to all bidders with lumpy demand). Overall, the marginal values for a given bidder in a given category where the bidder has lumpy demand will increase linearly until the peak valuation and then decrease linearly from the peak valuation in such a way that the 'zereth' and eleventh lot would be worth exactly €0, if they existed. In other words, if $k = 4$, the first lot will be worth a quarter of the value of the fourth lot, the second lot will be worth half the value of the fourth lot and the fifth lot will be worth 6/7 of the value of the fourth lot. We have included the parameter k parameter because of the risk that if bidders exhibit the same pattern of lumpy demand and if each auction has 10 lots per category, there is a risk of a large number of simulated auctions generating exactly the same number of unsold lots, which would be an unnatural pattern triggered by our somewhat arbitrary choice of auction parameters.
 - If the bidder does not exhibit lumpy demand in a given category, it will hold the maximal marginal valuation described above for the first lot and the marginal valuation for subsequent lots will decrease linearly in such a way that, if the relation was extrapolated to a hypothetical eleventh lot, the eleventh lot would be worth €0. The potential existence of both lumpy and non-lumpy demand in one auction will represent the fact that incumbents might not exhibit lumpy demand for spectrum in an

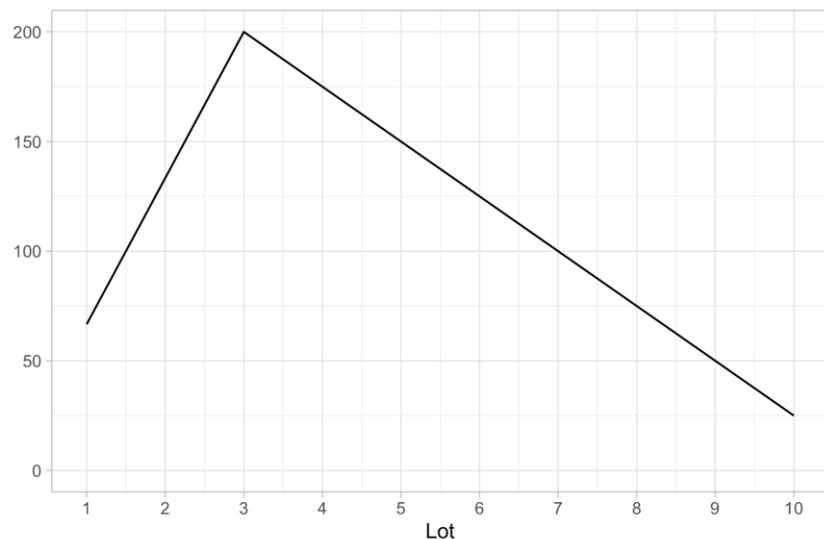
auction because they already possess similar spectrum acquired in previous awards;

- The degree of complementarity between lot categories will be represented by adding synergies into bidders' valuations. In auctions with 4 lot categories, for each bidder, we will identify 3 categories that the bidder is most interested in (those with the highest $M_r + M_{b,r}$). We will program one synergy which will reward the bidder for acquiring at least k lots (k defined above) in all of these 3 categories with a value equal to the sum of marginal valuations of the k first lots in these 3 categories times a multiplier, equal to 0, 0.5 or 1 equiprobably, representing the degree of complementarity in the valuations. In auctions with 12 categories, for each bidder, we will insert 4 mutually exclusive synergies:
 1. one for k lots in the 4 most important regions;
 2. one for k lots in the 8 most important regions;
 3. one for $k+2$ lots in the 4 most important regions and k lots in the 8 most important regions; and
 4. one for $k+2$ lots in the 8 most important regions,

where the value of all 4 synergies will be determined using the same method as in auctions with 4 categories (with the relevant multiplier being equal for all 4 synergies). The parameter k represents the granularity of the blocks sold in the auction (i.e. whether the spectrum has been divided into relatively large or small blocks) and therefore regulates both the lumpiness of bidders' demand and the structure of their synergies.

Figure 9 illustrates how a bidder with lumpy demand, where $k = 3$, values lots in a category relative to each other.

Figure 9. Illustration of the marginal valuations with lumpy demand



It would not be practicable to generate scenarios which include all possible combinations of the described parameters, as this would

generate too many scenarios. Instead, for each auction, we will draw values of parameters randomly and independently of each other. For each parameter, we will give each value of the parameter an equal probability of being drawn.

6.2.2 Bidding behaviour

We simulate bidders who exclusively maximise surplus in each round. This is because the degree and form of strategic thinking exhibited by real bidders is not well documented and therefore difficult to simulate.

Some simple strategies, such as holding excessively high demand in order to resolve once common value uncertainty has been diminished, can be simulated by elevating bidders' valuations.

6.2.3 Results

Below we present an analysis of results from 5000 auctions using the framework described above. Whenever we report that a certain percentage of auctions exhibited a particular characteristic, the standard error of the measurement is up to 0.71 percentage points and therefore the 95% confidence interval for the share includes values up to 1.39 percentage points different from the point estimate.

Furthermore, all results are potentially highly sensitive to changes in the value of the parameters and changes to overall model for generating auction setups. Our aim was to produce a realistic sample of auction setups but, as real-life auctions are varied and there has only been a limited number of auctions on which we could base our model, findings from this exercise cannot be easily translated into either ready-made forecasts about how bids and prices will develop in a given ascending-price auction or hard-and-fast recommendations on how auction rules should be structured.

Prevalence of discounts

Figure 10 shows the mean proportion of bidders who ended up in four different 'discount situations' in the simulated auctions. A 'monotone discount' is a situation in which a bidder enjoys a discount in at least one round and the discount does not fall between any two consecutive rounds. A 'non-monotone but final' discount is a situation in which a bidder's discount has fallen between some two consecutive rounds but the bidder ends up enjoying a positive discount in (what will turn out to be) the final clock round. A 'disappearing discount' is a situation in which a bidder enjoys a

discount in at least one round, but not in the final clock round. Finally, some bidders do not get a discount in any round. The four types of discount situations distinguished in this way can be graded from least desirable to most desirable in the order shown from top to bottom on the chart.

As the figure shows, discounts were more prevalent in auctions with a fewer number of bidders. This is not surprising given that, as a necessary condition, a bidder must be 'responsible' for excess demand, and therefore a price increase, in a category, in order for it to earn a discount. At the same time, other bidders must be unable to shift enough demand to that category in a way which would still make them able to bid for all categories at the current price.

This situation will be much easier to accomplish when a single bidder accounts for a higher share of the overall demand. This can be achieved by either having bidders of differing strengths (in which case the larger bidders are likely to get a discount) or having fewer bidders (in which case, typically, every bidder is more likely to get a discount).

Although three-bidder auctions had a much higher occurrence of monotone discounts than five-bidder and eight-bidder auctions under both variants of activity rules, discounts in three-bidder auctions were more likely to disappear and to generally fall between some two consecutive rounds.

We propose a simple explanation for this. Let us consider a bidder who currently enjoys a discount. That must mean that in the previous round its rivals, on their own, expressed demand below supply in some categories (if rivals express demand at least equal to supply in each category, they can bid for the whole supply at current clock prices and there would not be a discount). Let us further assume that:

- the rivals have expressed, on their own, excess demand in some categories C ;
- from the previous round, prices have increased only (or largely enough) in categories C ; and
- neither the bidder nor its rivals do not change their demand in the current round.

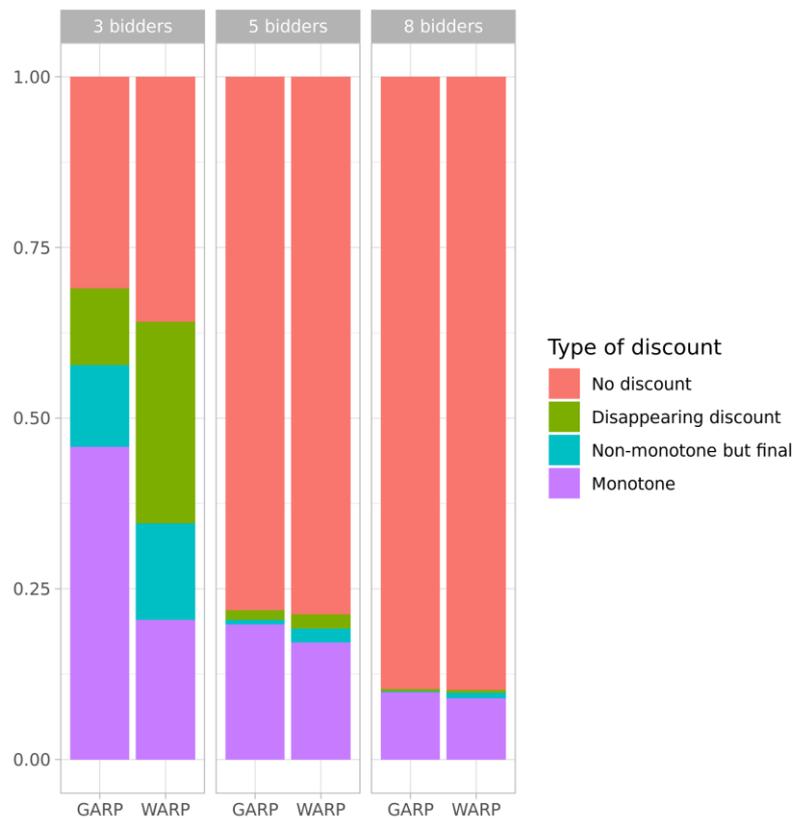
In this situation, the bidder's discount will fall. This is because, as categories C grow in price, the revealed preference rules will allow the rivals to exchange their excess demand in C for lots in other categories, which we will call C' (and where rivals collectively bid below supply), with a more and more favourable ratio. That is, if all bidders extend their behaviour indefinitely, at some point they will 'prove' that lots in C are so valuable that rivals' excess demand in C can be switched for all the lots in C' for which the rivals are not bidding. Therefore, rivals will be able to bid for the whole supply at current clock prices, vanquishing the discount.

It is important to note why a bidder may not be able to switch from one package to another in a particular round, but be able to do just that at a later point. On one hand, revealed-preference rules make bidders progressively accumulate constraints, restricting bidders' choice. However, *prices* of packages also change and bidding on a particular package only makes it more likely that its price will rise faster than that of other packages. A continued rise in the price of a package can make the revealed-preference rules progressively more 'sympathetic' towards a bidder switching from one package to another.

The difference between three-bidder scenarios and eight-bidder scenarios is that the more bidders there are, it is more difficult to see situations where *no bidder at all* is dropping demand. Still, very often a bidder's rivals' will display excess demand, which grows in value every round, but it is more likely that in each of these rounds round one of these rivals drops demand. Overall, the demand patterns are smoother, inducing more consistent discount developments.

Finally, GARP-based activity rules are more restrictive than WARP-based activity rules and result in bigger discounts.

Figure 10. Proportion of bidders enjoying different types of discounts, segregated by the number of bidders participating in the auction and the type of activity rules used to calculate the discount.



When discounts appear

As an auction progresses and bidders drop demand below the eligibility required to bid for the whole supply, discounts start appearing. In the last round, 30% of bidders enjoy GARP discounts and 21% of bidders enjoy WARP discounts. Averaged over 5000 auctions, the last several rounds show a consistent increase in discounts. However, that might not be the case in an individual auction and the presence of discounts would ultimately depend on the evolution of bidding during an auction.

Overall, differences between GARP and WARP become apparent a considerable time before the end of the clock round.

As one considers points further away from the end of the clock rounds, there are fewer auctions in the sample (as some auctions are short) and therefore the pattern is more unstable.

Figure 11. Mean proportion of bidders enjoying discounts depending on the distance to (what will turn out to be) the final clock round, split by the version of activity rules

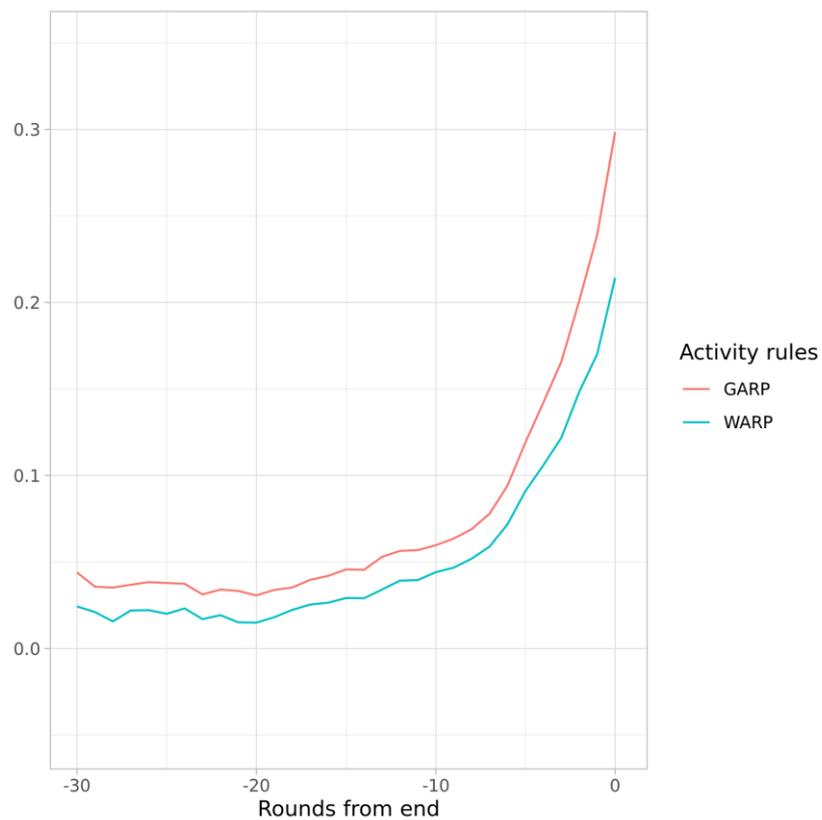
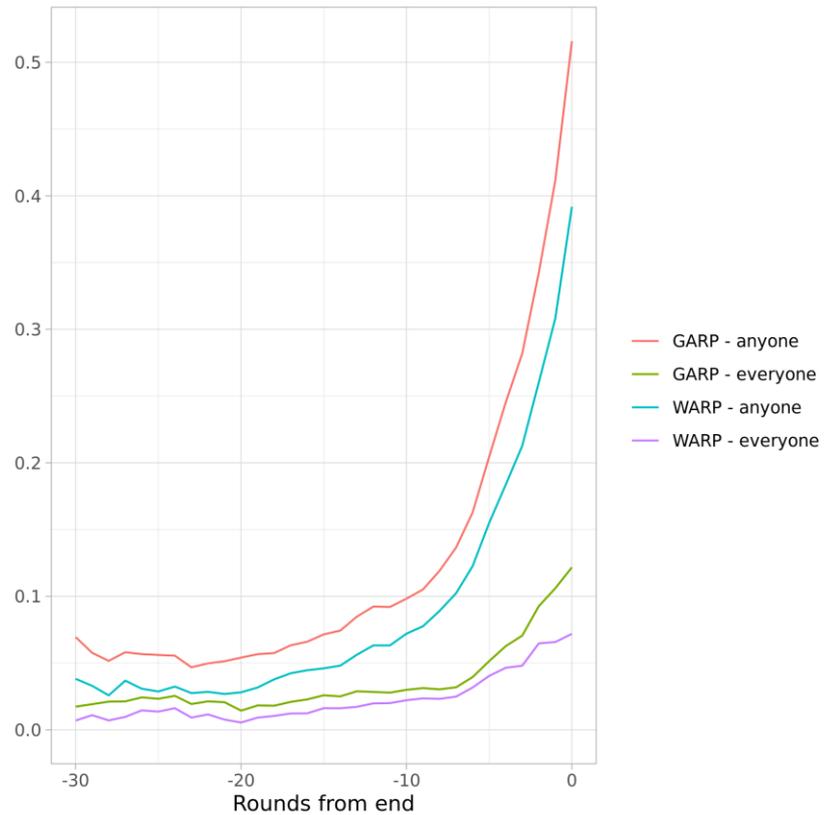


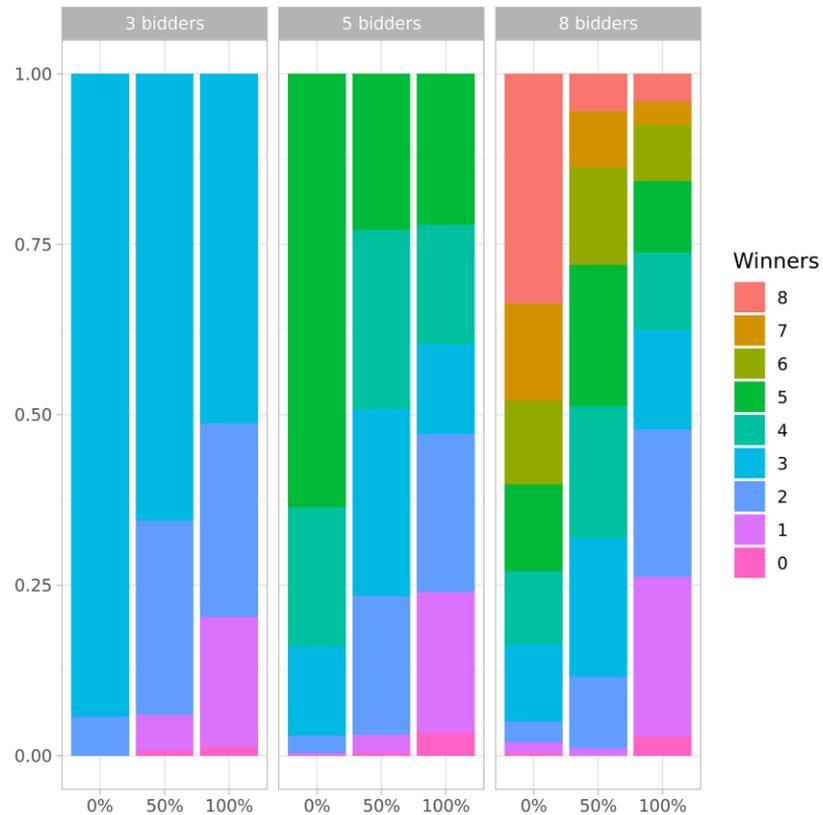
Figure 12. Proportion of auctions where anyone / everyone gets a discount depending on the distance to the end of the clock rounds



Number of winners

Figure 13 shows how an increase in the fraction of bidders with lumpy demand results in a decrease in the average number of bidders who win anything at all. This is not surprising, as lumpiness will more often induce 'all-or-nothing' situations, where bidders drop demand from 2-4 to 0 in one go, making room for a smaller number of bidders, compared with situations where bidders may accept one lot in a category given final clock prices.

Figure 13. Share of auctions with a particular number of winners, split by number of bidders and fraction of bidders with lumpy demand

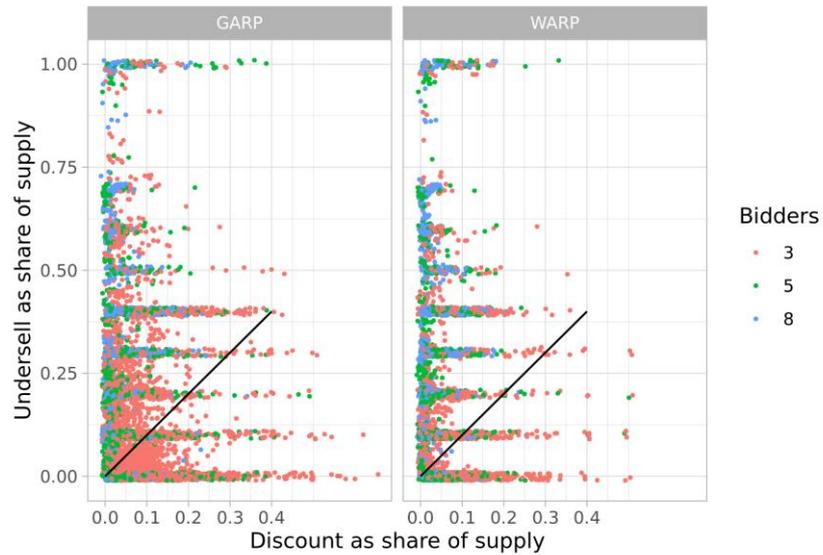


Undersell vs discounts

Figure 14 shows how bidders' discounts in the final clock round compare to undersell at the end of the clock stage. One point represents one bidder who got a discount in the final clock round. Discount is measured relative to the value of the whole supply. Both undersell and the value of the whole supply are measured at prices which are the difference of final clock prices and reserve prices. The points in the plot are slightly perturbed to improve legibility. The black line delineated cases where the value of the discount is smaller / larger than that of the undersell.

Of 5727 bidders who got a final round discount under GARP, for 2270 it was bigger than the value of undersell. Of 4456 bidders who got a final round discount under WARP, for 1549 it was bigger than the value of the undersell.

Figure 14. The size of the discount enjoyed by a bidder in the last clock round versus the size of the undersell after the clock rounds



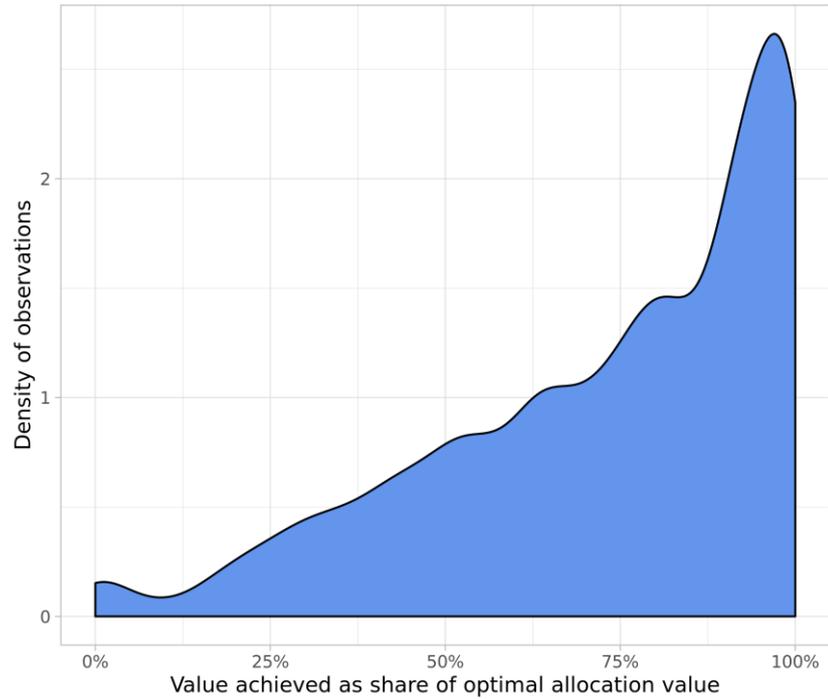
Outcome efficiency

If there are no non-convexities in bidders' demand, their valuations are drawn from a continuous distribution and the price increment is small enough, the ascending-price mechanism will find the efficient outcome and leave no undersell.

We investigate the efficiency of the ascending-price mechanism, for each auction, by looking at the value achieved by bidders in the optimal allocation versus the value achieved by them in the ascending-price allocation (note that we used a 5% increment in our simulations, which may exacerbate undersell on its own, relative to smaller increments).

Out of the 5000 auctions simulated, 4961 lasted more than 1 round. Of those, only 489 achieved the optimal allocation. The average value achieved, as a share of the optimal value, was 73.5%.

Figure 15. Distribution of the value of the ascending-price allocation relative to the optimal value of the allocation of the lots in play



For each of our scenarios, we have also investigated whether there exists a set of prices under which bidders would agree to the optimal allocation – i.e. each bidder, if it was surplus-maximising and facing these prices, would choose the package that is associated with that bidder in the optimal allocation.

7 Conclusions

This report considers how the pricing mechanism operates within CCAs and its advantages and limitations. We have seen how minimum revenue core pricing has a strong theoretical basis for use in CCAs, as it minimises incentives for bidders to deviate from bidding at value, whilst at the same time ensuring that the pricing outcome has certain desirable features. These include that winners are paying enough that losers do not wish to make a higher counteroffer, and that bidders do not have incentives to introduce shill bidders.

There have been criticisms of this approach, primarily around three main points:

- that bidders may be able to drive rival prices by increasing bids for packages larger than they intend to win;
- that there may be pricing disparities if some bidders do not compete during the supplementary bids round;
- that bidders face uncertainty about what they might need to pay if a bid wins.

With regard to price driving strategies within CCAs, this depends on a balance of cost and benefits. It is not sufficient simply to identify ways in which bidders can raise rivals' prices. In many cases, it is reasonable to expect bidders to face significant risks from such behaviour – through winning unwanted large packages – for little gain.

Pricing disparities due to missing bids are the converse problem – that rivals might not complete in the supplementary bids round and a bidder enjoy a discount as a result. This is of itself not that concerning unless there is an efficiency loss due to bidders omitting efficiency-relevant packages. Most of the concern around this problem appears to be rooted in early CCAs where bidders may not have understood the full ramifications of the MRC pricing.

Uncertainty about pricing can be addressed to some degree through providing bidders with additional information about what they might need to pay at most if their bid in a clock round of a CCA were successful. We call this the *exposure price* of that package. This is computed on the assumption that there are no unsold lots in the final clock round. This is an important assumption, as if there are unsold lots there is potential for significant competition in the supplementary bids round and it is possible that a bidder might need to bid – and pay – more to secure its final clock package.

We demonstrate that it is feasible to calculate these exposure prices and report them to bidders during the clock rounds. They take the form of each bidder being told a single discount that applied to any package it chooses (subject to reserve prices forming a floor).

Discounts can vary across bidders. They can also increase or decrease from one clock round to the next due to the interplay of accumulating constraints on supplementary bids and increasing clock prices (which loosen the final price cap).

It seems unlikely that releasing exposure prices would create any gaming opportunities. In essence, they are a distillation about the path of aggregate demand that each bidder faces from rivals.

Annex A Calculating exposure

The revealed-preference rules in the CCA limit what packages bidders can bid on in the clock stage and what bid amounts they can specify in the supplementary stage. This limits the opportunity cost bidders can impose on their rivals.

As a result, during the clock stage it may become apparent (to the auctioneer or any agent with enough information) that, if the clock stage ends with no excess supply, some bidders will pay less than the final clock price for their winnings.

In other words, a bidder's exposure may be limited by its rivals' revealed-preference constraints. Whether the bidder can anticipate this advantage depends on the demand information it is given. Below we describe when such an effect arises and how precisely it can be calculated given specific levels of information. Our primary source for the exposure calculation method detailed here has been the Canadian 600 MHz consultation (ISED, 2017) although exposure prices were ultimately not provided in that award.

Calculation with full bid information

The auctioneer (and bidders, if they are given full demand information) can, in certain cases, calculate the maximum amount bidders may pay for specific packages. After the clock stage and before the supplementary stage, the auctioneer can calculate the maximum price for any bidder for any possible package. In the clock stage, it is possible to calculate a *discount* for each bidder – the difference between the maximum amount that the bidder will have to pay for its package if the clock stage finishes in the next round with no excess supply.

Clock stage discount

Before each round, it is possible for the auctioneer to calculate, for each bidder separately, a *discount*: the minimum difference between what the bidder will pay for its winnings and the current price of these winnings under the assumption that (i) the clock stage will end in this round (ii) without excess supply.

The discount for bidder X is the difference between:

- All supply evaluated at current clock prices; and
- The maximum total value that X's rivals can place on the whole supply given their revealed-preference constraints.

It is computed in a stepwise procedure. First, each rival's constraints are calculated separately.

Under the GARP-based activity rules, this is done using the following procedure (where package size means its eligibility requirement):

- consider all clock packages (the packages that the rival has bid on so far). For each pair of different-sized packages, the smaller package generates a revealed preference for the larger package;
- packages whose size is equal to current eligibility are valued at current prices. All other packages are valued at the maximum amount which fulfils the constraints above, where all packages have to fulfil all the constraints at once;
- each clock package c then generates analogous constraints for any non-clock package larger than c .

Specifically, before round t , a bidder's maximum implied valuations can be calculated in the way detailed below.

For each package for which bidder j has bid and whose eligibility size is equal to the eligibility of bidder j for round t , the maximum implied valuation is:

$$V_k^j = \sum_{i=1}^m P_{t,i} * Q_{k,i}^j.$$

For other packages for which bidder j has bid so far, the maximum implied valuation is calculated by evaluating the following equation for each package, in a non-decreasing order of package sizes:

$$\tilde{V}_k^j = \min_{n \in \{1, \dots, t-1\}; e(Q_n^j) < e(Q_k^j)} \{V_n^j + \sum_{i=1}^m P_{n,i} * (Q_{k,i}^j - Q_{n,i}^j)\},$$

$$V_k^j = \min\{\sum_{i=1}^m P_{t,i} * Q_{k,i}^j, \tilde{V}_k^j\}.$$

Under the WARP-based activity rules, this is done using the following procedure (where package size means its eligibility requirement):

- clock packages whose size is equal to current eligibility and any additional packages which are no bigger than current eligibility are valued at current prices;
- each other clock package and each additional package bigger than current eligibility is constrained by the bid from the last round in which the bidder was eligible to bid for that package (i.e. the first round in which the bidder bid for a smaller package);

Specifically, before round t , a bidder's maximum implied valuations can be calculated in the way detailed below.

For each package for which bidder j has bid and whose eligibility size is equal to the eligibility of bidder j for round t , the maximum implied valuation is:

$$V_k^j = \sum_{i=1}^m P_{t,i} * Q_{k,i}^j.$$

For other packages for which bidder j has bid so far, the maximum implied valuation is calculated by evaluating the following formula for each package, in a non-decreasing order of package sizes:

$$n_{constr} = \min(n): e(Q_n^j) < e(Q_k^j),$$

$$V_k^j = V_{n_{constr}}^j + \sum_{i=1}^m P_{n_{constr},i} * (Q_{k,i}^j - Q_{n_{constr},i}^j).$$

The above equations are evaluated for each bidder. Then, for each bidder, its rivals' maximum collective valuation for the whole supply is calculated by solving a linear problem: for each rival, choose a bid amount and a vector of quantities that maximises the value of the problem subject to, among others:

- The revealed preference constraints mentioned earlier, binding each bidder's bid amount dependent on its bid quantities; and
- The supply constraints, binding bidders collectively.

Specifically, the maximum aggregate value from allocating all available blocks to the opponents of bidder j is calculated as follows:

$$W_t^j = \max_{Q^s, B^s} \left\{ \sum_{s \neq j} B^s + \sum_{i=1}^m P_{1,i} * \left(S_i - \sum_{s \neq j} Q_i^s \right) \right\}$$

subject to:

- $\forall_{i \in \{1, \dots, m\}}, \sum_{s \neq j} Q_i^s \leq S_i$ (supply constraint);
- $\forall_{s \neq j}, \sum_{i=1}^m e_i * Q_i^s \leq E_1^s$ (eligibility constraint);
- $\forall_{k \in \{1, \dots, t-1\}: e(Q_k^s) < e(Q^s), s \neq j} B^s \leq V_k^s + \sum_{i=1}^m P_{k,i} * (Q_i^s - Q_{k,i}^s)$ or $\forall_{k = \min(n): e(Q_n^s) < e(Q^s), s \neq j} B^s \leq V_k^s + \sum_{i=1}^m P_{k,i} * (Q_i^s - Q_{k,i}^s)$ (revealed preference constraints under GARP-based and WARP-based activity rules respectively); and
- $\forall_{s \neq j}, B^s \leq \sum_{i=1}^m P_{t,i} * Q_i^s$ (current clock price constraint).

In the equations above:

- k indexes rounds;
- i indexes products;
- s indexes bidders;
- m is the number of products;
- S_i is the total supply of the i^{th} product
- $P_{k,i}$ is the price of the i^{th} product in round k ;
- V_k^s is the maximum implied valuation for the package that bidder s bid on in round k ;
- E_1^s is the initial eligibility for bidder s ;
- $e(x)$ is the eligibility size of package x ; and
- $Q_{k,i}^s$ is the quantity of the i^{th} product demanded by bidder s in round k .

Then, the discount is simply equal to:

$$D_t^j = \sum_{i=1}^m P_{t,i} * Q_{t,i} - W_t^j.$$

The example below shows the intuition behind how a discount arises and grows in a single-category auction.

Example 13: Discount calculation in a single-category auction

Consider a CCA with 10 lots in 1 category and 2 bidders (X and Y). The reserve price is €1 and in each round the price increases by €1. In each round the bidders specify the number of lots they would like to bid on given the current price. The stage continues until demand does not exceed supply.

Round	Price	Demand		Discount	
		X	Y	X	Y
1	€1	5	8		
2	€2	5	8	€2	€5
3	€3	5	6	€4	€10
4	€4	5	6	€8	€15
5	€5	5	5	€12	€20

Before each round, the auctioneer calculates the discount for each bidder, which is the minimum difference between what a bidder will pay for its winnings compared to the current clock prices if the clock stage finishes in the current round with no excess supply.

The discount can only be calculated after the first round as before that bidders have not revealed any information on their valuations³⁹.

In round one, we learn that Y values 8 lots at least at a total of €8 (since it has decided to submit a bid for 8 lots at €8). If we denote Y's valuation for 8 lots as M , its valuation for 9 lots is at most $M + €1$ and its valuation for 10 lots is at most $M + €2$ (since it decided to exclude these 2 lots at €1 each). That means that there are 2 lots which Y values at not more than €1 on average. Respectively, X values 5 lots at least at a total of €5 but values further 5 lots at not more than €1 on average.

This information allows us to calculate the discount for the next round. The current price of each lot is €2, but there are 2 lots which X values at at most €1 on average and 5 lots which Y values at at most €1 on average. In a standard CCA, that would mean that if there is no excess supply after the clock stage (which requires X to win at least 2 lots), X's price will be at least €2 smaller than the final clock price of its winnings. Under the same assumption, X's price will be at least €5 smaller than the final clock price of its winning package.

In round two, bidders stay on their packages. That means that X values 5 lots at a total of at least €10 and Y values 8 lots at a total of at least €16. We do not learn anything new about their valuations for the other lots.

As we calculate the discounts for round three, we note that the *minimum* disparity between the implied valuations on the last 5 lots for X and the last 5 lots for Y and the clock price of these lots doubles to €2 for each lot. The discount doubles accordingly.

³⁹ Note that in this example the discount can be calculated from round 2, as both players must win a certain number of items. In practice, it may take many rounds before rivals drop their collective eligibility below the eligibility necessary to bid for all lots on sale, and therefore discounts may not arise until later rounds in the CCA,

In round three, Y drops demand from 8 to 6. Combined with previous rounds' information, that means that Y values 6 lots at at least €18, further 2 lots at an average of at most €3 per lot and further 2 lots at an average of at most €1 per lot. That means that, continuing to round four, X's discount will grow faster. It will be now calculated as $2(€4 - €3) + 2(€4 - €1) = €8$. Y's discount will grow at the same pace as before.

Before the fifth round, X's discount is €12 and Y's discount is €20, where the difference is a result of smaller valuations expressed by X for acquiring a sixth, seventh and eighth lot. As the clock stage ended after this round with no excess supply, X will pay at most $€25 - €12 = €13$ for its winnings and Y will pay at most $€25 - €20 = €5$ for its winnings. Whether X pays €13 or less depends on whether Y will submit the maximum bids permitted by its revealed preference constraints. At the same time, Y will win 5 lots at reserve price, as there were 5 lots for which X did not express any demand at reserve price and thus failed to generate an opportunity cost for Y which would be higher than that.

Conditions for the discount to be positive

The bidders can always bid for packages within their eligibility at current clock prices. When they drop eligibility, they can still compete for lots at a price at which they dropped eligibility below the level necessary to bid for the given package. Therefore, in order for a discount to exist, it is necessary that:

- rivals have dropped their collective eligibility below the eligibility necessary to bid for all lots on sale; and
- since that moment, there has been a price increase in at least one category.

In a single-category auction, these conditions are sufficient. However, in multi-category auctions, they are not sufficient as there could be a situation in which bidder X's rivals drop their demand in one category significantly below supply and, in another category, they maintain demand slightly above supply. This could result in both conditions being met, but no discount generated for bidder X.

On the other hand, it is not necessary for bidder X to submit any bid in order for it to get a discount. This could happen if bidder X's rivals switch back and forth between categories without having enough eligibility to bid for all of the supply in these categories at once. However, such 'unearned' discount would not be effective since in such a situation there would be undersell.

No undersell assumption

The assumption of no excess supply after the clock stage is necessary because if there are unsold lots, they may be leveraged against a bidder to raise its opportunity cost, as described in sections 4.2.3 and 4.3.1.

Together with the assumption that the current round is the final clock round, it ensures that the discount does not depend on what bidders bid for and can be communicated before the round.

The assumption that the current round is the final clock round ensures that the behaviour in the clock round does not influence bidders' revealed preferences.

Firstly, for a round to be the final clock round, bidders' current packages (from there on *final clock packages*), must not clash with each other. Since FCPs do not clash, bidders can only compete with each other by submitting bids where they add lots relative to their FCPs.

Secondly, the constraints generated by the final clock round (which are added to / interacted with the constraints from earlier rounds) say that:

- the final clock package can be bid for at an arbitrary amount; but
- regardless of the composition of the FCP, further lots can be added at a price not higher than the final clock price.

Although final clock round behaviour matters because it determines which lots are included in the FCP and whether undersell ensues, it does not change the constraints applying to lots outside the FCP. Therefore, bidders' final clock round behaviour does not matter for discount calculation (but it can affect undersell and therefore the final allocation price of a package, in a way we describe below).

Monotonicity

A bidder's discount may decrease from round to round, even dropping to zero, regardless of whether GARP- or WARP-based activity rules are used. This may happen even if bidders bid straightforwardly (which means that they do not use the eligibility points-based activity rules to make bids that are contradictory from a revealed-preference perspective). The example below illustrates that.

Example 14: The discount may disappear

Consider a CCA with 4 lots in each of 2 categories (A and B) and 3 bidders (X, Y and Z). The reserve price in both categories is €100 and in each round the price increases by €100. Each lot has 1 eligibility point associated with it.

In each round of the clock stage the bidders specify the number of lots they would like to bid on in each category, given the current price. The clock stage continues until, in each category, demand does not exceed supply.

Bidders bid according to their valuations, where A lots and B lots are valued independently.

X's marginal valuations are presented in the table below:

Lot	A	B
1 st	€300	€0
2 nd	€400	€0
3 rd	€300	€0
4 th	€195	€0

Y's marginal valuations are presented in the table below:

Lot	A	B
1 st	€0	€600
2 nd	€0	€0
3 rd	€0	€0
4 th	€0	€0

Z's marginal valuations are presented in the table below:

Lot	A	B
1 st	€300	€600
2 nd	€0	€700
3 rd	€0	€600
4 th	€0	€495

The following bids are submitted:

Round	Price A	Price B	X's bid	Y's bid	Z's bid
1	€100	€100	4,0	0,1	1,4
2	€200	€200	3,0	0,1	1,4
3	€200	€300	3,0	0,1	1,4
4	€200	€400	3,0	0,1	1,4
5	€200	€500	3,0	0,1	1,3

Before round 3, X enjoyed a discount of €200. This is because the highest bid its opponents could make was for any 6 lots at round 3 clock price and 2 other lots at reserve price. However, in later rounds, the prices for category A and B diverge and Y and Z continue to bid above supply in category B. As a result, revealed-

preference rules start allowing them to exchange one B lot for more than one A lot.

Specifically, Z's round 1 decision constrains its bid amount for each package larger than 5 lots to be less than:

$$B_{x_A, x_B}^Z \leq \text{€}100 * (x_A - 1) + \text{€}100 * (x_B - 4) + B_{1,4}^Z$$

For X to have no discount, it is sufficient that Z is able to bid for the package (4,3) at final clock prices (as Y will bid for (0,1) at final clock prices). If the clock price of package (1,4) rises faster than the clock price of package (4,3), it means that Z's maximum bid for package (4,3) will rise faster than the clock price of package (4,3), which means that at some point these two values may become equal (at which point the constraint above will stop binding and the final clock round constraint will start binding).

To understand the general mechanism why the discount may fall in the course of the clock stage, let us consider a split of all supply (S) into two parts – S_1 , the current clock package of bidder Z, and S_2 , which comprises all the other lots.

An intuitive understanding of how discounts for Z's opponents arise is that when a Z drops demand below S , its maximum implied valuation for S_2 becomes a fixed value and its maximum implied valuation for S_1 grows proportionately to the clock price of S_1 . At some point, S_1 becomes smaller than S . Therefore, the maximum implied valuation for S_1 starts growing slower than the clock price of S . Because the maximum implied valuation for S_2 is fixed, the maximum implied valuation for S grows slower than the clock price of S .

This understanding is largely⁴⁰ correct when applied to a single bidder but very misleading when applied to a collection of bidders. A collection of bidders C may hold demand for certain products D higher than the available supply in D . If the price of D grows much faster than the price of other products, the total price of the bidders' clock packages may increase faster than the price of all the supply available – even though the bidders' total activity is smaller than the points associated with S . As a rough approximation, this will usually happen if the price of the excess demand caused by C in products D grows faster than the price of the lots not demanded by C in products other than D .

By construction, prices increase for products for which demand is higher than supply. If C is defined as the set of all competitors of bidder X , in a given round, price will rise for D and products where a price increase is caused by X (which means that total demand exceeds supply but X 's opponents' demand alone does not).

⁴⁰ We describe some of the logic presented here as approximately or roughly correct because when, in the course of the clock stage, bidders switch demand instead of strictly dropping it, revealed-preference constraints become more complicated than it may appear from this description. However, the main conclusion still stands.

Knock-out bids

The effect of the potentially leveraged undersell can be offset from the discount to calculate, for each bidder, a 'knock-out bid'.

A bidder's knock-out bid is calculated in the following way:

- start at the value of the FCP at final clock prices;
- subtract the discount; and
- add the value of undersell at final clock prices minus the value of undersell at reserve prices.

These three steps can be represented (from left to right) using the following formula:

$$KO^j = (\sum_{i=1}^m P_{T,i} * Q_{T,i}^j - D_T^j) + \sum_{i=1}^m (P_{T,i} - P_{1,i}) * U_{T,i}$$

where:

- i indexes products;
- $Q_{T,i}^j$ is the quantity of the i^{th} product demanded by bidder j in the final clock round;
- D_T^j is the discount for bidder j for the final clock round;
- $P_{T,i}$ is the final clock price of the i^{th} product;
- $P_{1,i}$ is the reserve price of the i^{th} product; and
- $U_{T,i}$ is the number of unsold lots after the clock stage.

Earlier, we have written that "in order for a discount to exist, it is necessary that:

- *rivals have dropped their collective eligibility below the eligibility necessary to bid for all lots on sale; and*
- *since that moment, there has been a price increase in at least one category."*

For a bidder's knock-out bid to be lower than the final clock price of its final clock package (in other words, in order for there to be a chance that the discount will not be entirely offset by undersell), it is necessary that at least one of the price increases described in the second point was a price increase which would not have occurred without that bidder's demand.

Calculation under limited information

Bidders who face limited information in CCAs can calculate a conservative clock stage discount and knock-out bid. If bidders are told aggregate demand after each round, a conservative discount can be calculated by simulating all possible rivals' detailed bid histories consistent with auction rules and with the aggregate demand revealed by the auctioneer, calculating the exact discount applicable under each of these scenarios and taking the minimum of

them. Such discount will feed into the knock-out bid calculation, creating a conservative estimate of the knock-out bid.

This may be practical, since the number of possible bid histories grows exponentially with each round (and the required computing power rises accordingly) and by the time a discount arises it is likely that the bidder will not be able to calculate its full amount.

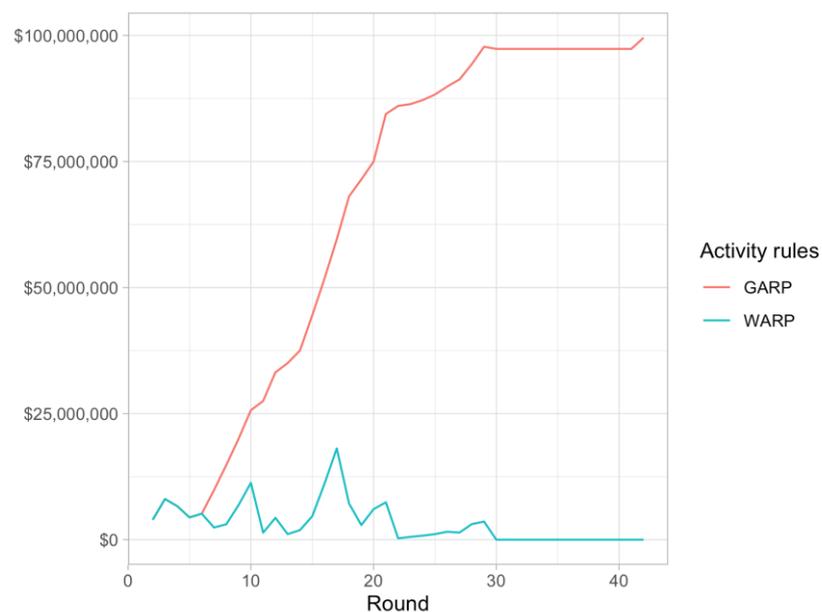
Therefore, it is typically easier for a bidder to assume a zero discount (and calculate their knock-out bid accordingly).

Annex B Simulation results

Canada 600 MHz discount calculation

Figure 16 presents the discounts Freedom enjoyed before each clock round in the Canadian 600 MHz auction, assuming either GARP-based constraints or WARP-based constraints. GARP-based relaxed activity rules were the ones used in the auction. No other bidder enjoyed a discount at any point in the clock stage.

Figure 16. Evolution of Freedom's discounts during the Canadian 600 MHz auction under GARP (actual) or WARP activity rules



The situation in which Freedom faced discounts from the earliest possible moment (before round 2) while Rogers, the biggest bidder in the auction by winnings, did not face any discount even in round 42 is largely due to the generous set-asides, for which Freedom was eligible in all regions and Rogers in none.

Freedom's discount

Let us consider Freedom's position before round 2. Freedom caused a price increase for lots in AL and BC in round 1 (it caused the demand for the set-aside products in these regions to be higher than 3 while open demand was at least 4). For Freedom to face no discount, among other conditions, other bidders would have had to be able to bid for all set-aside lots in AL and BC at clock prices. However, Freedom's main competitor for set-aside lots, Videotron, was not eligible for set-aside lots in AL and BC specifically.

Those eligible were Xplornet (with first round activity, and therefore round 2 eligibility, of 630 points), Novus (520 points), Iris (143 points) and Bragg (720 points). Their total round 2 eligibility was 2013, below the 2940 points required to bid for 3 lots in AL and BC. Theoretically, it would have been possible for Freedom's discount to disappear if the above-mentioned bidders' clock packages' prices had increased much faster than the price of (set-aside lots in) AL and BC. However, that did not happen.

Rogers' lack of discount

Rogers, the biggest bidder with regards to round 41 activity (as well as final winnings), did not face a discount before round 42, although it faced competitors whose activity associated with open products in round 41 was 4904 (consisting exclusively of TELUS' demand) with set-aside activity being 13516. The sum of these two numbers falls much below the 32081 points associated with the whole supply in all areas. Still, before round 42 Rogers faced no discount as its competitors were able to bid for the whole supply at round 42 prices (which then became the final clock prices).

This means that it is possible to allocate the whole supply between Rogers' competitors in such a way that each of them was able to bid for their package at round 42 prices. In fact, there were many such allocations.

In one such solution, TELUS is bidding for a package worth 12390 points (let us call it package T). It contains 4 lots in SO, 4 lots in SQ and no lots in AL or BC. Package T is larger than (and therefore constrained by) TELUS's round 12 package. Between round 12 and 42, the price of each open product has increased. However, TELUS's was still able to bid for packages larger than its round 12 package at round 42 prices because of the mechanism described in Annex A. Specifically, this is because, towards the end of the auction, TELUS was bidding on products whose price per eligibility point was much higher than those contained in T .

Annex: 13 Worked examples of Exposure Pricing

A 13.1 The EAS will inform Bidders of the Exposure Price associated with a Package of Lots it may wish to bid for in a given Round, as described in Section 4.2.2.

A 13.2 To do this, the EAS calculates a 'discount', using the history of Bids made in the Auction to that point. The discount is then subtracted from the Bid Amount of a Package of Lots to give the Bidder's Exposure Price for that Package of Lots i.e. the maximum amount the Bidder would be required to pay for that Package of Lots if the Primary Bid Rounds were to finish at the end of the current Round with demand equal to supply. Note that the discount is specific to each Bidder, and for a given Bidder is constant across Packages of Lots in a given Round.

A 13.3 The discount for a particular Bidder in a given Round is calculated by finding the difference between:

- the value of all Lots at current Round Prices; and
- the maximum total value that the Bidder's rivals can place on the whole supply, given the Relative Caps arising from the Activity Rules and subject to no value for a given Package exceeding the current Round Price of the Package¹⁸⁰.

A 13.4 In this annex we provide some simple examples on how Exposure Prices are calculated. Further examples and a more detailed explanation of the formal methodology can be found in Annex 12.

Calculation of Exposure Prices – worked examples

A 13.5 Suppose that there are only two Bidders, X and Y, and three Lot Categories. Lot Category A contains Lots that cover both Time Slices, while the other Lot Categories (B and C) include Lots in the same band, but in Time Slice 1 and 2 respectively. Category A contains four Lots (also referred to as 'A-Lots'), while B and C contain ten Lots each (also referred to as 'B-Lots' and 'C-Lots').

A 13.6 Suppose that the Reserve Price for A-Lots is €2, and the Reserve Price for B-Lots and C-Lots is €1. The Initial Bid submitted by each Bidder is for four Lots

¹⁸⁰ This is determined by considering hypothetical Bids for all Packages by each rival Bidder, with Bid Amounts set at the maximum level that would be allowed in the current Round (subject to any applicable Relative Caps), and establishing the combination of Bids that yields the maximum total value, subject to the number of Lots included in the combination being equal to supply.

in A and ten Lots in each of B and C (i.e. all Lots available in the Auction).

A 13.7 Let (a,b,c) represent the Package of Lots containing a Lots in A, b Lots in B and c Lots in C, so both Bidders' Initial Bids are for the Package $(4,10,10)$, which we subsequently refer to as Package S.

A 13.8 Eligibility is calculated independently in each Time Slice. A-Lots have an Eligibility score of two (which counts in both Time Slices). B-Lots have an Eligibility score of one in Time Slice 1 and 0 in Time Slice 2. C-Lots have an Eligibility score of 0 in Time Slice 1 and 1 in Time Slice 2. Let (E_1, E_2) denote Eligibility of E_1 in Time Slice 1 and E_2 in Time Slice 2. Therefore, each Bidder's Initial Eligibility is $(18,18)$.

A 13.9 We assume for the purposes of this example that there are no Bidding Restrictions.

A 13.10 The evolution of Initial/Primary Bids and Exposure Prices for the subsequent examples are summarised in Table A13.1. In Table A13.2 we summarise the calculation of discounts for each Bidder in each Round.

A 13.11 In our examples, Round 0 represents the Application Stage, in which Bidders submitted their Initial Bids at Reserve Prices.

Table A13.1. Initial/Primary Bids and Exposure Prices

Round	Price per Lot (€)			Demand		Bid Amount (€)		Exposure Price (€)	
	A	B	C	X	Y	X	Y	X	Y
0	2	1	1	(4,10,10)	(4,10,10)	28	28	28	28
1	3	2	2	(4,5,5)	(4,8,8)	32	44	32	44
2	4	3	3	(4,5,5)	(4,8,8)	46	64	42	54
3	5	4	4	(2,4,4)	(2,4,8)	42	58	34	38
4	5	4	5	(2,4,4)	(2,4,8)	46	66	36	

Table A13.2. Calculation of discounts

Round	Price of S (€)	Max. Bid for S (€)		Discount (€)	
		X	Y	X	Y
0	28	28	28	-	-
1	52	52	52	0	0
2	76	66	72	4	10
3	100	80	92	8	20
4	110		100	10	

No discount

A 13.12 A discount for a particular Bidder arises only when other Bidders cannot collectively submit Bids for all available Lots at current Primary Bid Round prices, because of constraints applied as a result of the Activity Rules.

A 13.13 If other Bidders collectively have sufficient Eligibility to include all available Lots in their Bids at current Round Prices, then there will be no discount. In this case, the Exposure Price associated with a Bid for a particular Package of Lots will be equal to the price of the Package of Lots at current Round Prices (i.e. the Bid Amount).

A 13.14 In the first Primary Bid Round, both Bidders are eligible to bid for the Package of Lots including all Lots in all three Lot Categories, because the Package subject to their Initial Bids is the Package (4,10,10), which is equal to the supply. Therefore, no discount will apply for either Bidder and the Exposure Price for each Bidder is equal to their Bid Amount, which is €32 for Bidder X and €44 for Bidder Y.

Discount emerges

A 13.15 In the first Round, prices were €3 for A-Lots and €2 for B- and C-Lots. In Round 2 they were €4 for A-Lots and €3 for B- and C-Lots.

A 13.16 Suppose that, in Round 1, Bidder X submitted a Bid for $X_1=(4,5,5)$ and Bidder Y submitted a Bid for $Y_1=(4,8,8)$. These are both Eligibility-reducing Primary Bids, so the Bidders' Eligibilities are now (13,13) and (16,16) respectively.

A 13.17 The reductions in Eligibility generate constraints (Relative Caps) on the Bid Amounts each Bidder can subsequently submit for Packages of Lots with

greater Eligibility than the Package they bid for in Round 1 (including Package S). An individual Bidder is no longer eligible to bid for all Lots (i.e. Package S), so for each Bidder we can calculate a discount for Round 2.

- A 13.18 Note that a Bidder is given Aggregate Demand information at the end of each Round and knows its own Bid history. It may, therefore, expect that a discount exists under certain circumstances. However, without knowledge of other Bidders' Bid histories, it will not be able to calculate its exact discount (and corresponding Exposure Prices).
- A 13.19 To calculate the discount for Bidder X in Round 2, we first need to know the maximum value that could be expressed by 'opponent Bidders' for all of the available Lots in Round 2. In this example there is only one other Bidder (Bidder Y), so we establish the maximum Bid Amount that Bidder Y would be allowed to submit for Package S, given the Round 2 prices and the Relative Cap set by Bidder Y's Round 1 Bid.
- A 13.20 In Round 1, Bidder Y made an Eligibility-reducing Primary Bid, creating a Relative Cap for Bidder Y on Package S. The Constraining Round for Package S is Round 1 and the Constraining Package for S is the Package Y_1 , which Bidder Y bid for in the Constraining Round. In Round 1, the price of Package S was €52 and the Price of Package Y_1 was €44. Therefore, the maximum Bid Amount that Bidder Y could submit for S is equal to its maximum Bid Amount for Y_1 plus €8.
- A 13.21 In Round 2 the price of Package Y_1 is €64, so Bidder Y would be allowed to Bid at most €64 + €8 = €72 for Package S. The value of S evaluated at Round 2 prices is €76. The difference between the value of all of the Lots available at Round Prices and the maximum value that Bidder Y can express for these Lots is thus €76 - €72 = €4. Therefore, in Round 2, Bidder X's discount is €4.
- A 13.22 Suppose that, in Round 2, Bidder X bids for the Package $X_2 = (4,5,5)$. Its Bid Amount would be €46, and its Exposure Price is the Bid Amount minus the discount, which is €46 - €4 = €42 in this case.
- A 13.23 Assume that Bidder X and Bidder Y both Bid for the same Packages of Lots in Rounds 1 and 2 (i.e. $X_1=X_2$ and $Y_1=Y_2$), as shown in the table above. We can calculate Y's discount in Round 2 in the same way.
- A 13.24 The most that X can bid for S in Round 2 is its highest Bid for X_1 plus €20 (€52 minus €32), because X_1 is the Constraining Package for S for Bidder X. The price of X_2 in Round 2 is €46, so the most that Bidder X can bid for S in Round 2 is €46 + €20 = €66. Therefore, the discount for Y is €76 - €66 = €10. The price of Y_2 in Round 2 is €64, so Y's Exposure Price for Y_2 is €64 - €10 = €54.

Discounts can increase without reductions in demand

A 13.25 In Round 2, both Bidders submit Bids for the same Package of Lots they bid for in the previous Round. However, the maximum Bid Amount that they can submit for Package of Lots S will not increase by as much as the *price* of Package of Lots S going into Round 3. Therefore, the discounts increase for both Bidders.

A 13.26 In this example, the increase in the discount is equal to the increase in price of all of the Lots not included in the other Bidder's Bid.

A 13.27 For example, Bidder X's discount in Round 3 is calculated as the value of all Lots evaluated at Round 3 prices minus the maximum value that Y can place on S in Round 3 (which is the price of Y_1 at Round 3 prices plus €8), which gives $€100 - (€84 + €8) = €8$.

Effect of a further reduction in Eligibility

A 13.28 In Round 3, both Bidders made Eligibility-reducing Primary Bids, for $X_3 = (2,4,4)$ and $Y_3 = (2,4,8)$ respectively.

A 13.29 To calculate the discount in Round 4 for Bidder X, as before we need to consider the maximum Bid Amount that Y can submit for Package S in Round 4.

A 13.30 The Constraining Round for Package Y_2 is Round 3 and the Constraining Package is Y_3 . In Round 3, the price of Y_2 was €84 and the price of Y_3 was €58. Therefore, the maximum Bid Amount for Y_2 can be no greater than the maximum Bid Amount for Y_3 plus €26.

A 13.31 There is now a chain of constraints; from earlier, we have that the maximum Bid Amount for S is no greater than the maximum Bid Amount for Y_2 plus €8. Therefore, the maximum Bid Amount that Bidder Y can submit for S can be no greater than the maximum bid for Y_3 plus €34.

A 13.32 Consequently, the maximum amount that Bidder Y can bid for S based on Round 4 prices is $€66 + €34 = €100$. The price of S at Round 4 prices is €110, so the discount for Bidder X in round 4 is $€110 - €100 = €10$. The Exposure Price for Bidder X's Round 4 Bid is $€46 - €10 = €36$.

Monotonicity

A 13.33 In cases with at least three Bidders, it is possible for the discount to decrease from one Round to the next.

A 13.34 Consider a new example with four Lots in each of three Categories, A, B and C.

- A 13.35 Using the same notation as above, suppose that the Eligibility associated with the A-Lots is (1,1), with B-Lots is (1,0) and with C-Lots is (0,1). The Reserve Price per Lot for all categories is €1.
- A 13.36 There are three Bidders. Bidder X's Initial Bid is for the Package of Lots $X_1 = (4,4,0)$. Bidder Y bids for the Package $Y_1 = (1,1,4)$ in all Rounds (including 'Round 0' – the Applications Stage), and Bidder Z bids for the Package $Z_1 = (0,0,1)$ in all Rounds.
- A 13.37 For the first Primary Bid Round, all prices are increased to €2 and Bidder X Bids for the Package $X_2 = (3,3,0)$. The value of all Lots at Round Prices in Round 1 is €24.
- A 13.38 For the maximum value that Bidders Y and Z can jointly express for all Lots, we consider hypothetical Bids from Bidder Y for $Y_r = (4,4,3)$ and from Bidder Z for $Z_1 = (0,0,1)$.¹⁸¹ This covers all available Lots. The Constraining Package for Y_r is Y_1 , and the most Bidder Y can bid for Y_r is its maximum Bid for Y_1 plus €5 (the difference in the price of Y_r and Y_1 at Reserve Prices). There is currently no Relative Cap for Bidder Z on Z_1 .
- A 13.39 The maximum value that Bidders Y and Z could collectively place on total supply in Round 1 is the price of Y_1 in Round 1 (€12) plus €5, plus the price of Z_1 (€2) in Round 1. This gives a total of €12 + €5 + €2 = €19.
- A 13.40 Therefore, Bidder X enjoys a discount of €24 - €19 = €5 in Round 1, and its Exposure Price when bidding for the Package of Lots (3,3,0) is €12 - €5 = €7.
- A 13.41 Suppose that Bidders Y and Z continue to bid on the Packages Y_1 and Z_1 respectively in Round 1. There is now no excess demand in Categories A and B, so prices in these Categories remain at €2 in Round 2. The price of C-Lots increase to €4.
- A 13.42 The value of all Lots at current Round Prices is now €32.
- A 13.43 Consider again the Packages, Y_r and Z_1 for calculating the maximum value that Bidders Y and Z can express for all Lots. Because the price of Y_1 has now increased to €20, Y can bid €25 for Y_r . The price of Z_1 is now €4. The total value that can be expressed by Y and Z for all Lots is now €29. This is €3 less than the value of all Lots at Round Prices.
- A 13.44 Intuitively, as a result of the increase in prices, the Relative Caps will allow the Bidders to substitute one C Lot for more than one A or B Lot as the relative

¹⁸¹ Note that there would be a number of alternative combinations of Bids from Bidders Y and Z that would give the maximum value they can jointly express for all Lots – we do not list all of those in this annex, but have simply chosen one of the options for the purpose of the example.

price of C Lots increases.

A 13.45 The discount that applies for Bidder X has therefore decreased from one Round to the next, falling from €5 to €3. Moreover, the Exposure Price faced by Bidder X for Package of Lots X_2 has increased from €7 to €9, even though the price of the Package of Lots evaluated at Round 1 and Round 2 prices has remained the same.

Annex: 14 Relocation Rebate

A 14.1 This annex sets out details of the Relocation Rebate that applies to Eir in relation to its Existing 2.1 GHz Band Licence where it incurs Relocation costs as a result of the Assignment Stage that it would not have incurred otherwise.

A 14.2 A Relocation Rebate will be granted to compensate Eir for Relocation costs in the following circumstances:

- *Scenario 1:* where Eir does not apply for and obtain early liberalisation for its Existing 2.1 GHz Band Licence and does not win spectrum rights of use in the 2.1 GHz Band in Time Slice 2. In such cases, the Relocation Rebate will be equal to the Relocation costs necessitated as a result of the Assignment Stage. The Relocation costs incurred by Eir will be examined by ComReg, as set out below, to determine the Relocation Rebate.
- *Scenario 2:* where Eir does not apply for and obtain early liberalisation for its Existing 2.1 GHz Band Licence and wins spectrum rights of use in the 2.1 GHz Band in Time Slice 2. In such cases, the Relocation Rebate will consist of the additional time-value-of-money costs associated with bringing forward the Relocation activities necessitated as a result of the Assignment Stage, but not the Relocation costs themselves. To determine the Relocation Rebate under Scenario 2, the Relocation costs incurred by Eir will be examined by ComReg as set out below.

When the total Relocation costs have been determined, a time-value-of-money adjustment factor will be calculated based on the quantum of time involved, i.e. the period of time by which Relocation activities are brought forward such that they occur before the commencement date of new rights of use for spectrum in the 2.1 GHz Band in Time Slice 1, rather than the before the original licence expiry date¹⁸². The time-value-of-money adjustment factor will be based on an appropriate discount factor. ComReg will consider whether it is appropriate to consider changes to the level of Relocation costs for

¹⁸² Based on Eir's existing licence expiry date of 11 March 2027 and the expected commencement date of 16 October 2022 for new rights of use for spectrum in the 2.1 GHz Band in Time Slice 1, Eir's Relocation activities would be brought forward by approximately 4 years 5 months.

the time period between when these costs are actually incurred and when they would have been incurred in the future¹⁸³.

- *Scenario 3:* If Eir can reasonably prove to ComReg that it has directly incurred Relocation costs as a result of the Assignment Stage that it would not have otherwise incurred at some point in time, ComReg will consider applications for a Relocation Rebate. The Relocation costs incurred by Eir will be examined by ComReg, as set out below, to determine the Relocation Rebate.

A 14.3 To the extent that additional costs result from a negotiated assignment (resulting from the Negotiation Phase), ComReg considers that such costs are a matter for the Winning Bidders themselves and will not provide compensation.

ComReg's examination of Relocation costs

A 14.4 In order for ComReg to grant a Relocation Rebate, Eir must pre-notify ComReg of its expected Relocation costs for information purposes.

A 14.5 ComReg will examine these Relocation costs to determine if such costs are objectively justified and proportionate. Eir must demonstrate to ComReg that any costs submitted as part of a Relocation Rebate application have been incurred directly as a result of the Assignment Stage and these costs would not have otherwise been incurred as a result of the Award Process or would only have been incurred at a later date. If Relocation costs include upgrades of equipment that are not required exclusively for the purpose of the Assignment Stage, these costs may be disallowed, or appropriately discounted by ComReg. ComReg reserves the right to have the relocation costs independently evaluated and/or verified.

A 14.6 Subject to the provisions of ComReg's guidelines on the treatment of confidential information as set out in ComReg Document 05/24, ComReg will publish on its website all Relocation cost information received from Eir of a Relocation Rebate and details of any Relocation Rebate granted by ComReg.

¹⁸³ ComReg recognises that it will be necessary to make certain assumptions about the future cost of Relocation activities in 2026 or 2027 (i.e. the time Eir would have been required to relocate in advance of its licence expiry date of 11 March 2027) compared to contemporaneous cost levels, as these future costs are unknown.