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Auction design options for the award of spectrum in the 2.3 and 2.6 GHz bands

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Summary

Purpose

In this note we consider options for the design of a potential auction process for the award of spectrum in the 2.3 GHz and 2.6 GHz bands.

Objectives for the award

The TKK's objectives (based on the provisions in the TKG) are to run an award process that provides legal certainty and is robust to challenges, ensures an efficient use of spectrum, protects and promotes competition, promotes the availability and quality of services and supports business development and innovation.

For this specific award, we understand that the assignment of an obligation to provide MVNO access is under consideration.

Spectrum available for award

There are 60 MHz in the 2.3 GHz band, available for TDD use. This spectrum is newly being made available for electronic communication services. In the 2.6 GHz band, there are 190 MHz available, currently assigned to the three MNOs with licences running to the end of 2026. The current hybrid band plan (2x70 MHz FDD with a duplex gap of 50 MHz for TDD use) will need to be retained in the short to medium term, though eventually a migration to full TDD use might take place.

Structure of demand

Both bands can be seen as capacity bands and are likely to be substitutes, though current use and investments in the 2.6 GHz band and the less well-established ecosystem for the 2.3 GHz band give rise to value differences.

We understand that operators and vendors suggest that the minimum bandwidth supporting a commercial roll-out is typically around 30 – 40 MHz for TDD spectrum (with 20 MHz mentioned as lower bound for hotspot coverage, but insufficient for wider deployment) and 2x20 MHz for FDD spectrum (although 2x10 MHz might be sufficient for carrying on using the spectrum with existing equipment). Thus, offering the spectrum in small block reflecting the minimum technical channel width (5 MHz / 2x5 MHz) would mean that the first blocks within each band are complements.

Spectrum assignments are more valuable if they form a contiguous frequency range, as fragmented assignment would require within-band carrier aggregation with an associated loss of spectral efficiency.

Overall, this means that we need to ensure that final assignments are contiguous within a band, that bidders can switch their demand between bands and that aggregation risks arising from minimum usable quantities are addressed.

Expected participation

There is interest from the three MNOs in both bands. The prospect of interest from new entrants should not be discarded, especially given that the spectrum could be used for a variety of applications.

General features of the auction process

To facilitate the assignment of contiguous frequencies to winners of spectrum, we envisage initially offering the spectrum in the form of frequency generic lots. Specific positions in each band would be assigned to winners in a follow-up process. We are not aware of any reason for substantive value differences between different portions of each band and therefore suggest that spectrum be offered in three lot categories corresponding to the three bands (b7/n7, b38/n38 and b40/n40).

We propose to use an open multi-round process for the assignment of frequency generic lots, as this simplifies bid strategy. For the assignment of specific frequencies, we suggest using the same single-round sealed-bid with opportunity-cost pricing that has been used successfully in past awards in Austria (assignment bid stage).

Reshuffling in the event of migration to TDD in the 2.6 GHz band

We propose that the specific frequencies for winners of bandwidth in the 2.6 GHz band are reassigned if the use in that band is switched to TDD in the future. This could in the first instance be left to agreements between operators, with a further assignment bid stage as a backstop. This would be conducted when migration takes place and an agreement between operators cannot be reached. Corresponding obligations requiring that licence-holders accept this process would have to be included in the spectrum licences.

Spectrum packaging

There is a tension between offering small spectrum blocks to provide flexibility for bidders to assemble spectrum portfolios that best suit their needs and support granular outcomes and safeguarding them from winning an amount of spectrum that is below the minimum usable quantity. This can be addressed by offering lots of different size, but this may create switching impediments.

The scope for highly granular outcomes in the TDD bands is limited by the small amount of spectrum available overall relative to the minimum usable amount. Given this we propose to package TDD spectrum as:

- two 30 MHz blocks for the 2.3 GHz band; and
- a single 40 MHz block in the 2.6 GHz band (with the winner also being assigned the 5 MHz guard bands on either side, which may be of very limited use while the hybrid band plan is in force but become usable if and when the band is converted to full TDD use, as set out in the consultation document).

Regarding the FDD spectrum, supporting outcomes at the granularity of the incremental channel width (2x5 MHz) would seem desirable. Therefore, we propose to offer FDD spectrum in 2x5 MHz blocks. This may expose bidders to aggregation risks, which are partly mitigated by the proposed spectrum caps and could be addressed through a combinatorial auction format or an auction format that allows bidders to withdraw bids to avoid winning a small number of blocks. Alternatively, noting that there might be a case for introducing an obligation to provide access to MVNOs, some of the FDD spectrum could be offered as one or more larger blocks (of 2x15 MHz, for example) tied to an obligation to offer MVNOs access.

Spectrum caps

There appears to be a strong argument for ensuring that existing operators can continue to use the installed equipment in the 2.6 GHz band, for which 2x10 MHz should be sufficient. To achieve this, we propose a cap of 2x30 MHz on the FDD spectrum, which creates an implicit reservation of 2x10 MHz for each MNO if there are no other bidders.

The support of wider carriers with new radio technology suggests that it could be more efficient to allow operators to acquire larger TDD blocks in individual bands but limit the amount of spectrum they can acquire across bands. Given the total amount of spectrum available, we propose an overall cap of 100 – 120 MHz. A cap of 120 MHz, for example, would allow a single bidder to acquire:

- all TDD spectrum plus an additional 2x10 MHz of FDD spectrum; or
- all the TDD spectrum in the 2.3 GHz band and up to 2x30 MHz of FDD spectrum.

Auction format for the assignment of frequency generic lots

Stakeholders have expressed a strong preference for re-use of one of the formats used in the recent Austrian spectrum auctions, namely the 2020 multiband award, which used an SMRA-Clock hybrid format, and the 2024 auction of spectrum in the 26 GHz band (including residual 3.5 GHz spectrum), which used an eSMRA format.

Both formats could expose bidders to aggregation risks in relation to winning fewer lots than those needed to obtain the minimum usable bandwidth. However, aggregation risks should be acceptable given the proposed use of large blocks for the assignment of TDD spectrum and the proposed bidding constraints for FDD spectrum, which should allow MNOs to acquire at least 2x10 MHz of FDD which is sufficient for business continuity. Therefore, both formats are in principle suitable for the planned award and a decision for one or the other can be made based on their relative merits.

Proposed award design

As noted, we propose separating the assignment of bandwidth and the assignment of specific positions within the band, using a second-price sealed bid mechanism (as used in previous Austrian spectrum auctions) for the latter. If possible, a deferred bidding process for the re-assignment of positions following a change from hybrid use to full TDD use should be adopted. Alternatively, separate assignment bids for prospective post-migration positions could be collected in the same round.

For the assignment of bandwidth, we suggest two options, depending on whether an MVNO obligation should be assigned:

- If no MVNO obligation were to be assigned by means of the auction, we propose offering all the spectrum in a single step, with fourteen lots of 2x5 MHz FDD and one lot of 40 MHz TDD in the 2.6 GHz band and two lots of 30 MHz TDD in the 2.3 GHz band. Bidders would be subject to a spectrum cap of 2x30 MHz on FDD spectrum, and an overall cap of 100 – 120 MHz across all spectrum being offered in this procedure.
- If there were an intention to assign an obligation to provide MVNO access, we would suggest tying this obligation to each of three larger blocks of 2x15 MHz of FDD spectrum. These would be offered in an initial step, where bidders would be allowed to bid for at most one lot. If it were sufficient for a single operator to take on the MVNO obligation, we suggest offering exemptions from the obligation alongside these lots, with the number of exemptions being one less than the number of large lots assigned. The remaining spectrum (including any spectrum in large blocks that remained unsold in the initial step) would be offered in a second step, with between five and fourteen lots of 2x5 MHz FDD and one lot of 40 MHz TDD in the 2.6 GHz band and two lots of 30 MHz TDD in the 2.3 GHz band. In this second step, bidders would only be subject to an overall cap of 100 – 120 MHz across all spectrum being offered in this procedure.

For both options, we propose using an eSMRA format, given that it is the format that has been used most recently.

1 Introduction

Background

TKK/RTR is preparing the assignment of spectrum in the 2.3 GHz band, which has become available for the provision of mobile services, and the spectrum in the 2.6 GHz band that was assigned in 2010 and for which licences expire at the end of 2026.

We understand that pursuant to the provisions of the updated Telecommunications Act (TKG 2021), the use of an auction process will only be considered for frequencies for which it has been determined that the number of rights of use is to be limited. For such scarce frequencies, the use and users that generate the greatest benefits for end users in a competitive downstream market should be identified through a comparative or a competitive selection process (e.g. a beauty contest or an auction).

Whilst the number of rights of use for the 2.3 GHz frequencies is limited pursuant to the Ordinance on Frequency Usage (FNVO, Anlage 2), such a decision for frequencies in the 2.6 GHz band is under review. Moreover, no decision has yet been made about which type of selection mechanism is to be used for frequencies for which the number of rights of use is limited. However, to provide clarity to prospective users, we have been asked by RTR to identify options for the design of an auction process for the award of these bands should an auction ultimately be chosen as the selection mechanism.

It is well understood that there is no single 'best' auction design. Different formats have their advantages and disadvantages, and the choice of design depends on the specific circumstances of an award such as the objectives of the awarding body, the available spectrum and technical requirements (which affect the appropriate lot structure), the structure of valuations and the likely level of participation.

Scope

In this note we identify the factors that are relevant for the choice of an appropriate auction design, covering ***spectrum packaging***, ***bidding constraints*** and ***auction format***; and identify several options that in our view would be suitable for an award of these bands via an auction.

We assume that the reader is familiar with the basic features of different auction formats, their activity rules, and key concepts such as substitutability and complementarity between individual lots. More detailed descriptions of the working of the different designs and key concepts can be found in reports prepared for previous consultations.[1]

[1] See, for example, Vergabeverfahren 3,4 – 3,8 GHz: Optionen für das Produkt – und Auktionsdesign; Options for the design of the auction in the 700, 1500 and 2100 MHz bands; Auction design options for the award of spectrum in the 3.4 – 3.8 GHz and 26 GHz bands.

2 Salient factors for the identification of suitable auction design options

In the remainder of this section, we set out our understanding of these salient factors and draw their implications for the choice of auction format.

2.1 Objectives

Objectives

The overarching objectives guiding any decision about the specific design of the award process are based on the provisions of Telecommunications Act (cf. Article 15(3) of the TGK 2021) and have been expressed by the TKK as running a process that:

- provides legal certainty and is robust to legal challenge,
- ensures an efficient use of the spectrum;
- protects and promotes competition;
- promotes availability and quality of services; and
- promotes innovation and business development.

In addition, the award process should be robust to legal challenge and afford the participants a high degree of legal certainty. This means that the process should be simple and straightforward to avoid ambiguities and the scope for bidding mistakes that arise from unduly complex rules.

Implications for award design

Efficient spectrum allocation requires that spectrum ends up with those users who can generate the greatest value, which should be reflected in their willingness to pay (always provided that spectrum cannot be acquired to restrict or distort competition). This means that bidders who might have materially different requirements should be able to assemble the spectrum portfolio that best meets their needs given conflicting demands from others. This can be achieved by allowing bidders to express their valuations for different spectrum portfolios and identifying the combination of portfolios with the greatest total value that can feasibly be assigned, or by enabling bidders to switch between or adjust spectrum portfolios in response to price signals that indicate relative scarcity of different types of spectrum.

The award needs to ensure that bidders are not able to use the acquisition of spectrum to limit the ability of their competitors to grow their business and attract customers in the downstream markets. This may require, for example, the use of limits on the amount of spectrum any individual bidder will be allowed to acquire (spectrum caps). Usage or deployment conditions may also be used to avoid spectrum hoarding.

Where appropriate, obligations that improve competition in downstream markets might be attached to the rights to use spectrum. For this specific award, we understand that the assignment of an obligation to provide MVNO access is under consideration.

Similarly, it may be appropriate to attach specific coverage obligations aimed at increasing overall coverage to spectrum usage rights. However, we understand that for this specific award (and reflecting the nature of the spectrum that is to be assigned) coverage requirements are not under consideration.

Finally, bidders should not end up with spectrum endowments that are too small to support efficient deployment or limit the scope for offering innovative services.

2.2 Available spectrum

The spectrum available for assignment comprises:

- 60 MHz in the 2.3 GHz band; and
- 190 MHz in the 2.6 GHz band.

The 2.3 GHz spectrum is newly being made available for electronic communication services. The 2.6 GHz spectrum has first been assigned in 2010, with licences running to the end of 2026.

Band plans

The 60 MHz in the 2.3 GHz band are available for TDD use (b40/n40).

The 2.6 GHz spectrum is currently split into 2x70 MHz for FDD use (b7/n7) with a duplex gap of 50 MHz for TDD use (b38/n38), of which 40 MHz are usable (as a 5 MHz guard band is required on either side for the protection of FDD use). An alternative band plan for this band would see the full 190 MHz deployed as TDD spectrum (b41/n41).

The 2.6 GHz band is currently assigned to and deployed by the three MNOs, as shown in the following table.

Table 1: Available spectrum

	FDD	TDD
A1	2x25 MHz	25 MHz not used
TMA	2x20 MHz	
H3A	2x25 MHz	25 MHz used

There appears to be broad agreement across operators and most equipment manufacturers that, from a technological perspective, it would be more efficient to use the whole band for TDD. However, at least in the short to medium term, commercial considerations (current use with associated investments) and a regulatory environment that favours the hybrid use of the band imply that a move from mixed use to full TDD use is not possible at this point.

Nevertheless, a migration to full TDD use (b41/n41) could become commercially viable and attractive for all users within the licensing period. Where relevant, the award design should not inhibit (but potentially facilitate) such a change of use by mutual agreement of all users in the band.

Implications for award design

This means that we need to consider an award based on the current band plan for the 2.6 GHz band, but with options for a potential migration to full TDD use within the licence period.

2.3 Structure of valuations

Both bands can be seen as capacity bands, supporting greater bandwidth and speed for a greater number of customers. They should therefore in principle be regarded as substitutes.

Value differences are driven mainly by the fact that the 2.6 GHz band is currently used by MNOs, who have made substantial investments in band-specific equipment. Even though the relative importance of this band may vary across the three operators, all derive substantial value from being able to continue using frequencies that are currently part of their spectrum portfolio.

Given that the 2.6 GHz band has been in use for mobile services in many jurisdictions for many years, the equipment ecosystem for this band is better developed than for the 2.3 GHz band, which also contributes to making the 2.6 GHz band somewhat more valuable for mobile use; ecosystem considerations matter less for FWA use, and therefore the value difference between the two bands may be less pronounced from the perspective of deploying the spectrum mainly for FWA services.

Minimum usable quantities

For both bands, the minimum usable quantity indicated by operators and vendors[2] in discussions with RTR exceeds the minimum channel width of 5 MHz/2x5 MHz:

- for TDD spectrum – whether in the 2.3 or 2.6 GHz band – the minimum bandwidth supporting a commercial roll-out is typically seen to be around 30 – 40 MHz (with 20 MHz mentioned as lower bound for hotspot coverage, but insufficient for wider deployment);

[2] This is a summary of our understanding of views expressed by operators and equipment vendors in discussions with RTR.

- for FDD spectrum, efficient use requires a minimum of 2x20 MHz, although 2x10 MHz might be sufficient for carrying on using the spectrum with existing equipment.

This means that if spectrum were offered in block sizes reflecting the minimum technical channel width, the first blocks within each band would be complements and incremental valuations would be increasing until the minimum efficient usable bandwidth is reached.

Contiguous assignments of spectrum within a band are of greater value than fragmented assignments, which would require within-band carrier aggregation with an associated loss of spectral efficiency.

Implications for award design

Overall, this means that we need to ensure that final assignments are contiguous within a band, that bidders can switch their demand between bands and that aggregation risks arising from minimum usable quantities being greater than the minimum channel width are addressed.

2.4 Level of participation

Given their current use, there is clear interest from the three MNOs in the 2.6 GHz spectrum. MNOs have also expressed interest in the 2.3 GHz band, which has already been assigned in several other European countries, albeit to a varying degree.

There is, at this point, no obvious interest from new entrants in the available spectrum. However, as the spectrum could be used for a variety of applications, the prospect of interest from new entrants should not be discarded and the award design should not discriminate against new entrants.

3 Key elements of the award process

In this section, we identify some general features of the award process we consider to be desirable. We then discuss the key elements of the process and identify the most suitable options, namely:

- how the available spectrum should be packaged into lots;
- what constraints might need to be imposed on the bids bidders can place and the amount of spectrum they can acquire; and
- the specific auction format to be used.

3.1 General features

Regardless of how spectrum is being packaged into lots and the detailed decisions about bidding constraints and auction rules, we consider that the award design should have the following general features.

Separate assignment of bandwidth and specific band positions

As noted above, for efficient spectrum use frequency assignments within each band should be contiguous.

A contiguous assignment of frequencies to winners of spectrum can best be achieved by splitting the assignment of bandwidth from the assignment of specific frequencies. This means that spectrum should, to the maximum extent possible, be offered initially in the form of frequency generic lots, allowing bidders to bid for bandwidth in the safe knowledge that they will eventually obtain a contiguous assignment. Specific positions in each band would then be assigned to winners of bandwidth in a separate process.

This works particularly well when there are little or no differences in the value of spectrum in different parts of a band as in this case individual spectrum blocks within a band can be regarded as homogenous. We are not aware of any reason for substantive value differences between different portions of each band and therefore suggest that spectrum be offered in three lot categories corresponding to the three bands (b7/n7, b38/n38 and b40/n40).

Use of an open multi-round process for the assignment of bandwidth

Whilst sealed bid processes tend to be quicker, mechanically simpler, and less susceptible to gaming than open, multi-round processes, they require bidders to state their valuation for a potentially wide range of spectrum portfolios.[3] Depending on the pricing rule, they may also create strategic complexity for bidders.

By comparison, open multi-round processes in which bidders can respond to price information revealed during bidding may be a better way of achieving an efficient outcome. Even though the benefits of an open multi-round process in terms of helping bidders to deal with common value uncertainty[4] may be limited in the present instance, the outcome discovery function of an open auction format continues to be an important reason for choosing such a design. In an open multi-round process, bidders will be able to gradually narrow down the range of possible market clearing outcomes and get a better understanding of the number of lots they may be able to win in the various categories.

Particularly, where bidders face budget constraints and are therefore not able to express their full valuations for different packages in their bids, being able to adjust bids in view of what outcomes can realistically be expected greatly simplifies bid strategy.

In addition, placing many bids and letting the auction mechanism decide which, if any of these, will be successful, often creates governance problems. Therefore, bidders may prefer to limit the number of bids they make to narrow down the possible outcomes they could face, even if this increases the chances of winning a sub-optimal package or leaving the auction empty-handed (and potentially paying a premium for reducing the risk of not winning anything).

[3] An efficient outcome can only be achieved if bidders make bids for the lots they should be assigned in an efficient allocation. A sealed bid process provides a single opportunity for bidders to make bids and therefore bidders may need to place many bids reflecting the range of outcomes that might pertain. With no information about what combination of bids will eventually clear the market, there is limited scope for eliminating combinations that turn out to be unwinnable. Therefore, bidders might potentially need to bid on all packages in which they are interested even if their chance of winning them is very small.

[4] A common argument in favour of an open multi-round format is that being able to observe bidding from others can help bidders to adjust their value estimates if there is a common value element to the valuation of spectrum (i.e. where part of the valuation is driven by factors that are the same for all bidders but uncertain and where bidders therefore need to form expectations). Seeing the decisions made by others will reduce the impact of this common value uncertainty and increase the chances for an efficient outcome. However, we do not believe the reduction in common value uncertainty to be a strong argument for an open process in this case. This is because there are likely to be only few bidders whose valuations are strongly affected by bidder-specific factors (such as existing subscriber base, existing network configuration etc.). As a result, there is little scope for any meaningful updating of value estimates based on the bid decisions made by others.

For all these reasons, we prefer an open multi-round process to a sealed bid process for the assignment of bandwidth.

Second price sealed bid for the assignment of specific positions in the band

By contrast, a sealed bid process will work well for the assignment of specific positions in the band to winners of bandwidth. This is because the number of assignment options, and thus of potential bids a bidder might need to make, is limited and preferences for specific positions are likely to be known. Using a second pricing approach ensures that bidders will only have to make payments for specific placements to the extent that their preferences are conflicting, but not otherwise.[5] Therefore, we would suggest using the same single-round sealed-bid process with an opportunity-cost price rule that has been used successfully in past awards in Austria (assignment bid stage).

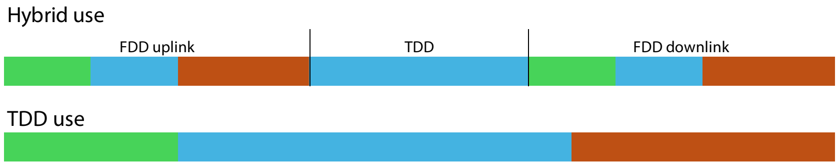
Provisions for re-shuffling if migration to full TDD use takes place

Given the benefits of having an assignment of contiguous frequencies, the migration from hybrid use to full TDD use of the 2.6 GHz band would require a re-shuffling of positions so that each operator holding spectrum in this band can use its bandwidth as a contiguous block. There are different options for how this might be achieved.

In the first instance, the re-assignment of positions within the band could be left to negotiations between operators. However, there would need to be some backstop for the case where no agreement can be reached. There are different options for such a backstop:

The reassignment of specific frequencies could be rule-based, e.g. so that the order of operators within the band would be preserved (see illustration below) and each operator retains the same amount of bandwidth. This would kick in automatically in case of a failure of coming to an agreement.

Figure 1: Illustration of rule-based re-assignment of positions post migration



Such an automatic reassignment – even if only as a backstop – would mean that bidders must reflect a combination of their preferences for the placement under hybrid use and a prospective future TDD use in the assignment bids they make.

Alternatively, there could be separate assignment bids for the placement under hybrid use and the placement after a migration to full TDD use that would apply unless operators agree on a different

[5] Should there be objections to the use of a second-price rule, it would be straightforward to use a first-price (pay-as-bid) rule instead.

reassignment. This would give bidders the opportunity to obtain a default position in the band post-migration that would apply unless there is mutual agreement on a different assignment.

Both options provide bidders with certainty over their default position if the band were converted to full TDD use, though whether and when this happens of course remains uncertain. Both options would require bidders to consider the relative merits of different positions in a b41/n41 environment, which may however be highly uncertain and depend on factors such as the likely migration to TDD use in neighbouring countries.

An alternative backstop option would be to provide for running a separate assignment bid process in the future as and when migration makes re-shuffling necessary and no agreement between operators can be reached. This has the benefit that bids for the placement can be made at a point where the value of different positions is likely to be better understood. It might also be more conducive to reaching an agreement about migration which might otherwise be difficult to achieve if, for example, one operator knew that it would have to move to an unfavourable band position.

Overall, we would suggest the third of these options as a backstop for the determination of band positions under a prospective future full TDD use, provided a proper legal basis can be found for such a solution (e.g. specification of an obligation to submit to a re-assignment process in the case that a migration to b41/n41 takes place in the licence conditions and an agreement about the reassignment of frequencies cannot be reached within a reasonable time period).

3.2 Spectrum packaging

General considerations

The division of the available spectrum into individual lots determines the granularity of possible outcomes and thus the flexibility of bidders to assemble spectrum portfolios that best suit their needs. This suggests that offering smaller spectrum blocks is more likely to support an efficient outcome. The starting point is therefore the minimum (incremental) channel width, i.e. 2x5 MHz for paired spectrum and 5 MHz for unpaired spectrum.

At the same time, where the minimum usable bandwidth is larger than the minimum channel width, the use of small blocks can expose bidders to the risk of winning unusably small amounts of spectrum, making deployment commercially unviable or inefficient. This can be avoided by offering blocks that provide the minimum usable quantity or can be mitigated through an auction format (such as a clock auction or a combinatorial format) or bidding constraints that allow bidders to avoid unusably small portfolios.

The tension between offering blocks that provide the minimum usable bandwidth and supporting more granular outcomes at the margin might be addressed by dividing the available spectrum into blocks of different size – larger blocks to allow bidders to acquire a critical amount of bandwidth and smaller blocks to support competition for incremental spectrum. The use of different block sizes, however, can create problems for bidders wishing to switch between portfolios. This can lead to substantially different prices per MHz that are not reflective of the underlying valuations.

TDD blocks

For the available TDD spectrum, the benefits of using small blocks are limited. With minimum usable bandwidth of around 30 MHz and a total amount of available spectrum of 60 MHz in the 2.3 GHz band and 50 MHz in the 2.6 GHz band, of which only 40 MHz are usable at present, there is no scope for highly granular outcomes.

Given this, we propose to package TDD spectrum in the 2.6 GHz band as a ***single block of 40 MHz***. The remaining 10 MHz would be assigned to the winner of this block but would only be fully usable in the event of migration to a full-TDD band plan; during hybrid use of the band, they would in practice provide a 5 MHz guard band on either side to protect adjacent FDD use.

In the 2.3 GHz band, a 40/20 MHz split of the available 60 MHz might conceivably be appropriate (given that according to some views 20 MHz may be usable for hotspot cover), but a division into three blocks of 20 MHz each creates the risk of a highly fragmented outcome of 20/20/20 MHz. For this reason, dividing the spectrum into ***two 30 MHz blocks***, or alternatively into ***one block of 20 MHz and one block of 40 MHz*** seems appropriate.

FDD blocks

Regarding the FDD spectrum, supporting outcomes at the granularity of the incremental channel width (2x5 MHz) would seem desirable. Therefore, we propose to offer FDD spectrum in ***2x5 MHz blocks***.

As this is smaller than the minimum usable bandwidth, there may be concerns about exposing bidders to aggregation risks. However, these may be mitigated to some extent by the bidding constraints we propose below to protect competition. They also could, in principle, be addressed through a combinatorial auction format or an auction format that allows bidders to withdraw bids to avoid becoming stuck on an unusably small number of blocks.

Alternatively, one might offer larger blocks that provide the minimum usable bandwidth. Noting that there might be a case for introducing an obligation to provide access to MVNOs, we consider that, optionally, ***one or more larger blocks*** (of 2x15 MHz, for example) tied to an ***obligation to offer MVNOs access*** to the licence-holder network on specified terms might be offered in a separate step.

3.3 Bidding constraints

Bidding constraints limiting the amount of spectrum that an individual bidder can acquire (spectrum caps) are typically used to prevent strategic acquisition of spectrum to restrict or distort competition. Such spectrum caps may also guarantee a minimum number of successful bidders. They will typically be set in consideration of the competition issues or business continuity concerns that have been identified in connection with a specific award and taking account of the constraints they impose on potential outcomes.

Constraints on FDD spectrum

In the present case, there appears to be a strong argument for ensuring that existing operators can continue to use the installed equipment in the 2.6 GHz band, for which 2x10 MHz should be sufficient. Safeguarding such an outcome can be achieved by imposing a ***cap of 2x30 MHz on the amount of FDD spectrum that any individual bidder can acquire***. This creates an implicit reservation of 2x10 MHz for each MNO in the case where no new entrant participates. With entrant participation the guarantee of 2x10 MHz no longer exists, but it is reasonable to assume that the intrinsic valuation of current users should be sufficiently high to allow each of the established MNOs to secure this amount in the face of entrant competition.

An alternative to the 2x30 MHz cap would be to offer three larger blocks (e.g. 2x15, potentially subject to the MVNO obligation) in an initial step where each bidder could bid for at most one lot. This would provide an incentive for bidders to take up the MVNO obligation, by allowing them to secure enough spectrum for business continuity purposes. In this case, the remaining FDD spectrum could be offered in a second step without a specific cap on FDD.

Overall spectrum cap

There does not appear to be a strong reason for preventing a single bidder from acquiring all the spectrum in the 2.3 GHz band. The support of wider carriers with new radio technology indeed suggests that it could be more efficient to allow operators to acquire larger blocks in individual bands but limit the amount of spectrum they can acquire across bands. This would enable operators to focus on acquiring larger blocks in fewer bands.

Given the total amount of spectrum available, an ***overall cap of 100 – 120 MHz*** appears to be appropriate. A 120 MHz, cap, for example, would allow a single bidder to acquire:

- all TDD spectrum plus an additional 2x10 MHz of FDD spectrum; or
- all TDD spectrum in the 2.3 GHz band and up to 2x30 MHz of FDD spectrum.

3.4 Auction format for the assignment of bandwidth

Stakeholders have expressed a strong preference for re-use of one of the formats used in the recent Austrian spectrum auctions – specifically the 2020 multiband award and the 2024 auction of spectrum in the 26 GHz band (including residual 3.5 GHz spectrum). Therefore, we confine our discussion to the suitability of these formats for the award at hand.

Both auctions used a hybrid form of the simultaneous multi-round ascending auction:

- The 2020 auction was run with an SMRA-Clock-Hybrid format, in which bid collection was done using a clock auction mechanism[6] and the auctioneer designated provisional winners (standing high bidders) at the end of each round.
- The 2024 auction employed a so-called 'enhanced' (e)SMRA format, which also uses a clock auction mechanism for the collection of bids (augmented with the option of submitting intra-round bids), but where the auctioneer does not designate provisional winners explicitly. Rather, it used a requirement that bidders could not reduce demand in any category where this would result in (an increase in) excess supply – this implicitly created standing high bids that could not be withdrawn or switched between lot categories.

Common to both formats is that bids placed are 'sticky' and that a bidders can only reduce demand or switch across lot categories those bids that have not been designated as standing high bids or are required to avoid an increase in excess supply. This makes every bid decision potentially committing and can discourage strategic bidding, but at the same time exposes bidders to the risk of winning a subset of the lots they wish to acquire.

However, these aggregation risks should be acceptable given the use of large blocks for the assignment of TDD spectrum and the proposed bidding constraints for FDD spectrum, which ensure that MNOs should be able to acquire at least 2x10 MHz of FDD. Should larger FDD blocks be assigned in an initial step, aggregation risks are largely absent across all bands.

Therefore, both formats are in principle suitable for the planned award and a decision for one or the other can be made based on their relative merits:

- Both formats leverage the procedural efficiency of the clock mechanism for bid collection and avoid the 'long tails' that are

[6] In general terms: Lots are grouped into lot categories. In each round, the auctioneer announces a price per lot for each lot category and bidders specify the number of lots they wish to acquire at this price.

typically associated with standard SMRAs where, with many lots available, many rounds are required to resolve small amounts of excess demand.

- The SMRA-Clock-Hybrid entails small and temporally limited information asymmetries where bidders who have only part of their demand designated as standing high bids may draw inferences about the behaviour of other bidders. It may also lead to prices for similar lots differing by up to one price increment in each lot category.
- The eSMRA avoids these information asymmetries and results in a uniform price for each lot category but exposes bidders to uncertainty over outcomes as the bids they submit may not be fully processed owing to the demand retention rules. This difference between submitted and processed bids means that attempts to switch between portfolios may be only partly successful, with the risk that the bidder ends up with an undesirable mix of spectrum in different categories. Adding provisions to protect against such partially processed bids adds complexity to the rules.

4 Proposed award design

In this section, we present two options for the design of the process for awarding bandwidth, combining the different elements discussed in the previous section.

Having looked at the key aspects of an award process design separately in the previous section, it is important to bear in mind that the decisions on spectrum packaging, auction format and competition safeguards are closely interlinked. For example, small block sizes that provide bidders with substantial flexibility to assemble portfolios may expose them to aggregation risks with an auction format where winning bidders are established for individual lots and bidders therefore win subsets of the lots on which they have bid. These risks may be mitigated through competition safeguards that effectively guarantee each bidder a minimum quantity, at least as long as there is no strong competition from new entrants. Therefore, the individual elements of an award design need to be evaluated holistically.

4.1 Overall structure

As noted in the previous section, we would suggest a two-step process, separating the assignment of bandwidth and the assignment of specific positions within the band.

A second-price sealed bid mechanism as used in previous Austrian spectrum auctions would be most appropriate for the assignment of specific frequencies to winners of bandwidth. If possible, a deferred bidding process for the re-assignment of positions following a change from hybrid use to full TDD use should be adopted. Alternatively, separate assignment bids for the post-migration positions in the band should be permitted, as any rule-based mapping of initial band positions into post-migration positions pollutes preferences for band positions during the hybrid use phase with expectations about the likelihood of a migration and the relative merits of different band positions in a full TDD environment.

For the first step, an open multi-round bidding process should be employed. Either of the two auction formats used in the recent Austrian awards would be suitable in principle, perhaps with a slight preference for the eSMRA given that it is the format that has been used most recently.

We consider that there are two options for how spectrum might be packaged and offered in this first step, depending on whether part of the objective is to assign obligations for providing MVNO access.

4.2 Option 1: no MVNO obligations

If there is no intention to use the auction process for the assignment of an MVNO obligation, our suggestion for the assignment of bandwidth would be as follows:

Spectrum would be packaged as shown in Table 2.

Table 2: Lot categories under Option 1

Lot category	Size of lots	Number of lots available
A (b7/n7, 2.6 GHz FDD)	2x5 MHz	14
B (b38/n38, 2.6 GHz TDD)	40 MHz	1
C (b40/n40, 2.3 GHz TDD)*	30 MHz	2

** Alternatively, the 2.3 GHz band could be offered as two individual lots C1 and C2 with a size of 20 and 40 MHz respectively.*

All lots would be offered simultaneously, and bidders would be able to switch between lot categories in line with the activity rules (including the provisions on the determination of standing high bids in the case of an SMRA-Clock-Hybrid design or the demand retention rules if an eSMRA were used). Details about the bidding points associated with each lot would have to be determined, but an initial suggestion would be to assign points in proportion to bandwidth and consider using some relaxation of activity requirements to enable fluid switching between FDD and TDD and between the bands.

Bidders would be limited to acquiring at most:

- six lots in category A (2x30 MHz of FDD spectrum); and
- 100 – 120 MHz overall.

4.3 Option 2: Assignment of MVNO obligation

If there is an intention to assign an obligation to provide MVNO access by means of an auction, we would suggest tying this obligation to three larger blocks of paired 2.6 GHz spectrum. Acquiring such a block should give an operator sufficient spectrum to support business continuity and form the basis for acquiring at least five additional blocks of paired and additional unpaired spectrum to increase capacity. A size of 2x15 MHz would seem appropriate, noting that this would also convert into a total of 30 MHz for any prospective TDD use in the event of migration to a full-TDD band plan.

These blocks could be offered in an initial, separate step, with each bidder limited to bidding for at most one block. Bidding in this step would only be required if the number of bidders interested in taking such blocks is greater than the number of blocks available. If any of these blocks remained unsold, the associated spectrum would be converted into smaller 2x5 MHz blocks and included in the second step.

If it is sufficient for an MVNO obligation to apply to only one operator, it would be possible to offer exemptions from the obligation alongside these larger blocks. The number of exemptions must be one less than the number of large blocks assigned, which will not be known in advance of the auction, but only after bids for the large blocks have been submitted (i.e. at the end of the first round).

The lot structure would be as shown in Table 3 where N is the number of bids placed on A1 lots in the first round.

Table 3: Lot categories under Option 2

<table>
<tr><th>Lot category</th><th>Size of lots</th><th>Number of lots available</th></tr>
<tr><td>A1 (b7/n7, 2.6 GHz FDD with MVNO obligation)</td><td>2x15 MHz</td><td>3</td></tr>
<tr><td>A2 (b7/n7, 2.6 GHz FDD)</td><td>2x5 MHz</td><td>Depends on N:<table><tr><th>N</th><th>Available lots</th></tr><tr><td>0</td><td>14</td></tr><tr><td>1</td><td>11</td></tr><tr><td>2</td><td>8</td></tr><tr><td>≥ 3</td><td>5</td></tr></table></td></tr>
<tr><td>B (b38/n38, 2.6 GHz TDD)</td><td>40 MHz</td><td>1</td></tr>
<tr><td>C (b40/n40, 2.3 GHz TDD)*</td><td>30 MHz</td><td>2</td></tr>
<tr><td>E (exemption from MVNO obligation)</td><td>N/A</td><td>Depends on N:<table><tr><th>N</th><th>Available lots</th></tr><tr><td>≤ 1</td><td>0</td></tr><tr><td>2</td><td>1</td></tr><tr><td>≥ 3</td><td>2</td></tr></table></td></tr>
</table>

** Alternatively, the 2.3 GHz band could be offered as two individual lots C1 and C2 with a size of 20 and 40 MHz respectively.*

A1 and E lots would be offered simultaneously in a first step. With three A1 lots, there may only be a need for a bidding process for exemptions.

Lots in categories A2, B and C would be offered simultaneously in the same manner as under Option 1.

The following bidding constraints would apply:

- In the first step, bidders would be able to bid for at most one A1 lot.
- Bids for exemptions can only be placed by bidders who have also placed a bid for an A1 lot.

- Taking account of the spectrum in the first step, bidders in the second step are limited to acquire at most 100 – 120 MHz overall (without any further constraints on the amount of FDD spectrum they can acquire).