

MBSA2 Evaluation Report

Prepared for ComReg

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Executive Summary

Introduction, purpose and scope

In this report, and as part of our post award review, we provide an assessment of the **second Irish Multi-Band Spectrum Award** in Ireland ('MBSA2'), completed in 2023.

This auction successfully awarded 465 MHz of spectrum rights across the 700 MHz, 2.1 GHz, 2.3 GHz and 2.6 GHz bands, an increase of 46% on the amount of spectrum previously assigned. All three Mobile Network Operators (MNOs), Eir, Three and Vodafone, increased their spectrum holdings. Imagine, a wireless fixed broadband operator, also won a large amount of spectrum.

This outcome provides a highly favourable situation for a competitive Irish telecoms industry to deliver improved services for customers. It will enhance capacity and speed for existing services and enable new 5G services. 700 MHz spectrum will allow the cost-effective deployment of widespread 5G coverage, including on transport paths and in rural areas.

Award Framework

Objectives

A primary objective of the award was to allocate the spectrum efficiently, leading to its optimal use, subject to ComReg's obligation to ensure no distortions to competition (amongst MNOs). ComReg does not have a revenue raising objective. Subject to the constraint of downstream competition remaining effective, efficient allocation can usually be achieved by allocating spectrum to whoever values it most.

Given the large amount of spectrum available in the award, and the pre-existing asymmetry between the MNOs, there were well-founded concerns about MNOs bidding in pursuit of severely asymmetric post-auction spectrum holdings, with consequent risks to competition in downstream markets if won. For this reason, spectrum competition caps were both necessary and appropriate.

Spectrum competition caps

Two spectrum competition caps limited the amount of spectrum bidders could acquire in the auction:

- **Sub 1-GHz cap:** a cap of 70 MHz (2x35 MHz) across the 700 MHz, 800 MHz and 900 MHz bands, limiting the amount of 700 MHz spectrum that could be acquired;
- **Overall cap:** a cap of 375 MHz across the 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz, 2.3 GHz, 2.6 GHz and 3.6 GHz bands.

ComReg also wanted to ensure that participation from smaller bidders was not discouraged, noting that some of the spectrum rights on offer could be attractive for services other than mobile, such as fixed wireless access.

Award design

The main stage of the auction determined the amount of spectrum to be assigned to each bidder. This used a Combinatorial Clock Auction (CCA) format with relaxed bidding activity rules (rather than a simpler eligibility point based rule). A follow-up assignment stage used a sealed bid process to establish which specific frequencies would be assigned to winners.

Alignment of licence dates

Eir's existing licence in the 2.1 GHz band is due to expire in 2027, causing a misalignment with the rest of the band, which was available from 2022. Because of this, ComReg decided to award new licences in the 2.1 GHz band in two distinct "time slices":

- Time slice 1 covered the period up to 11 March 2027; and
- Time slice 2 covered the period from 12 March 2027 to 13 February 2042.

Spectrum in the 2.3 GHz and 2.6 GHz bands was also offered in these time slices because of its likely close substitutability with 2.1 GHz spectrum. This provided flexibility for the long-term allocation of the supra-1 GHz bands.

Legal challenge and delays to the award

Legal dispute

Following the publication of ComReg's final decision on the award in December 2020, Three submitted a legal challenge. This largely concerned the implications of the sub-1 GHz cap in combination with ComReg's chosen auction format.

During the prior consultation process, Three had contested the sub-1 GHz cap¹, which prevented it from bidding on a third 700 MHz lot (because it had the largest existing sub-1 GHz holdings). However, in a subsequent consultation response², Three said that its complaint was not with the cap *per se*, but with its interaction with the auction format. Three theorised that its inability to bid for a third block of 700 MHz spectrum, even if that bid did not win, would lead to it paying more than other MNOs for winning two blocks.

ComReg considered these issues and responded in detail to Three in its Decision³, including extensive analysis from DotEcon showing

¹ ComReg document 19/124g, Chapter 1.8.

² ComReg document 20/78.

³ ComReg document 20/122. See Chapter 6.

why these concerns were unfounded⁴. Nevertheless, Three appealed ComReg's Decision, leading to significant delay to the award.

Following the publication of the results of the Main Stage, Three discontinued its appeal of the Decision in its entirety⁵. **The award outcome itself demonstrates that none of the harms claimed by Three came to pass.**

Short-term licences

Given the extraordinary circumstances of the COVID-19 pandemic, short-term licences ('COVID licences') were issued in the 700 MHz and 2.1 GHz bands to the three MNOs, to support those operators dealing with significant changes to network traffic patterns presented. These licences were available to use until October 2022.

Due to the delays caused by the legal challenge, the need to avoid consumer disruption left ComReg with little option but to introduce a further temporary licence scheme beyond October 2022. This was an unsatisfactory situation. MNOs did not have long-term certainty of spectrum access, depressing incentives to invest in network assets complementary to this spectrum. Furthermore, any MNO prepared to risk network investment on this basis would have a toehold over that spectrum that might distort bidding behaviour within the subsequent auction of long-term rights.

Delay costs

As part of the MBSA2 litigation, ComReg submitted evidence from Dr. Dan Maldoom⁶ (which was verified by Prof. Peter Clinch⁷) regarding the very high costs to the Irish economy of delays to widespread 5G roll-out. These were estimated by DotEcon to be in the order of €1 bn per annum, and potentially double that.

Whilst ComReg was justified in not acceding to Three's request to relax the sub-1 GHz cap for the reasons set out in its Decision, it is worth noting that even if ComReg had acceded to Three's request to relax the sub-1 GHz cap, there is no certainty that this would have avoided the resulting delay and its costs. Such a fundamental modification of the rules could simply have triggered an appeal from an interested party other than Three, which could also have delayed matters.

In addition, had ComReg modified the sub-1 GHz cap, say to allow all MNOs to acquire three blocks of 700 MHz spectrum within the auction, this could have permitted outcomes for the distribution of sub-1 GHz spectrum that were much more asymmetric than the pre-

⁴ ComReg Document 20/122a. See pages (v) and (vi) of the Executive Summary for an overview of the issues.

⁵ Extract from Grounding Affidavit of Mr Tom Hickey (Three Ireland) "... *Three believes it would now be of benefit to it, and to the market in general, for ComReg to be permitted to proceed to award licences on foot of the Auction Process and that it is no longer necessary to pursue the Reliefs sought in the Appeal*" "*In these circumstances, Three wishes to discontinue the Proceedings and to have the Stay Lifted.*"

⁶ ComReg Document 23/35a

⁷ ComReg Document 23/35b

auction position, potentially with one MNO holding twice as much sub-1 GHz spectrum as another. This would have entailed substantial economic welfare losses from distorted downstream competition, potentially over an extended period, as there are no current plans for further release of sub-1 GHz spectrum that could rectify such an outcome.

Therefore, **even in hindsight knowing the delay that ensued, we consider that ComReg's sub-1 GHz cap was entirely justified.**

*Delays may have
benefitted the MNOs*

We also note that delay of the award may have benefited the MNOs in that ComReg had little option but to continue to provide short-term access to spectrum initially provided through COVID licences, at a peppercorn charge of €100 per 3-month licence. As above, the lack of long-term access to spectrum also provided a common constraint on network investment across all MNOs, deferring capital expenditure. A general observation is that an existing spectrum licensee may have a strong incentive to delay a spectrum award when this also constrains its competitors access to new spectrum.

Assessment of the award outcome

*Outcome of the
award*

The award achieved a very good outcome which provides a highly favourable framework for a competitive Irish telecoms industry.

The auction awarded 465 MHz of spectrum rights in the 700 MHz, 2.1 GHz 2.3 GHz and 2.6 GHz bands, representing a 46% increase on the amount of spectrum previously assigned. All the MNOs increased their spectrum holdings, with the level of spectrum asymmetry between them reducing. A non-MNO bidder (Imagine) also won a large amount of spectrum.

The MBSA2 raised nearly EUR 450 million in spectrum fees (including both upfront auction prices and ongoing usage fees).

Only one lot remained unsold (the top 2.6 GHz Time Division Duplex (TDD) spectrum block, which was constrained by usage restrictions given adjacent 2.6 GHz Frequency Division Duplex (FDD) users).

Each of the incumbent MNOs (Eir, Three and Vodafone) won a combination of 700 MHz spectrum and higher frequencies, allowing for the continued provision of existing services, the expansion of existing networks and the roll-out of high-speed 5G services.

Comparing pre- and post-award differences in spectrum holdings across MNOs, asymmetry has reduced, measured both in absolute terms and as a percentage of total MNO holdings. This outcome should be favourable for downstream competition and partially redresses the much more asymmetric situation created by the

Hutchison-Telefónica merger, which was opposed by ComReg⁸ but cleared by the European Commission.

Imagine, a non-MNO, won 55 MHz of TDD spectrum for use until 2042. This was likely facilitated by ComReg's use of the CCA format, which encourages bidders to compete for greater amounts of spectrum. In this format, competing unsuccessfully for more spectrum does not lead to a higher price for a smaller quantity eventually won, avoiding incentives for strategic demand reduction.

FDD vs TDD pricing

In the final primary bid round prices for the frequency generic 5 MHz TDD lots (in both the 2.3 GHz and 2.6 GHz bands) were similar to (and slightly in excess of) the final round prices for the 2x5 MHz frequency generic lots in the 2.6 GHz band, which contradicts the historic view that FDD is materially superior to TDD. This differs from previous ComReg auctions in which TDD spectrum has sold at a significant discount on a per MHz basis relative to FDD spectrum in the same frequency band.

The MBSA2 offered a rare opportunity to observe operator demand for substitutable TDD and FDD spectrum offered in a greenfield environment without being affected by incumbency valuations. **The evidence is consistent with the view that, on a per MHz basis, TDD is becoming more important and valuable to operators,** most likely as a result of the benefits it offers for services with asymmetric uplink/downlink traffic patterns.

Impact of spectrum competition caps

The spectrum competition caps do not appear to have shaped the auction outcome. No bidder won the maximum amount of spectrum allowed under the overall cap of 375 MHz. Therefore, this overall spectrum cap had a purely prudential function.

In the 700 MHz band, both Vodafone and Eir won 2x10 MHz, strictly below the maximum amount they could have acquired, while Three obtained an amount strictly equal to its cap (two blocks of 700 MHz). We do not know whether Three would have sought a third block had it been able to do so, but such an outcome was considered to be potentially harmful to downstream competition.

Performance of the auction design

The choice of a CCA format for the main stage met the objective of mitigating bidders' exposure to aggregation risks due to the scope for complementarities between lots (arising from combining multiple similar lots, lots across bands and across time periods). Bidders often combined lots across time slices. There was also switching of multiple lots as a block across bands. All bidders won a combination of lots that is consistent with enjoying the benefits from expected complementarities, so without any stranded lots (such as single lots that may not be technically efficient).

Use of activity rules

Some of the most sophisticated aspects of the auction, such as the greater opportunity that the relaxed activity rules gave bidders in

⁸ ComReg Document [14/53](#)

relation to switching demand and time slicing, were used by bidders. Therefore, bids were made that would not have been possible without time slicing or relaxed activity rules.

This suggests that the additional complexity introduced by these more sophisticated features is likely justified and was understood by bidders. A less efficient auction outcome might well have occurred absent the relaxed activity rules.

Exposure pricing

This auction modified the information policy used in previous ComReg CCA auctions to provide additional information to bidders during the clock rounds about the likely prices that could, in the worst case, be paid once the auction completes. These “exposure prices” calculated the highest price that a bidder could pay if the next clock round were the final one and closed with no unallocated lots. This indicates to bidders to what extent competition has been resolved in the clock rounds or has yet to happen in the supplementary round. It does not reveal details about the individual bids being made by rival bidders but does provide additional aggregated information about the structure of competition within the auction that cannot be inferred from aggregate demand reported to the end of each clock round.

This was the first time that exposure prices have been used in any auction and was developed in response to concerns raised by stakeholders during the consultation process for the award. This novel approach was developed in a parallel project undertaken by DotEcon with ComReg, then implemented as a separate module within the MBSA2 Electronic Auction System (EAS). Despite this being a potentially challenging computation, exposure prices worked well during the actual auction and provided bidders with information on the most it might have to pay for any lots it wins.

Prior to the auction, bidders had access to a web-based system where they could experiment with exposure prices by submitting hypothetical sets of auction bids and receiving back the calculated exposure prices. This system was used by several bidders.

Assignment stage

The assignment stage was complicated in this award by the need for lots with special restrictions at band ends and the potential for frequency assignments to change across the two time periods. It is completely infeasible to create all possible frequency assignment options and then to filter these for those with desirable characteristics due to the astronomical number of possibilities involved. Given this, we developed an algorithm for creating a range of assignment options that (i) provided choice for different bidders to select a wide range of positions across each band, (ii) provided contiguous frequency assignments where possible and (iii) avoided unnecessary rearrangement of frequency assignments across the two time periods. This approach is of wide applicability to other spectrum management issues (not just auctions) where a limited set

of frequency assignment options needs to be generated with certain restrictions.

Ultimately the main stage of the auction ended with all winning bidders getting the same contiguous spectrum allocation in each time slice (including Eir's existing 2.1 GHz holdings) and the resulting assignment option generation was relatively simple. Nevertheless, **the assignment stage (including the assignment option generation algorithm) worked well**, with all winning bidders receiving contiguous frequencies aligned across time slices in each band and having a wide range of choice.

Bidder engagement and training

Steps were taken to engage actively with bidders to ensure that there was a sufficient level of understanding of the rules, their implications, and the operation of the EAS. This included extensive documentation, presentations (available as recorded videos), mock auctions and access to a 'playground' version of the EAS on which bidders could prepare by running their own training auctions. These activities were intended to reduce the advantages that well-resourced and more experienced bidders might have.

The fact that both the three MNOs and a non-MNO bidder won a considerable amount of spectrum suggests that **the auction design and training provided to bidders also met the objective of ensuring a level playing field amongst interested parties.**

Concluding remarks

Overall, we consider that the **award was conducted in a way that met ComReg's objectives and statutory obligations, leading to a very good outcome that facilitates downstream competition**, and that ComReg's choices in relation to the auction design and measures to ensure effective competition were justified and appropriate.

1 Introduction

In January 2023, ComReg completed the award of spectrum rights of use in the 700 MHz, 2.1 GHz, 2.3 GHz and 2.6 GHz bands (the Multi Band Spectrum Award 2022, or 'MBSA2') assigning 465 MHz of highly valuable spectrum into the Irish telecoms market. This represents a 46% increase on the amount of spectrum previously assigned to the market. The award of spectrum in the 700 MHz band was of particular importance given its favourable characteristics for the deployment of widespread 5G coverage, including on transport paths and in rural areas.

1.1 Framework for the award

Spectrum available

The spectrum on offer in the award comprised:

- 2x30 MHz of FDD spectrum in the 700 MHz duplex band;
- 2x60 MHz of FDD spectrum in the 2.1 GHz band (2x45 MHz available from 16 October 2022 on expiry of Three and Vodafone's existing licences; and a further 2x15 MHz available on expiry of Eir's existing licence in March 2027);
- 100 MHz of TDD spectrum in the 2.3 GHz band, with the top 10 MHz subject to tighter usage restrictions than the rest of the band;
- 2x70 MHz of FDD spectrum in the 2.6 GHz band; and
- 50 MHz of TDD spectrum in the 2.6 GHz band, with the top and bottom 5 MHz blocks subject to usage restrictions given adjacent 2.6 GHz FDD users.

The award provided a rare and important opportunity to allocate several important wireless broadband bands at the same time. Annex A provides further details about the spectrum available in each of the bands.

Efficiency was the primary objective

The design of the award process was underpinned by ComReg's statutory obligations⁹, including achieving efficient allocation and optimal use of the spectrum. Of particular consideration were the scope for potentially strong complementarities across and within bands, and the uncertainty over the efficient long-run distribution of the substitutable higher frequency bands.

Competition concerns

The main competition concern was the potential for highly asymmetric spectrum holdings across the MNOs after the award, which could lead to distortions of competition in the downstream mobile market. This was a founded concern given the large amount

⁹ Including promoting effective competition, promoting the interests of users, and ensuring the effective management and efficient use of spectrum in Ireland.

of spectrum on offer as well as the pre-existing asymmetry in spectrum holdings across MNOs (in part caused by the 2014 merger between Telefónica and Hutchison 3G, which was opposed by ComReg¹⁰, and which left Three with more spectrum than the other MNOs). This concern applied to total spectrum holdings, as well as sub-1 GHz spectrum separately due to the importance of the lower frequency bands to mobile operators for cost-effective, widespread 5G coverage.

On the other hand, some asymmetry across operators is reasonable (and potentially efficient). Therefore, the design of the award needed to balance the efficiency benefits of allowing market mechanisms in the auction to establish the optimal split of spectrum between operators with the risk of highly asymmetric MNO spectrum holdings post-auction.

Potential for non-MNO participation

Before the award, ComReg considered that, although uncertain, there was a reasonable possibility of successful participation by parties other than the MNOs, noting that:

- the supra-1 GHz bands may be attractive for services other than mobile, such as fixed wireless access (FWA); and
- there was successful participation of two non-MNOs (Imagine and Dense Air) in the 2017 3.6 GHz band award in Ireland.

Another consideration for the award was, therefore, the need to ensure that participation from smaller bidders was not discouraged.

Misalignment of frequency availability dates in the 2.1 GHz band

Ideally, all of the rights of use within a band should have the same start date and duration, to ensure that the distribution of spectrum in the long run is not affected by differences in same, and to avoid potential disruption to consumers if different frequencies became available or expire at different times. However, the existing licence expiry dates in the 2.1 GHz band were misaligned:

- the licences held by Vodafone and Three prior to the award were due to expire in 2022, but with Three's licences expiring slightly earlier than Vodafone's; and
- Eir's licence is due to expire significantly later, in 2027, but was included in the award to support long-term efficient allocation and management of the spectrum.

The difference between Vodafone's and Three's expiry dates was removed by giving Three the option of taking up short-term interim licences to effectively align the expiry of its 2.1 GHz band licences with that of Vodafone's. ComReg could then apply a common start date for new licences for the associated spectrum.

However, using the same approach in relation to Eir's 2.1 GHz band licence was unreasonable given the significant difference in expiry dates. ComReg therefore decided to award new licences for

¹⁰ ComReg Document [14/53](#)

spectrum in the 2.1 GHz band in two distinct time periods ("time slices"):

- **Time slice 1** covered the period up to 11 March 2027; and
- **Time slice 2** covered the period from 12 March 2027 to 13 February 2042.

Time slicing was also applied to the 2.3 GHz and 2.6 GHz bands due to their likely close substitutability with 2.1 GHz spectrum, giving flexibility over the long-term allocation of the supra-1 GHz bands in the auction. Spectrum blocks in the 700 MHz band were offered for the whole duration and no time slicing was used for this band.

Complications from time slicing

Time slicing introduced some issues that needed to be considered in the design of the award:

- It introduced complementarities between lots in the same band across the two time slice periods;
- The different time slices were not expected to be substitutes, but rather only complements. However, allowing switching across time slices might have provided gaming opportunities for bidders. Preventing this required sophisticated activity rules; and
- It was reasonable to expect bidders to have a strong preference for being assigned the same or nearby frequencies across both time slices. To reflect this, the determination of assignment options in the assignment stage in the time sliced bands presented assignment options with no or relatively little misalignment across both time periods.

Covid licences

In April 2020, following the Irish Government's emergency measures against the COVID-19 pandemic, ComReg issued Temporary ECS licences ('COVID licences') in the 700 MHz and 2.1 GHz bands to the three MNOs. Due to the exceptional circumstances created by the pandemic, these licences were needed to support those operators dealing with the significant changes to network traffic patterns.

The COVID licences took the form of short-term three-month rights of use, with a peppercorn charge of €100 for each licence and the option to renew for a further three months. The COVID licences gave the MNOs access to:

- up to 2x10 MHz each in the 700 MHz band; and/or
- liberalised use of the frequencies currently assigned to the operators in the 2.1 GHz band (which were previously limited to provision of UMTS/3G service).

The COVID licensing framework was renewed a number of times by ComReg, until the final COVID licences were issued on 2 July 2022 with expiry on 1 October 2022).

All three MNOs took up the 700 MHz COVID licences for the maximum term available. Eir also utilised a liberalised COVID licence in the 2.1 GHz band for the whole duration, whereas Vodafone and

Three ceased to use them as of July 2021, following liberalisation of their existing licences under the terms of the MBSA2.

Short-term licences

Delays to the MBSA2 caused by the legal challenge subsequently meant that new licences could not be issued before expiry of the COVID licences in October 2022. To avoid consumer disruption, ComReg therefore had little option but to introduce a further temporary licence scheme that allowed continued use of the 700 MHz and 2.1 GHz spectrum by the MNOs beyond October 2022 until the start of new licences.

Implications of COVID/short-term licences

Whilst the COVID/short-term licences had limited implications for the award of the 2.1 GHz band, they changed the landscape going into the award in respect of the 700 MHz band. With these licences, the MNOs had made certain investments to use the 700 MHz band, thereby potentially creating a toehold on this spectrum. That meant a sizeable risk of dampening competition in the auction for valuable spectrum that operators would otherwise have been able to freely bid for without any incumbency coming into play. Unfortunately, this was unavoidable given the exceptional circumstances of the pandemic and the lack of alternative options available to ComReg.

1.2 Award design

Auction stages

ComReg established a two-stage process for the allocation of the available spectrum:

- the '**main stage**' used a Combinatorial Clock Auction (CCA) with relaxed bidding activity rules to determine the amount of spectrum, offered in a number of frequency-generic and frequency-specific lot categories, to be assigned to each bidder; and
- the '**assignment stage**', which used a sealed bid process for establishing the specific frequencies to be assigned to winners of frequency-generic lots in the main stage, allowing winning bids for different locations within the band.

Lot structure

For the main stage, the majority of the spectrum available could be offered as frequency-generic 5 MHz or 2x5 MHz lots within the relevant band. The exceptions to this were the top 10 MHz in the 2.3 GHz band and the top and bottom 5 MHz blocks in the 2.6 GHz TDD band, which are unavoidably subject to usage restrictions and were offered as frequency-specific lots in separate lot categories.

Spectrum in the 700 MHz band was offered for the whole duration with no time slicing, whilst spectrum in the supra-1 GHz bands was offered separately for each time slice.

Fees and minimum prices

As with ComReg's approach in previous spectrum awards, the fees to be paid by winning bidders for each lot were split between an upfront spectrum access fee (SAF) determined in the auction

(payable prior to licence issue), and spectrum usage fees (SUFs) payable annually for the duration of the licence.

To set reserve prices and SUFs for each lot, ComReg set a minimum price for each lot and split this between the reserve price (which establishes the minimum SAF) and the SUFs using a 40:60 ratio.

The lot structure and minimum prices are set out in Table 1. Overall, the main stage of the auction involved 113 lots, split across 15 lot categories.

Table 1: MBSA2 lot structure and minimum fees

Lot category	Band	Mode	Frequency range	Time slice	Licence term	Lot size	No. lots	Reserve price per lot (€)	Annual SUF per lot (€)
B700	700 MHz	FDD	703–733 MHz / 758–788 MHz	1&2	02 Oct 2022 – 13 Feb 2042	2x5 MHz	6	8,971,000	998,931
B2.1/1	2.1 GHz	FDD	1920–1980 MHz / 2110–2170 MHz	1	16 Oct 2022 – 11 Mar 2027	2x5 MHz	9	1,434,000	525,753
B2.1/2	2.1 GHz	FDD	1920–1980 MHz / 2110–2170 MHz	2	12 Mar 2027 – 13 Feb 2042	2x5 MHz	12	3,275,000	525,753
B2.3/1	2.3 GHz	TDD	2300–2390 MHz	1	02 Oct 2022 – 11 Mar 2027	5 MHz	18	145,000	52,575
B2.3/2	2.3 GHz	TDD	2300–2390 MHz	2	12 Mar 2027 – 13 Feb 2042	5 MHz	18	327,000	52,575
A2.3/1	2.3 GHz	TDD	2390–2400 MHz	1	02 Oct 2022 – 11 Mar 2027	10 MHz	1	197,000	52,575
A2.3/2	2.3 GHz	TDD	2390–2400 MHz	2	12 Mar 2027 – 13 Feb 2042	10 MHz	1	285,000	52,575
B2.6F/1	2.6 GHz	FDD	2500–2570 MHz / 2620–2690 MHz	1	02 Oct 2022 – 11 Mar 2027	2x5 MHz	14	289,000	105,151
B2.6F/2	2.6 GHz	FDD	2500–2570 MHz / 2620–2690 MHz	2	12 Mar 2027 – 13 Feb 2042	2x5 MHz	14	655,000	105,151
A2.6TL/1	2.6 GHz	TDD	2570–2575 MHz	1	02 Oct 2022 – 11 Mar 2027	5 MHz	1	25,000	5,000
A2.6TL/2	2.6 GHz	TDD	2570–2575 MHz	2	12 Mar 2027 – 13 Feb 2042	5 MHz	1	35,000	5,000
B2.6T/1	2.6 GHz	TDD	2575–2615 MHz	1	02 Oct 2022 – 11 Mar 2027	5 MHz	8	145,000	52,575
B2.6T/2	2.6 GHz	TDD	2575–2615 MHz	2	12 Mar 2027 – 13 Feb 2042	5 MHz	8	327,000	52,575
A2.6TU/1	2.6 GHz	TDD	2615–2620 MHz	1	02 Oct 2022 – 11 Mar 2027	5 MHz	1	25,000	5,000
A2.6TU/2	2.6 GHz	TDD	2615–2620 MHz	2	12 Mar 2027 – 13 Feb 2042	5 MHz	1	35,000	5,000

Spectrum competition caps

Two (precautionary) spectrum competition caps were applied to limit the amount of spectrum bidders could acquire in the auction, taking into account existing holdings in other relevant bands:

- **Sub 1- GHz cap:** a cap of 70 MHz (2x35 MHz) across the 700 MHz, 800 MHz and 900 MHz bands, limiting the amount of 700 MHz spectrum that could be acquired in the MBSA2;
- **Overall cap:** a cap of 375 MHz across the 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz, 2.3 GHz, 2.6 GHz and 3.6 GHz bands.

1.3 Process – consultation steps and legal dispute

Consultation process

The MBSA2 was subject to a comprehensive sequence of consultations covering both key policy/substantive decisions and technical details of the award process. Plans for the award began in 2014 with a consultation on the award of spectrum in the 2.6 GHz with the possible inclusion of the 700 MHz, 1.4 GHz, 2.3 GHz and 3.6 GHz bands. ComReg subsequently separated out the 3.6 GHz band and awarded this in a separate process in 2017. Consultation on a multi-band award recommenced in 2018 with a consultation on the bands to include. Subsequent consultations covered coverage obligations, spectrum caps, spectrum packaging and guard bands, and detailed auction format. Annex C provides a list of the documents related to the auction design published by ComReg.

During the consultation process, Three contested the sub-1 GHz competition cap, in particular when combined with the CCA. Initially it argued that the cap itself was discriminatory, with the issues exacerbated by the proposal to also use a CCA.¹¹ Subsequently Three said that its complaint was not with the cap per se but with its interaction with the auction format (and even proposed various alternative approaches it considered acceptable whilst allowing for the cap to remain unchanged). In particular, Three theorised that its inability to bid for a third block of 700 MHz spectrum, even if that bid did not win, would lead to it paying more than other MNOs for winning two blocks or potentially not winning any 700 MHz spectrum at all.

ComReg considered the concerns raised by Three in detail in Chapter 6 of Document 20/122 and responded to Three in its consultation response. This was supported by a detailed analysis from DotEcon, showing why Three's concerns were unfounded.

¹¹ ComReg document 19/124g, Chapter 1.8.

*Legal challenge
followed ComReg's
final Decision*

Nevertheless, following publication of ComReg's final Decision on the award (Document 20/122) in December 2020, Three lodged a legal challenge of the Decision, concerning the implications of the spectrum competition cap on sub-1 GHz spectrum within the chosen auction format. This caused significant delays to the award, although ComReg made efforts to progress as quickly as possible and proposed to commence the auction pending judgement on the appeal.

Further delays then occurred following an application from Three and subsequent granting by the High Court of a stay on commencing the main stage of the auction. However, the stay was amended following successful appeal by ComReg, allowing ComReg to run the auction but not issue new licences pending judgement in the main proceedings.. Annex D provides further details about the timing of Three's legal challenge and its resolution.

*Conclusion of the
auction*

The main stage of the auction was completed in December 2022, following which Three discontinued its appeal of the Decision in its entirety. The stay was subsequently lifted, and consequently there was no longer any impediment to completing all remaining stages of the MBSA2 and issuing new licences. The auction process was completed in January 2023, with the outcome itself showing that none of the harms claimed by Three came to pass.

*Impact of the legal
challenge*

A significant consequence of the appeal and subsequent legal process was the cost to the Irish economy resulting from a long delay to the award of important spectrum for the roll out of widespread 5G and improved WBB services. As part of the MBSA2 litigation, ComReg submitted evidence from Dr. Dan Maldoom¹² (which was verified by Prof. Peter Clinch¹³) regarding the magnitude of these costs, which were estimated by DotEcon to be in the order of €1 bn per annum, and potentially double that.

Other practical complications also arose as a result of the delay since:

- new licences could not be issued before the expiry date of some existing licences in the 700 MHz and 2.1 GHz bands, requiring the introduction of a short-term licensing framework for those bands to deal with the interim period;
- the start dates of new licences needed to be adjusted, requiring updates to the minimum prices for each time slice; and
- the auction could ultimately not be completed in time for new licences to start on the formal commencement dates set out in the IM (which needed to be set before the application deadline for the award) and the contingency process for establishing

¹² ComReg Document 23/35a

¹³ ComReg Document 23/35b

refunds on licence prices in accordance with delayed commencement.

The sub-1 GHz cap was justified despite the delay

While we are of the view that ComReg was fully justified in not acceding to Three's request to relax the sub-1 GHz cap for the reasons set out in its Decision, it is worth noting that even if ComReg had acceded to Three's request to relax the sub-1 GHz cap, there is no certainty that this would have avoided this delay and its costs. Such a modification could simply have triggered an appeal from an interested party other than Three, which could also have delayed matters.

In addition, had ComReg modified the sub-1 GHz cap, say to allow all MNOs to acquire three blocks of 700 MHz spectrum within the auction, this could have permitted outcomes for the distribution of sub-1 GHz spectrum that were much more asymmetric than the pre-auction position, potentially with one MNO holding twice as much spectrum as another. This would have entailed substantial economic welfare losses from distorted downstream competition, potentially over a long period, as there are no current plans for further release of sub-1 GHz spectrum.

Therefore, even in hindsight knowing the delay that ensued, we consider that ComReg's sub-1 GHz cap was entirely justified.

MNOs may have benefited from the delay

We also note that delay of the award may have benefited the MNOs in that ComReg had little option but to continue to provide short-term access to spectrum, initially through COVID licences, at a peppercorn charge of €100 per 3-month licence. Lack of long-term access to spectrum also provided a common constraint on network investment across all MNOs, deferring capital expenditure. A general observation is that situations can arise where an existing spectrum licensee has ability and incentive to delay a spectrum award when this also constrains its competitors.

1.4 Outcome of the award

The MBSA2 outcome provides a highly favourable framework for a competitive Irish telecoms industry. All of the available spectrum sold (except for the upper 2.6 GHz TDD lot which was subject to usage restrictions given adjacent 2.6 GHz FDD users) with a good distribution across winners, resulting in indicative total licence fees of EUR 448,280,279 to be paid across the life of the licences.

The auction results are summarised in the table below.

Table 2: MBSA2 auction results

Band	Time Slice	Imagine	Eir	Three	Vodafone
700 MHz	1&2	-	2 x 10 MHz	2 x 10 MHz	2 x 10 MHz
2.1 GHz	1	-	2x5 MHz	2 x 20 MHz	2 x 20 MHz
	2	-	2x20 MHz	2 x 20 MHz	2 x 20 MHz
2.3 GHz B lots	1	30 MHz	60 MHz	-	-
	2	30 MHz	60 MHz	-	-
2.3 GHz A lots	1	10 MHz	-	-	-
	2	10 MHz	-	-	-
2.6 GHz FDD	1	-	-	2 x 35 MHz	2 x 35 MHz
	2	-	-	2 x 35 MHz	2 x 35 MHz
2.6 GHz TDD A lot (lower)	1	5 MHz	-	-	-
	2	5 MHz	-	-	-
2.6 GHz TDD B lots	1	10 MHz	-	-	30 MHz
	2	10 MHz	-	-	30 MHz
2.6 GHz TDD A lot (upper)	1	-	-	-	-
	2	-	-	-	-
Base price		€12,370,000	€56,761,000	€48,508,000	€48,091,000
Additional price		€0	€0	€100	€183,664
Total SAF		€12,370,000	€56,761,000	€48,508,100	€48,274,664
Total SUFs ¹⁴		€9,085,325	€83,484,262	€91,901,689	€97,895,239
Total price		€21,455,325	€140,245,262	€140,409,789	€146,169,903

¹⁴ SUFs are indexed to CPI and paid annually over the duration of the licence. SUF figures presented here do not assume any adjustment and are thus indicative.

2 Assessment of the auction outcome

Overall, the award has resulted in a very good outcome for the Irish telecommunications market and consumers. All of the incumbent MNOs added to their existing spectrum holdings in the sub-1 GHz and higher frequency bands, the distribution of spectrum across MNOs is less concentrated than before the award, and the auction saw a significant amount of spectrum awarded to a non-MNO, Imagine.

2.1 MNO spectrum holdings

All MNOs won a mix of sub-1 GHz and higher frequencies

Each of the incumbent MNOs (Eir, Three and Vodafone) won a combination of 700 MHz spectrum and higher frequencies:

- the 700 MHz band was split evenly between the MNOs, with each operator winning 2x10 MHz;
- the 2.1 GHz band was also shared by the MNOs, with each of them having access to 2x20 MHz over the duration of the new licences¹⁵; and
- each of the MNOs increased their total holdings of higher frequency spectrum, with Vodafone and Three winning spectrum in the 2.6 GHz band and Eir winning a significant amount in 2.3 GHz band.

This outcome will allow for both the continued provision of existing services as well as the expansion of existing networks and the widespread roll-out of high-speed 5G services.

Reduced concentration of holdings across MNOs

The outcome of the award should also be favourable for consumers, in terms of supporting competition between the MNOs. All of the MNOs have increased their overall spectrum holdings, with additional spectrum in both the sub-1GHz and higher frequency bands, and with no individual operator being clearly deficient in spectrum relative to the others.

The tables below show the pre-award and post-award positions of the MNOs in terms of spectrum holdings and resulting asymmetry¹⁶

¹⁵ Eir has an existing licence for 2x15 MHz of spectrum in the 2.1 GHz band that runs until 11 March 2027, so even though it only won a single 2x5 MHz lot in the 2.1 GHz band for time slice 1 it will still have access to a total of 2x20 MHz in the band over the full duration of both time slices.

¹⁶ We measure asymmetry as the difference between the largest and smallest spectrum holdings (amongst the MNOs).

expressed both in absolute terms and as a percentage of the total spectrum licensed to the MNOs.¹⁷

Table 3: MNO spectrum holdings pre- and post-award

Band	Pre-award holdings (MHz)			Post-award holdings (MHz)		
	Eir	Three	Vod.	Eir	Three	Vod.
700 MHz	-	-	-	20	20	20
800 MHz	20	20	20	20	20	20
900 MHz	20	30	20	20	30	20
Total sub-1GHz	40	50	40	60	70	60
1800 MHz	30	70	50	30	70	50
2.1 GHz	30	60	30	40	40	40
2.3 GHz	-	-	-	60	0	0
2.6 GHz FDD	-	-	-	0	70	70
2.6 GHz TDD	-	-	-	0	0	30
3.6 GHz	85	100	105	85	100	105
Total >1 GHz	145	230	185	215	280	295
Total	185	280	225	275	350	355

Table 4: Pre- and post-award asymmetry in MNO spectrum holdings

Bands	Pre-auction asymmetry		Post-auction asymmetry	
	MHz (largest – smallest)	% of total MNO holdings	MHz (largest – smallest)	% of total MNO holdings
Sub-1 GHz	10	7.69%	10	5.62%
Total	95	13.77%	80	8.16%

¹⁷ For this discussion on asymmetry, we use Three's pre-award holdings of 2x30 MHz in the 2.1 GHz band, rather than its holdings in the band at the time of the auction (2x20 MHz).

We observe that:

- in the sub-1GHz bands, the asymmetry has improved in terms of the percentage of the total sub-1 GHz spectrum assigned to the MNOs, and has remained the same in absolute MHz (since all MNOs won the same amount of 700 MHz spectrum in the award); and
- the overall asymmetry in overall spectrum holdings has fallen, both in absolute terms and as a percentage of total MNO holdings.

Overall, the distribution of licensed spectrum between the MNOs is notably more even than it was before the award. Moreover, the post-award asymmetry is smaller than the maximum that would have been allowed under the spectrum competition caps. For example, if we assume there were no other winners and the MNOs won as much as they could, the asymmetry could have been as much as 20 MHz in the sub-1 GHz bands¹⁸ (double the asymmetry arising from the award outcome) and 85 MHz overall¹⁹. If we keep Imagine's winnings in the auction fixed and redistribute the remaining spectrum amongst the MNOs, the post-award asymmetry could have been 20 MHz in the sub-1 GHz bands and 140 MHz overall.

2.2 Non-MNO winner

A large amount of spectrum was awarded to a non-MNO, Imagine, which offers fixed wireless broadband services as an alternative to FTTH, also targeting customers in rural areas with limited or no access to fibre networks.

As a result of the MBSA2, it has been assigned rights of use for a total of 55 MHz until 2042, consisting of 40 MHz in the 2.3 GHz band (40% of the available spectrum in the band), along with 15 MHz in the 2.6 GHz TDD band. This spectrum is added to its existing 60 MHz of 3.6 GHz spectrum in regional parts of Ireland which it was awarded in the 2017 3.6 GHz award.

2.3 FDD vs TDD

Historically, FDD has been considered a superior option to TDD for mobile services and the primary choice for 2G and 3G networks where data traffic was broadly symmetric. However, modern 4G and

¹⁸ Asymmetry of 20 MHz in the sub-1 GHz bands would have arisen in the case that Vodafone won three 700 MHz blocks (2x15 MHz), Three won two 700 MHz blocks (2x10 MHz) and Eir won a single 700 MHz block (2x5 MHz).

¹⁹ Overall asymmetry of 85 MHz would result from Vodafone winning 180 MHz in the award, Three winning 155 MHz, and Eir winning the remaining 135 MHz.

5G technologies can make effective use of both FDD and TDD frequencies, with TDD being particularly useful for services with asymmetric traffic patterns (such as mobile broadband and fixed wireless broadband).²⁰

*Greenfield
environment in the
MBSA2*

The MBSA2 provides an interesting case study in that the 2.3 GHz and 2.6 GHz bands were unassigned going into the award, offering an opportunity to observe how demand and prices for TDD and FDD spectrum might emerge in a 'clean slate' environment where:

- operators can choose the mix of TDD/FDD desired on a forward-looking basis with both types of spectrum requiring new investment and no constraints to use the frequencies for maintaining legacy services; and
- consequently, prices could be expected to represent operators' views on the relative value of FDD and TDD based on future use of the spectrum, without being skewed by the intrinsic value associated with frequencies already in use due to avoiding the need to reconfigure networks and disruption to existing services.

This is a scenario that is not typically observable (in the current environment) in other European countries due to historic assignments of spectrum in comparable bands with significant amounts of FDD and TDD available for Mobile and Fixed Communications Networks (MFCN) (such as 2.6 GHz).

*Round prices do not
suggest that FDD is
preferred to TDD*

Bidding in the MBSA2 suggests that FDD is no longer considered materially superior to TDD. Indeed, final round prices for frequency-generic 5 MHz TDD spectrum were similar to (and slightly in excess of) prices for the 2 x 5 MHz 2.6 GHz FDD spectrum on a per-lot basis (so more than double per MHz), which would be unlikely if FDD spectrum were significantly more valuable than TDD. This may be relevant for future spectrum awards when setting relative minimum prices and/or eligibility points, which often take into account expected relative value of the spectrum.

²⁰ With FDD, the uplink and downlink capacities are fixed, meaning that if traffic is asymmetric some of the spectrum will be underused and that operators will have had to acquire more overall bandwidth than necessary.

3 Performance of the auction design

3.1 Spectrum competition caps

Spectrum competition caps aimed at preventing extreme outcomes

The spectrum competition caps for the award were set to prevent award outcomes with excessive (and potentially anti-competitive) asymmetry in spectrum holdings across the MNOs, whilst also allowing for the allocation of spectrum to be determined by competition in the award.

In terms of the sub-1 GHz cap, it is important to recognise that, under the objective above, there was little choice for ComReg but to apply a 70 MHz cap. Anything more would have created the possibility for one MNO (Three) to hold double the amount of sub-1 GHz spectrum than another (either Vodafone or Eir) after the award. A more restrictive cap would have meant the MNOs could not acquire all the 700 MHz spectrum between them, risking inefficiently unsold spectrum in the absence of demand from other parties.²¹

Evidence that caps did not unduly restrict bidders or efficiency of the outcome

No bidder won the maximum amount of spectrum allowed under the overall cap of 375 MHz (inclusive of existing holdings).²² In the 700 MHz band, both Vodafone and Eir won 2x10 MHz, strictly below the maximum amount they could have acquired, while Imagine did not win any. These bidders were therefore not ultimately constrained by the cap on sub-1 GHz holdings. Three won 2x10 MHz, which was the maximum it could acquire under the cap given its existing sub-1 GHz holdings. It is feasible that Three might have bid for and won more 700 MHz spectrum if it had not been constrained by the sub-1 GHz cap, but such an outcome was considered to be potentially harmful to downstream competition.

On that basis, the distribution of spectrum would have been determined solely by competition within the award, without being shaped by the caps and with the role of the caps entirely to prevent highly asymmetric outcomes with consequent risks to competition in downstream markets.

3.2 Use of a combinatorial format

Complementarities

One of the main reasons for using a combinatorial format was to mitigate aggregation risks that might arise from complementarities

²¹ See ComReg document 19/59a for a more detailed assessment of the options for setting spectrum competition caps.

²² Of the Three MNOs, Vodafone came the closest, but still ended the award with 20 MHz less than it could have acquired.

between the lots offered in the auction. In particular, there was an expectation of complementarity:

- within bands, due to bidders requiring a minimum number of lots in order to obtain a minimum usable bandwidth;
- across bands, due to bidders seeking a portfolio of spectrum in different bands e.g. a mix of sub-1 GHz spectrum (for coverage) and higher frequencies (for capacity); and
- across time slices, where there would likely be benefits from not having to contract spectrum holdings/usage (if acquiring spectrum in time slice 1 but not time slice 2) or needing to wait until time slice 2 to make use of the spectrum (if acquired only for time slice 2).

The auction outcome is consistent with the presence of such complementarities, as:

- all winners won more than one lot in each band;
- all winners won spectrum in more than one band; and
- all winners won the same bandwidth in both time slices in each band, with the exception of Eir in 2.1 GHz, which won less bandwidth in time slice 1 where it already held some spectrum.

Moreover, aggregate demand data from the primary bid rounds provides evidence of bidders switching multiple lots as a block across lot categories, suggesting synergies arising from holding multiple lots within a band.

It is not possible to know what the outcome would have been under a format that exposed bidders to aggregation risks, but the outcome does not suggest that bidders would have been willing to take lots expected to be complementary on a standalone basis.

3.3 Facilitating participation from non-MNOs

The CCA facilitates participation by smaller bidders and non-MNOs

Another reason for choosing the CCA for the award was that the format is well set up for incentivising smaller bidders to participate and compete for spectrum against larger players. The outcome, with a non-MNO winner, suggests that the format was successful in encouraging non-MNO players to participate.

The CCA has advantages for small/new players. In particular, new players may have greater complementarities than established ones (like MNOs) in relation to the lots they bid for, as bidders who already hold frequencies can use these as complements to new lots they acquire. By suppressing aggregation risk, the CCA can encourage participation from small bidders who need to be prepared to reduce demand or even leave the auction in the event that lots become too expensive. Imagine competed for (and won) a significant amount of spectrum, including a large block of contiguous frequencies in the 2.3 GHz band. If Imagine had strong synergies in

that band, then the use of a CCA might have been crucial in not discouraging its participation.

The CCA also allows bidders to compete for larger quantities of spectrum (rather than reducing demand at prices below valuation) without fear that doing so could affect the price they might pay for a smaller package. This, along with the open nature of the format, supports smaller players in exploring the maximum amount of spectrum they could realistically win and how their demand might fit in against larger bidders. The decision to use the CCA may therefore have played a role in Imagine winning as much spectrum as it did.

However, the drawback when using a combinatorial auction is that it draws on mechanics that can appear complex relative to some other (potentially less suitable) formats. In order not to discourage small/new bidders, it is important to provide support in ensuring that the auction rules and mechanics are well understood by all participants.

Bidder training was effective

In advance of the auction, steps were taken to actively engage with bidders to ensure that there was a sufficient level of understanding of the rules, their implications, and the operation of the Electronic Auction System (EAS). This included extensive documentation, presentations (available as recorded videos) and scripted mock auctions to demonstrate the functionality of the EAS and the activity rules.

Bidders were also provided with access to training tools that allowed them to become familiar with both the auction rules and the specific software implementation. Specifically, bidders were given access to:

- the Auction Playground – a training version of the EAS used to run the main stage of the auction (including exposure price calculations), allowing users to run their own auctions themselves for training and testing purposes; and
- the Online Winner and Price Determination (WDP) tool – a tool allowing users to run scenarios through the algorithms used for establishing winners and prices (for both the main stage and the assignment stage) and for generating assignment options.

These activities were intended to reduce the advantages that well-resourced and more experienced bidders might have.

These training tools were utilised by bidders and appear to have worked very well, with no bidders needing any technical support with the system during the auction. Moreover, the fact that both the three MNOs and a non-MNO bidder won a considerable amount of spectrum suggests that the auction design and training provided to bidders also facilitated a level playing field amongst interested parties.

The fee structure may also have helped Imagine

The structure of minimum prices may also have supported participation from Imagine. The minimum price for each available lot was split into:

- a reserve price, which is the minimum SAF a bidder would need to pay at the end of the auction for a lot it had won; and
- ongoing SUFs, payable annually for the duration of the licence.

For both the MBSA2 and 3.6 GHz awards, ComReg made the decision to apply a 40:60 split of the minimum prices between the minimum SAF and the total (discounted) SUFs. Putting more of the minimum prices into the SUFs meant that a larger proportion of the licence fees would be spread out across the licence duration. This makes it easier for stakeholders with more limited access to upfront capital to bid in the award, thus encouraging smaller players to participate. Indeed, in its response to ComReg document 18/60, Imagine highlighted the difficulties for smaller participants to secure large up-front cash resources and the benefits, in terms of allowing smaller bidders to compete with larger players, of distributing a larger proportion of the fees across annual payments over the term of the licence.²³

3.4 Relaxed activity rules

The auction used so-called relaxed activity rules. Under these rules, bidders are constrained in the bids they can make based on bidding behaviour in previous rounds. However, they allow bidders to increase their activity if doing so would be consistent with revealed preference constraints that arise from their bids in earlier rounds.

Setting eligibility points

The relative eligibility points across different lot categories, used for implementing the activity rules, are typically, and ideally, set such that bidders:

- are able to switch cleanly between substitutable combinations of lots; but
- cannot (or at least find it more difficult to) hide demand in less valuable lots only to bid for more valuable lots later on.

For the MBSA2, ComReg set the eligibility points for lots in the supra-1 GHz bands according to the total bandwidth available in each lot, on the basis that:

- the bands were expected to be substitutes for one-another so bidders should be allowed to switch freely between them; and
- bidders would want to bid for a particular bandwidth and switch between bands as prices evolved.

For the 700 MHz band, each 2x5 MHz lot was worth four eligibility points, on the basis that:

- the 700 MHz spectrum is not a direct substitute for the supra-1 GHz bands; and

²³ See ComReg document ComReg 19/59f.

- applying a larger eligibility weighting to the 700 MHz lots mitigates the risks of bidders hiding demand in the less valuable supra-1 GHz bands before bidding for 700 MHz only in the later stages of the primary bid rounds.

Concerns over relative eligibility points eased by relaxed bidding

However, the large number of different bands and types of spectrum (FDD and TDD) available meant it was very difficult to know whether the eligibility points accurately reflected bidders' valuation structure and desired switching ratios, or how they might be set better. In this context, the use of the relaxed activity rules is important, as it allows bidders to increase their activity when doing so is consistent with revealed preference.

Impact on information revealed during the primary bid rounds

The use of the relaxed activity rules also improves the information revealed in the primary bid rounds. First, because primary bids can be more reflective of bidders' actual valuations. However, also because the relaxed activity rules set an additional constraint on supplementary bids that limits the amount that the bidder can offer for any package relative to the amount it offers for its final primary bid package. As a result, there is less scope for the final outcome to deviate from assigning each bidder its final primary bid and for auction prices to exceed final round prices.

There were relaxed primary bids

There was submission of relaxed primary bids in the auction, suggesting that at least some bidders used the advanced options provided by the relaxed activity rule. This implies that the additional complexity introduced by these sophisticated features was likely justified (i.e. a less efficient auction outcome might well have occurred absent the relaxed activity rules).

3.5 Exposure pricing

Uncertainty about final prices

The MBSA2 was the first spectrum award to implement exposure pricing as part of the information policy. It was introduced by ComReg in response to concerns raised by stakeholders about managing their financial exposure within a second price auction and complications for internal governance with significant uncertainty over final prices relative to bid amounts.

Information revealed by exposure pricing

In each round, each bidder is informed of the discount it could expect to enjoy relative to round prices in the event that the primary bid rounds were to end in that round without excess supply. The discount is calculated by assessing the maximum value that the bidder's competitors can offer for the lots available. If competitors are still able to offer round prices for all of the lots, then the discount is zero. However, if the maximum value that competitors can offer is below round prices, then the bidder can expect a discount (equal to the difference between the value of lots at round prices and the maximum value that competitors can offer). The large number of lot categories in the MBSA2 meant that such a scenario was a realistic

possibility, and so the award offered an ideal opportunity for introducing and testing the new feature.

Support from stakeholders

Stakeholders were supportive of ComReg's efforts and engaged with the introduction of exposure pricing, even providing comments during the preparatory stages for the award that allowed for some refinement of the methodology. The limitations of the information and relevant assumptions appear to have been well understood.

Zero discounts

In many cases, exposure discounts will emerge as zero for all bidders in every round. This occurs whenever rivals have the capability at that point in the auction jointly to bid for all the available lots at round prices. Nevertheless, knowing that their discount is zero is still valuable information for a bidder, as it indicates to the bidder that it may have to pay the full round price for any lots it wins.

Exposure pricing calculations ran smoothly

Before the auction, there were some concerns over the heavy computational load of running the optimisations for calculating exposure price discounts, and the implications that might have for ComReg being able to schedule and run through rounds in a timely manner. ComReg therefore had to undertake to provide the exposure price information to bidders on a 'best efforts' basis. In practice, however, no difficulties arose, there was no additional delay created to the running of primary bid rounds, and the auction has demonstrated the feasibility of calculating exposure price discounts in real time during a CCA. Indeed, ComReg was able to run more rounds per day than in any of its previous auctions and still facilitate the calculation of exposure pricing.

3.6 Time slicing

Reasons and assumptions behind time slicing

The key reasons for time slicing in the 2.1 GHz band were to support inclusion of the frequencies associated with Eir's existing licences in the same auction as the rest of the 2.1 GHz band, whilst avoiding the risks associated with having to allocate frequencies in the same band but with significantly different licence terms for some of the spectrum compared to the rest. In particular, ComReg sought to mitigate the risk of a scenario where a subset of the spectrum would very likely be of much greater interest to one bidder (Eir) than to the others,²⁴ which could have:

- created a clear split of the 2.1 GHz spectrum between Eir and the other MNOs that might have formed the basis for tacit collusion to avoid competition in the award; and/or

²⁴ If time slicing was not applied in the 2.1 GHz band and new licences for the 2x15 MHz of spectrum linked to Eir's existing licence could not start until 2027, the expectation was that those (shorter) licences would naturally have been much more attractive to Eir than to other bidders.

- left Eir susceptible to potential attempts at strategic bidding by others.

Given its likely close substitutability with 2.1 GHz spectrum ComReg also applied time slicing in the 2.3 GHz and 2.6 GHz bands, to allow free switching across all supra-1 GHz bands and provide full flexibility to bidders over their options for long term spectrum holdings. This decision took account of the scope for a redistribution of the 2.1 GHz band and the introduction of likely substitutable spectrum (i.e. 2.3 GHz and 2.6 GHz), with the long-term efficient distribution of the three bands unclear. With Eir's incumbency in the 2.1 GHz band over the beginning period of new licences, time slicing across all supra-1 GHz bands was necessary to facilitate all possible assignments (within the bounds of the spectrum competition caps) beyond 2027. Moreover, time slicing in the 2.3 GHz and 2.6 GHz bands protected Eir from the risk of a scenario where it wished to bid for an amount of spectrum within 30 MHz of the overall competition cap but was then unable to switch out of the 2.1 GHz band as prices evolved.²⁵

Before the award there were questions raised by stakeholders over whether it was necessary to apply time slicing, in particular in the 2.3 GHz and 2.6 GHz bands where all of the spectrum on offer was available for the full duration of both time slices.

Auction outcome could have been achieved without time slices

The eventual outcome of the award would have also been feasible without time slicing, as:

- Vodafone, Three and Imagine all won exactly the same amount of spectrum in each time slice; and
- Eir only won different amounts of spectrum across time slices in the 2.1 GHz band, and that outcome would have been achievable by having long/short 2.1 GHz licences starting in 2022 and 2027.

However, the use of time slicing allowed for a wider range of options and may have affected the degree of competition in the auction. This was important, given the significance of the award for long-term spectrum holdings in Ireland, the uncertainty over the optimal distribution of the higher frequency bands, and the need to ensure an efficient outcome was reached.

Time slicing was appropriate

Time slicing appears to have been appropriate in all three of the supra-1 GHz bands. Whilst it is difficult to fully assess the impact it had, we believe there is nothing in the outcome of the award to suggest that the risks of not time slicing identified prior to the auction were invalid. Furthermore, aggregate demand data indicates that during the auction some bidders did utilise the option to express

²⁵ Given Eir's existing holdings counted towards the competition cap (so it could not bid in the award for as much spectrum in time slice 1 as in time slice 2), if it wanted to end the award with total holdings close to the cap in both time slices it would be forced to bid for the 2.1 GHz time slice 2 lots, since all 2.3 GHz and 2.6 GHz lots (if not time sliced) would count against the cap in both time slices.

valuations for packages with different amounts of spectrum in the two time slices.

3.7 Assignment option generation

The design of the assignment stage (in particular the determination of assignment options for bidders) was highly challenging, primarily due to the use of time slices in the 2.1 GHz, 2.3 GHz and 2.6 GHz bands, but also due to the need for lots with special restrictions at the end of some bands.

Expected benefits from contiguous spectrum and alignment over time slices

There were reasonable grounds to expect bidders winning spectrum in a particular band across both time slices would benefit from being awarded the same contiguous frequencies in both time slices. This is because there are benefits to obtaining contiguous frequencies and there is likely to be some cost and potential consumer disruption associated with having to retune equipment at the end of the first time slice to use different frequencies for the second. ComReg therefore sought to assign contiguous frequencies and reduce the risks to bidders by including provisions in the assignment option generation process that ensured reasonable alignment of frequencies allocated across the two time slices, where possible.

But need to give reasonable choices across bands

However, it was also necessary to be conscious of potential preferences amongst bidders for specific frequencies in each band, some of which could be bidder-specific and some that might be common across multiple bidders. Whilst absolute priority could have been given to minimising misalignment across time slices, that would have the consequence of potentially restricting the options available for some bidders.

Therefore, subject to ensuring all winners were assigned contiguous frequencies (to the extent possible), a balance was needed between the objectives of:

- alignment across time slices; and
- giving winners a broad choice of frequencies across the relevant band.

Meeting these objectives is straightforward in a scenario where, in a given band, all bidders won the same combination of lots in time slice 1 as in time slice 2. In that case, bidders would be assigned the same contiguous frequency range in each time slice (given the lots they won) and assignment options would correspond to the various permutations of winning bidders that were feasible given any other constraints that applied (e.g. ensuring contiguity of fixed lots and frequency generic lots won by the same bidder). However, the situation would be far more complicated in the event that some bidders won different numbers of lots in each time slice and/or different combinations of fixed and frequency generic lots across time slices. In this case it would be completely infeasible to create all

ComReg adopted a novel and complex approach to determining assignment options

possible frequency assignment options and then filter those for options with desirable characteristics due to the potentially astronomical number of possibilities involved.

The resulting algorithm that was developed to generate a range of assignment options balancing the objectives set out above was novel and highly challenging, needing to be robust to the wide range of possible main stage outcomes, as well as the various other restrictions on assignment options. However, this additional complexity was entirely on ComReg's side and would not have affected the ease of participation in the assignment stage for bidders. Consequently, and while ComReg and DotEcon took on the burden of developing this approach, it reduced the likelihood that operators would need a transition process between time slices, saving operators time and resources, and avoiding potential consumer disruption during this period.

The approach may also have wider applicability for other spectrum management issues in the future. In particular, the methodology potentially provides a basis for any scenario where a limited set of frequency assignment options needs to be generated with certain restrictions. This is not limited to auctions, but may, for example, also be relevant for the administrative assignment of frequencies with particular objectives or where certain assignments need to be avoided.

A detailed description of the process for generating assignment options can be found in the Information Memorandum for the award.

3.8 Performance of the assignment stage

AOG process worked very well

Ultimately, the assignment option generation process, and the assignment round in general, worked very well.

Although the assignment options in the auction would have been very simple (since all bidders were assigned the same bandwidth in each time slice) the approach taken meant that:

- all bidders were awarded identical frequency ranges across time slices; and
- winners in the 700 MHz, 2.1 GHz and 2.6 GHz FDD bands had multiple assignment options to bid for (with allocations in the 2.3 GHz and 2.6 GHz TDD bands fixed due to other restrictions on assignment options).

We note that two bidders, Vodafone and Three, were required to pay additional prices resulting from bids submitted in the assignment round. Vodafone paid an additional €183,664 on top of its base price, whilst Three's additional price was €100. Clearly, there were preferences over location within at least one band present amongst

*Importance of
including Eir's 2.1
GHz holdings*

bidders, validating the objective of ensuring bidders had a reasonable range of options.

It is also important to highlight the role of the requirement for Eir's existing holdings in time slice 1 to be incorporated into the assignment stage as if it had been won by Eir in the auction. Without this provision it would not have been possible to allocate contiguous spectrum to all winning bidders in time slice 1 in the 2.1 GHz band since there were only three blocks located below Eir's existing holdings. Given the main stage outcome, at least one winning bidder would have been forced to accept a split 2.1 GHz assignment in time slice 1. Alternatively, bidding in the main stage may have been affected (bidding for four lots in time slice 1 would conceivably have been less attractive if there was a significant risk of receiving non-contiguous frequencies), potentially leading to a less efficient outcome.

4 Concluding remarks

The outcome of the award provides a highly favourable framework for downstream competition, with reduced asymmetric spectrum holdings across the MNOs relative to the pre-award situation.

The choice of auction format, motivated by the scope for complementarities/substitutability within and between bands and the objective to ensure that non-MNOs could compete on a level playing field, appears to have been appropriate given the outcome of the award, with a non-MNO amongst the winners and packages allocated being consistent with expected synergies between lots.

The spectrum competition caps do not appear to have been unduly restrictive, with the outcome of the award determined primarily (if not entirely) through competition and no indication that an outcome considered acceptable for downstream competition might have been prevented.

Moreover, the concerns raised during the legal challenge (which related to the combination of the CCA and cap on sub-1 GHz holdings) do not appear to have arisen or affected the award outcome, and thus we believe it was appropriate for ComReg to proceed on the basis of its proposals and avoid further delays to the award.

Annex A Frequencies available

A total of 470 MHz of spectrum was available for award, split across the 700 MHz, 2.1 GHz, 2.3 GHz and 2.6 GHz bands.

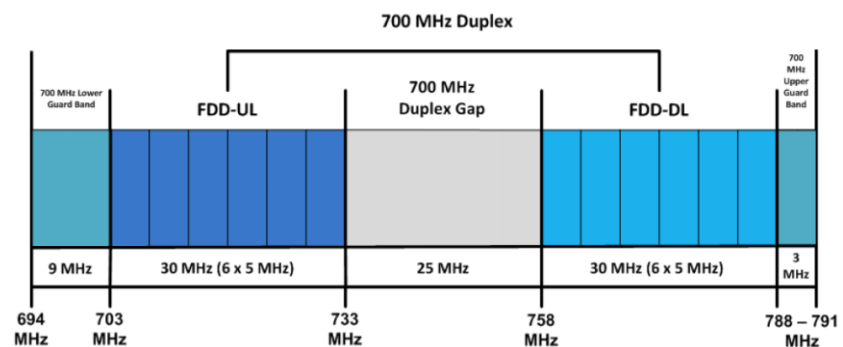
The 700 MHz Duplex band

700 MHz spectrum available

In the 700 MHz band, a total of 2x30 MHz of spectrum was available for award, specifically:

- 703–733 MHz (uplink); paired with
- 758–788 MHz (downlink).

Figure 1: The 700 MHz band



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

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

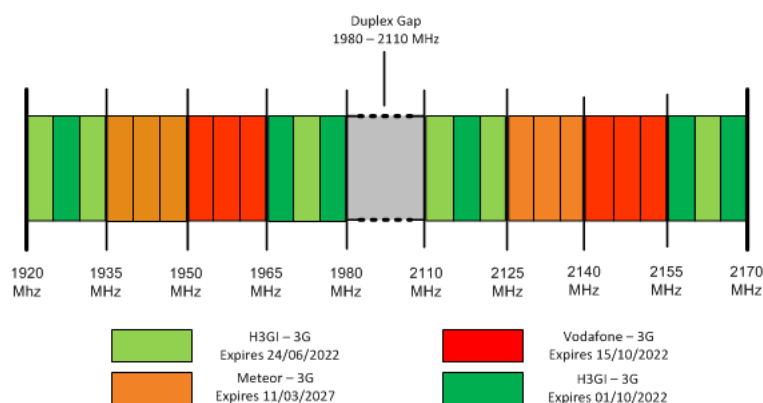
The 700 MHz band became available in Ireland on 4 March 2020. Previously, parts of the band were assigned to Raidió Teilifís Éireann (RTÉ) and used for the provision of Digital Terrestrial Television (DTT).

The 2.1 GHz band

2.1 GHz spectrum available

A total of 2x60 MHz of paired spectrum in the 2.1 GHz band was available in the award, comprising the frequency range 1920-1980 MHz; paired with 2110-2170 MHz.

Figure 2: The 2.1 GHz band



This spectrum is harmonised:

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

Existing 2.1 GHz licences

Prior to the award, Eir, Vodafone and Three all held long-term (20-year) licences for spectrum in the 2.1 GHz band for the provision of UMTS/3G services,²⁶ with varying bandwidths and expiry dates:

- Eir's existing licence is for 2x15 MHz of spectrum and expires on 11 March 2027;
- Vodafone had a licence for 2x15 MHz of spectrum in the band, expiring on 15 October 2022; and
- Three held two licences for a total of 2x30 MHz of spectrum in two non-contiguous blocks; these comprised three 2x5 MHz spectrum rights in the 'A Licence', which expired on 24 July 2022, and three 2x5 MHz spectrum rights in the 'B Licence', which expired on 1 October 2022.

This meant that:

- 2x45 MHz of spectrum in the band was available for the award of new licences commencing in 2022; and
- an additional 2x15 MHz was available from March 2027.

The 2.3 GHz band

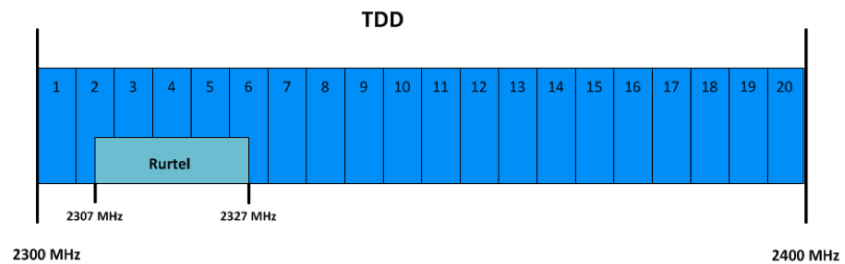
2.3 GHz spectrum available

The 2.3 GHz spectrum available in the award comprised a contiguous 100 MHz block in the frequency range 2300–2400 MHz. However, the top 10 MHz (2390–2400 MHz) is subject to a lower in block EIRP

²⁶ In accordance with ECC Decision (06)01.

limit than the rest of the band, to support coexistence with systems above 2.4 GHz.

Figure 3: The 2.3 GHz band



The band is harmonised at CEPT level via ECC Decision (14)02, which sets out the frequency arrangement and LRTC for the band.

Use of the band by RurTel

Prior to the award, the 2.3 GHz band was largely unused in Ireland. However, in 2019, when ComReg first consulted on proposals for the award, Eir held 45 regional licences for spectrum in the range 2307–2327 MHz, covering parts of Kerry, Galway and Donegal. These licences were used by Eir to operate its RurTel service (a point-to-multipoint system providing fixed telephony in rural areas), in order to meet its universal service obligation (USO). ComReg considered that national licences could be awarded for those frequencies, but with the potential need for coordination zones around the areas covered by the RurTel licences.

Eir subsequently reduced the number of RurTel base stations in operation and is moving towards fully vacating the band. On publication of ComReg's final Decision for the award (ComReg document 20/122) in December 2020, the RurTel network had been decommissioned in Kerry, and ComReg had informed Eir that its RurTel licences in Galway would not be renewed as of January 2021. This left only the Donegal part of the RurTel network in operation. ComReg has worked closely with Eir to formulate a final transition plan that is expected to see the RurTel operations in the 2.3 GHz band fully decommissioned in 2024.

The 2.6 GHz band

2.6 GHz spectrum available

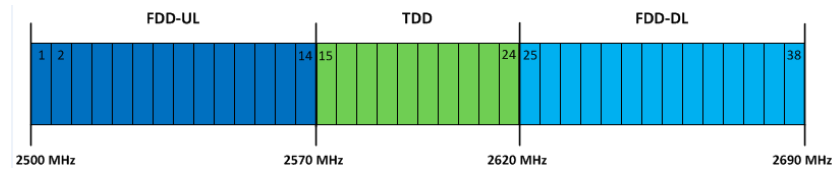
A total of 190 MHz was available for award in the 2.6 GHz band, in the frequency range 2500–2690 MHz.

ECC Decision (05)05 (amended in July 2015 and again in July 2019) harmonises the band for MFCN at CEPT level, setting out the Least Restrictive Technical Conditions (LRTC) to be applied to the use of the spectrum as well as the (primary) band plan arrangement, comprising:

- the 2.6 GHz Duplex: 2x70 MHz for FDD operation in the frequency bands 2500–2570 MHz (uplink) paired with 2620–2690 MHz (downlink); and

- the 2.6 GHz Duplex Gap: a contiguous 50 MHz block of spectrum in the band 2570–2620 MHz, which can be used for TDD or other usage modes complying with the technical conditions.

Figure 4: The 2.5 GHz band



There was scope, under the provisions of European Commission Decision 2008/477/EC, to adopt an alternative band plan with some or all of the 2.6 GHz duplex sub-bands being used for TDD rather than FDD, but ComReg chose to adopt the primary band plan set out above.

2.6 GHz TDD restricted use blocks

In the TDD portion, the top and bottom 5 MHz blocks (2570–2575 MHz and 2615–2620 MHz) are subject to usage restrictions given adjacent 2.6 GHz FDD frequencies.

Coexistence with IAA radars

At the time of the award the 2.6 GHz band had no other users in Ireland and was entirely free for assignment. However, some measures were necessary to ensure compatibility and co-existence between:

- new MFCN base stations in the 2.6 GHz band; and
- four aeronautical radars owned and operated by the Irish Aviation Authority (IAA) using spectrum in the 2.7 GHz band.

Two of these radars are located in Dublin (one Thales Star 2000 radar and one Thales TA10M radar), while the other two (both Star 2000 units) are in Cork and Shannon.

To mitigate the potential for interference due to blocking and intermodulation, the Irish Aviation Authority (IAA) has agreed to install filters on its three existing Star 2000 radars, and to replace the TA10M unit with a new Star 2000 radar (with filter installed). On top of this, following the advice of Plum Consulting (ComReg's technical consultant):

- an out-of-band power flux density (PFD) limit at the radar receiver antenna must be satisfied by each MFCN operator to deal with MFCN spurious emissions; and
- a 1 km coordination zone applies around each of the radars, to protect the radars from MFCN base stations operating in close proximity.

If MFCNs are deployed before filters are installed on all radars, an additional in-band PFD limit will apply in the frequency range 2570–2690 MHz to address the issue of intermodulation and blocking at radar receivers. Filters have now been deployed in the radars in Cork and Shannon allowing operators to fully deploy services around

these areas. Work on the Dublin radars is ongoing with a planned completion date of Q1 2025.

Annex B Auction format

The bidding process had two stages:

- the **main stage**, where a mix of frequency-generic and frequency-specific lots were offered in lot categories; and
- the **assignment stage**, where winners of frequency generic lots not automatically assigned specific frequencies (in line with special provisions set out below) were able to bid for alternative frequencies.

The main stage used a Combinatorial Clock Auction (CCA) format with relaxed bidding activity rules.

The assignment stage used a second-price, combinatorial, sealed-bid auction format, run independently, but simultaneously, for each band.

B.1 The main stage

Structure of the CCA format

The CCA is a multi-round combinatorial auction format.²⁷ The CCA comprises two phases:

- It starts with the **primary bid rounds** (or clock stage). The primary bid rounds follow a simple clock auction format, but can adopt more sophisticated activity rules, like the relaxed activity rule used for this award. This phase provides information to bidders to help them narrow down their expectations about the likely outcome of the auction (both in terms of the lots they may expect to win and the prices they may have to pay).
- Once the primary bid rounds end, there is a **supplementary bids round**, in which bidders can make multiple additional bids (supplementary bids) for alternative packages, which will be considered alongside their primary bids. Bid amounts are discretionary, subject to activity rules that require relative bid amounts to be consistent with preferences implied by bids submitted in the primary bid rounds.

At the end of the supplementary bids round, winning bids are selected from all of the bids made in the auction with a view to maximising their total bid amount, subject to not selecting more than one bid for each bidder and supply constraints.

²⁷ A more detailed description and assessment of the CCA can be found in DotEcon's report for ComReg on the design of the award (ComReg document 19/59a) whilst the detailed rules for the MBSA2 along with worked examples are available in the Information Memorandum (ComReg document 21/40).

The primary bid rounds

The process is structured in rounds, which are time windows during which bidders can make their bids. This process is used to progressively increase a nominal price for lot categories with excess demand, until there is no excess demand for any of the lot categories.

In each round:

- The auctioneer announces a round price for each lot category. The round price will have increased relative to the previous round (or relative to reserve in the first round) for lot categories that had excess demand at the previous round price, and will remain unchanged otherwise.
- Bidders then indicate the combination of lots (or package) they wish to acquire at the round prices – this is the bidders primary bid for that round. Primary bids must satisfy the competition caps and the activity rules described below. In some cases, bidders may need to also submit so-called 'chain bids' along their primary bid in order to satisfy the activity rules.
- At the end of the round, aggregate demand across all the primary bids received in that round is calculated.

The primary bid rounds end as soon as there is no excess demand for any lot category. Conversely, if there is excess demand for one or more lot categories, a further primary bid round is run, with round prices adjusted accordingly.

The supplementary bids round

The supplementary bids round is run after the primary bid rounds, and provides an opportunity for bidders to make additional bids (the supplementary bids) for packages they have already bid for during the primary bid rounds, or other packages. All bids must satisfy the competition caps and the activity rules.

Each bidder is presented with a list of all the packages it bid for during the primary bid rounds, and the highest bid amount made for each of those. Bidders cannot lower or remove the bid amounts for these packages, but may be able to increase the bid amount subject to the activity rules. In addition, bidders can introduce new packages (subject to the competition caps) and a corresponding bid amount (subject to the activity rules and reserve prices).

Activity rules

Bidding is subject to *activity rules*. The activity rules are designed to ensure that the information revealed during the primary bid rounds is meaningful.

Each lot is assigned a number of eligibility points, which is used to be able to measure the activity (demand) associated with a bid. For this award, each 700 MHz lot was assigned four eligibility points, whilst the remaining lots were assigned one eligibility point per 5 MHz in the lot.²⁸ Bid activity was measured separately for each time slice, by adding up the eligibility points of all the lots that covered that time slice which were included in the bid.

During the primary bid rounds, the bidder's activity in that round was the activity of the bidder's primary bid. On application the bidder's activity was the activity of its application bid.

The activity rules:

- recorded the minimum previous activity of the bidder in each time slice as the bidder's *eligibility* in that time slice;
- set a *relative cap* (see below) on the bid amounts for any bids (*constrained bids*) that involve an activity that exceeds the bidder eligibility in any of the time slices; and
- set an additional *final price cap* (see below) on the bid amounts of all supplementary bids.

Bidders were only allowed to submit bids that satisfied all applicable caps.

The relative cap for a constrained bid was calculated as follows:

- First, it was necessary to identify the *constraining round* for that bid. This would be last round in which the bidder could have made a primary bid for the package of the constraining bid without reducing its eligibility.
- The *constraining bid* was the highest bid from the bidder for the package for which it made a primary bid in the constraining round; and the *constraining price differential* was the difference in price between the package of the constrained bid and the package of the constraining bid in the constraining round.
- The cap was then the sum of the constraining bid plus the constraining price differential.

A bidder was able to make primary bids with activity exceeding its eligibility, provided that this would not violate the relative cap. This included the possibility that the bidder might increase its bid for packages of its constraining bids (these constituted *chain bids*), subject to (i) only increasing its bid to the minimum required to

²⁸ The FDD lots (which had 2x5 MHz) and 10 MHz TDD lots in the 2.3 GHz band were assigned two eligibility points each; the remaining TDD (which had only 5 MHz) were assigned one eligibility point each.

satisfy the caps for submitting its primary bid; and (ii) not exceeding the current round price of the package (calculated as the sum of round prices for all the lots in the package). The auction software made all the necessary calculations to check if a bidder could make a primary bid and identify any necessary chain bids, and provided this information to bidders in their bid forms.

The final price cap only applied in the supplementary bids round and was similar to the relative cap, except that (i) it applied to all packages; and (ii) the constraining round for this cap was the final primary bid round (and thus the constraining bid was their primary bid in the final primary bid round).

Winner and price 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 primary bid rounds and the supplementary bids round). The winning bids are those that generate the highest total value, subject to selecting at most one bid from each bidder and ensuring that all bidders can be assigned the lots specified in their winning bids given the lots available.

The auction adopted a second-price rule, where winners are required to pay a price for their lots that is at least as high as the value that could be obtained from assigning these lots amongst the other bidders. However, subject to the condition above, the total sum of prices paid in the auction is minimised. Where there are alternative ways of meeting the previous conditions, prices are set in accordance with the Vickrey-nearest rule.²⁹

Exposure prices

*Exposure pricing
added to the
information policy*

The auction introduced a new feature to the information policy of the CCA, aimed at indicating to bidders the 'discount' relative to round prices they could expect in the event that the primary bid rounds were to end with no excess supply, given the constraints (arising from the activity rules) applicable to other bidders. This discount was calculated upon setting round prices, and each bidder was notified of its 'discount' along with the new round prices.

²⁹ Under this rule, the prices will be those that minimise the sum of squared differences between each bidder's price and the opportunity cost of assigning that bidder its winning option that arises from denying other bidders options they may prefer (the bidder's Vickrey price) – this is calculated as the difference between (i) the maximum value of bids that could be achieved if the bidder's bids had been zero for all options and (ii) the sum of winning bids from all bidders except this one.

The discount was calculated by the auction software as the difference between (i) the value of all lots at that round's round prices; and (ii) the highest value that could be achieved from selling all the lots amongst the bidder's competitors, taking into account the applicable relative caps and a hypothetical final price cap for each bidder for which the constraining bid was at that round's round prices. Therefore, the discount reflected the value that could only be achieved when accepting a bid from that bidder.

A consequence of this was that when it was possible for competitors to acquire all of the lots available at the prevailing round prices, then the discount was zero. This reflected the fact that in this case there is no guarantee that the second price will be below the round price for the package of the winning bid.

B.2 Assignment stage

The assignment stage consisted of a sealed bid auction process (run simultaneously but independently for each band) in which winning bidders could submit assignment bids to express preferences over different placements within the band (unless this was directly determined from special rules listed below).

Overview of the assignment stage

For each band:

- The auctioneer establishes the possible band plans, and the options for each bidder (given by their potential placements across the available band plans).
- Bidders who have multiple options for a given band can make discretionary bids for some or all of their options, reflecting their preferences over these.
- The value of a band plan is given by the sum of bids made by bidders for the placements they would get in that band plan. The winning band plan must achieve the maximum value across all band plans, with ties broken at random.
- Bidder's may be required to pay a price (an 'additional price') for their placement, determined based on an opportunity cost pricing rule and never exceeding the value of their winning bid.

Criteria for assignment option generation

The possible band plans for each band guaranteed contiguous spectrum (within the band) wherever possible. To support this, Eir's existing holdings in the 2.1 GHz band (covering the time slice 1 period) were included in the assignment stage as if Eir had won them in the main stage, and therefore could be moved within the band to ensure all bidders (including Eir) could be guaranteed contiguous assignments in time slice 1. However, the assignment option generation process applied several additional (non-standard) criteria, in particular:

- for bands that were time sliced, both time slices were included together in bidders' assignment options (so each assignment

option included a specific frequency range for time slice 1 and a specific frequency range for time slice 2), and provisions were included to minimise misalignment of frequencies allocated to bidders across the two time slices, where possible;

- in the 700 MHz band, for the purposes of protecting adjacent users a winner of more than 2x10 MHz and less than 2x30 MHz would not be assigned the lowest 2x5 MHz block, provided there was no other winner of more than 2x10 MHz, and any unassigned lots would be contiguous and placed at the bottom of the band;
- fixed frequency lots in the 2.3 GHz and 2.6 GHz TDD bands were included in the assignment round alongside the frequency generic lots in the corresponding band – priority was then given to ensuring contiguity of fixed frequency and frequency generic lots won by the same bidder in the same time slice; and
- any frequency generic 2.3 GHz lots won by Eir in either time slice would form a contiguous block of spectrum starting at 2300 MHz to align with the frequencies in use by RurTel, irrespective of whether Eir won the 2.3 GHz fixed frequency lot in one or both time slices.

For a detailed description of the assignment option generation process, see Annex 12 of the Information Memorandum (ComReg document 21/40).

Annex C Documents related to the award design

The table below sets out the key documents published by ComReg in relation to the award design. The full set of documents published by ComReg in relation to the award can be found on the ComReg website.

Table 5: Key documents relating to award design

Doc. No.	Publication date	Description
14/101	30 September 2014	Public consultation on the award of spectrum in the 2.6 GHz band, with the possible inclusion of 700 MHz, 1.4, 2.3 and 3.6 GHz bands.
14/102	30 September 2014	DotEcon report on key design issues for an award of spectrum in the 2.6 GHz band and other bands. Supporting report for 14/101.
18/60	29 June 2018	Consultation on which bands to include in a multi band spectrum award, with the preliminary view that the 700 MHz duplex (703–733 / 758–788 MHz), 2.1 GHz (1920 -1980 / 2110 -2170 MHz), 2.3 GHz (2300-2400 MHz) and 2.6 GHz (2500-2570 / 2620-2690 MHz and 2570-2620 MHz) bands should be included (following separate award of the 3.6 GHz band in 2017).
19/59R	18 June 2019 (updated 5 July 2019)	Response to consultation on 18/60 and further consultation on preliminary proposals for a multiband award for spectrum in the 700 MHz, 2.1 GHz, 2.3 GHz and 2.6 GHz bands.
19/59a	18 June 2019	DotEcon report on the potential design of the award. Supporting document for 19/59R.
19/59b	18 June 2019	Benchmarking report prepared by DotEcon with recommendations on minimum prices for the spectrum to be awarded. Supporting document for 19/59R.
19/124	20 December 2019	ComReg's Draft Decision on the award (document 19/124), including a response to submissions to the previous consultation on award design.
19/124a	20 December 2019	DotEcon report assessing submissions received in response to Document 19/59R relating to the award design and format. Supporting document for 19/124.
20/32	13 May 2020	Draft Information Memorandum and Draft Regulations setting out detailed rules for the award

		(including a report prepared by DotEcon on exposure pricing in Annex 12).
20/56	6 July 2020	Information Notice requesting views from interested parties on auction formats including potential alternative options or modifications to ComReg's proposed format.
20/122	18 December 2020	ComReg's final Decision on the MBSA2 award process (and assessment of submissions received in response to consultation documents 19/124, 20/32, and 20/56).
20/122a	18 December 2020	DotEcon assessment of submissions received in response to consultation documents 19/124, 20/32, and 20/56. Supporting document for 20/122.
21/39	16 April 2021	ComReg response to comments received on the Draft Information Memorandum (document 20/32).
21/39a	16 April 2021	DotEcon assessment of responses to the Draft Information Memorandum (document 20/32). Supporting document for
21/39b	16 April 2021	Updated benchmarking report and minimum fees recommendations, prepared by DotEcon, incorporating recent awards, revised licence terms, and using the new mobile WACC adopted in Ireland in October 2020.
21/40	16 April 2021	Final Information Memorandum (IM) and Draft Regulations for the MBSA2. Publication of the IM triggered formal commencement of the award.

Annex D Legal challenge

On 14 January 2021, Three lodged a legal appeal challenging parts of ComReg's final Decision on the award process. Three's objections focussed primarily on the use of the sub-1 GHz spectrum competition cap alongside the use of a CCA format, the asymmetric position faced by Three relative to Vodafone and Eir (in terms of ability to bid for a third 700 MHz lot), and the potential harm that Three might face as a result.

In particular, Three alleged that there could be three potential sources of harm to it:

- differences in the relative price paid for 700 MHz spectrum between Three and Vodafone/Eir due to the effect of the sub-1 GHz spectrum competition cap;
- potential strategic behaviour by Vodafone/Eir bidding in excess of their business case valuation for a third lot of 700 MHz, leading to Three paying more to win two lots; and
- similar strategic bidding for a third lot of 700 MHz leading to Three winning less spectrum.

ComReg continued to move the award forward, despite the appeal

Despite the appeal, and given that the appeal did not of itself stay the implementation of the MBSA2 Decision, ComReg continued to move forward with the award with the aim of issuing new licences as soon as possible and before expiry of some of the existing 2.1 GHz licences in October 2022. In April 2021, ComReg published its final Information Memorandum, triggering the formal commencement of the award process, with the auction (if required) initially anticipated to start around September/October 2021.

Deferred judgment delayed the auction, but ComReg progressed

However, the legal appeal process ran for longer than anticipated, with judgment deferred to an unspecified date, and the auction had to be pushed back. To maximise the chances of awarding the spectrum in a timely manner, ComReg continued to progress the award even without a judgment on the appeal. In May 2022, applicants to the award were informed of whether or not they qualified as bidders, and bidders were notified that the main stage of the auction would commence on 11 July 2022.

Stay on auction main stage

However, on 2 June 2022, Three applied to the High Court for a stay on the main stage of the auction – the auction start date was initially deferred by ComReg to 25 July 2022, but on 21 July 2022 a stay was formally granted by the Court, pending judgment in the main proceedings and effectively suspending the award until that time.

Appeal and varying of the stay

On 25 July 2022, ComReg lodged an appeal against the order granting the stay, which was heard on 19 October, 25 October, and 8 November 2022. On 8 November 2022, the Court of Appeal made an order varying the stay to allow the auction to proceed but precluding

The auction ran in November/December 2022

ComReg from issuing licences, pending a judgement on the main proceedings.³⁰

ComReg was therefore able to proceed with the auction and announced the results of the main stage on 14 December 2022.³¹ The second stage of the auction (the assignment round) ran on 19 December 2022.³²

The appeal was withdrawn in full

On 20 December, ComReg published an Information Notice³³ announcing that:

- On 14 December 2022 (following completion of the auction main stage) Three had filed a motion with the Courts Service seeking leave to discontinue its appeal of the MBSA2 Decision and have the stay granted by the High Court lifted; and
- On 19 December 2022, an Order was made by the High Court granting Three leave to discontinue the appeal and awarding ComReg its costs against Three.

On 21 December 2022, ComReg published an Information Notice³⁴ notifying interested parties that on 21 December 2022, the Court of Appeal:

1. delivered its judgment in respect of ComReg's appeal of the Stay ordered by the High Court (and Three's cross-appeal on certain aspects of same);
2. made an Order which lifted the Stay; and
3. ordered Three to pay ComReg's costs relating to both the High Court stay application and Court of Appeal Proceedings.

Consequently, there was no longer any impediment to completing all the remaining stages of the MBSA2 process and finally issuing licences for long-term spectrum rights of use.

³⁰ See ComReg document 22/92

³¹ ComReg document 22/105

³² See ComReg document 22/112

³³ ComReg document 20/113

³⁴ ComReg document 22/115