Auction 108 Clock-1 Auction Format Technical Guide

1   Introduction

This technical guide details the bidding procedures for Auction 108 under a clock auction format as described in the *Auction 108 Further Comment Public Notice*.[1] We refer to this auction format as the "clock-1" auction format, because in Auction 108 at most one license would be available in each category in a county. These details describe the clock-1 auction format as it would be implemented if it is adopted for Auction 108.

Auction 108 will offer geographic overlay licenses for unassigned spectrum in the 2.5 GHz (2496–2690 MHz) band. Up to three blocks of spectrum — 49.5 megahertz, 50.5 megahertz, and 17.5 megahertz blocks — will be offered in each county. The 49.5 megahertz block is designated as bidding category 1 (C1); the 50.5 megahertz block as bidding category 2 (C2); and the 17.5 megahertz block as bidding category 3 (C3).[2]

The clock auction design described here for Auction 108 differs in two respects from the design used in previous Commission clock auctions.

First, at most one frequency-specific license is available for each category in a county. In other words, the combination of a bidding category and a county defines a single specific license. In previous FCC clock auctions with multiple generic blocks in a category, the combination of a category and a geographic area was referred to as a "product." In this clock auction with a supply of one block in each category, a "product" is a single license. Accordingly, the clock rounds will determine the licenses won by each bidder and, as a result, no assignment phase is needed. Thus, a clock-1 auction will consist solely of clock rounds.

Second, bidders will be permitted to submit proxy instructions. Specifically, whereas the clock price is the maximum price associated with a round, a bidder will be allowed to submit a proxy instruction indicating a price above the current round's clock price at which the bidder wants to reduce its demand for a license from one to zero. If a proxy instruction has been submitted, the bidding system will automatically submit a proxy bid to maintain the bidder's demand for the license in every subsequent round as long as the clock price for the round is below the proxy instruction price. In the first round in which the clock price is greater than or equal to the proxy instruction price, the bidding system will submit a bid on behalf of the bidder requesting to reduce the bidder's demand for that license to zero at the proxy instruction price. Furthermore, if a bid to reduce demand to zero was not applied, e.g., because there was no excess demand at the bid price, the system will generate a proxy instruction to reduce demand to zero at the bid price to preserve the bidder's interests in future rounds.

Section 2 of this guide describes bidding, including the available bid types, proxy instructions and proxy bids, and the bidding requirements. Section 3 describes the calculations for the bidding information shown to bidders. Section 4 describes how bids are processed after a round, and Section 5 describes the stopping rule. Section 6 describes the information policy, and Section 7 describes how the system sets up the next round if the stopping rule has not been met after a round. Section 8 describes how final payments and per-license prices are calculated at the conclusion of the auction.

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[1] *Auction of Flexible-Use Licenses in the 2.5 GHz Band for Next-Generation Wireless Services; Further Comment Sought on Competitive Bidding Procedures for Auction 108*, AU Docket No. 20-429, Public Notice, DA 22-120 (*Auction 108 Further Comment Public Notice*).

[2] *See id.* at 5, para. 13.

2   Bidding

The clock-1 auction format will consist of a series of timed bidding rounds. A bidder in the auction indicates in each round its demand for licenses at the current prices. When submitting a bid, the bidder specifies a quantity and a price. Bids are processed after each round to determine the quantity of a bidder's requested demand that is applied (the *processed demand*) and the *posted price* of each license for that round. If, after the bids are processed, there is no excess demand for any license, then the auction ends and the *final price* for each license is equal to the posted price of the last round. Otherwise, the auction continues with a new round.

In Round 1, each bidder indicates the licenses it demands at the minimum opening bids by indicating a quantity of one for each of those licenses. For Round 1, the processed demands of a bidder are simply the quantities that it bid for in the round, and the posted price of a license is the minimum opening bid for that license.

In each round after Round 1, a range of prices is associated with each license. The *start-of-round price* is the lowest price in the range, and the *clock price* is the highest price in the range. The start-of-round price for a license is equal to the posted price of the previous round for that license.

If, after the bids are processed, there is no excess demand for any license, the auction will end and the *final price* for a given license will be equal to the posted price of the last round for that license. Otherwise, the auction will continue with a new clock round in which the start-of-round price for a license equals the posted price of the previous round.

2.1   Bid Types for Rounds After Round 1

Bidders are permitted to make two types of bids: *simple bids* and *switch bids*. A simple bid indicates a desired quantity (0 or 1) at a price (either the clock price or an intra-round price). A switch bid allows the bidder to request to move its demand for a license from C1 to C2, or vice versa, within the same county at a price for the "from" category (either the clock price or an intra-round price). Switch bids are allowed only in counties with both a C1 license and a C2 license. A bidder is not allowed to submit a switch bid involving a C3 license.

A bidder's processed demand after the previous round is either 0 or 1. We describe the bids that a bidder can submit depending on its processed demand.

Simple bid to maintain demand for a license at the clock price. A bidder can submit such a bid if it has processed demand for the license. A bid to maintain its demand at the round's clock price indicates that the bidder is willing to buy the license at all prices in this round up to and including this round's clock price. Intra-round bids to maintain demand are not permitted.[3]

Simple bid to reduce demand for a license. A bidder can submit such a bid if it has processed demand for the license. A bid requesting to reduce demand for a license (from 1 to 0) at price p in a round indicates that:

  (1) The bidder is willing to buy the license at all prices greater than or equal to the start-of-round price and less than the bid price p;

  (2) At price p, the bidder is indifferent between buying and not buying the license; and

  (3) The bidder is not willing to buy the license at a price above p.

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[3] A bidder cannot submit a bid to maintain its demand at a price below the round's clock price. Bids made at intra-round prices are used to indicate the price at which the bidder's requested demand *changes* from its processed demand from the previous round.

Simple bid to increase demand. A bidder can submit such a bid if it does not have processed demand for the license. A bid requesting to increase demand for a license (from 0 to 1) at price p indicates that the bidder is willing to buy the license at all prices associated with this round (*i.e.*, prices that are greater than or equal to the start-of-round price and less than or equal to the clock price).[4]

Switch bid from C1 to C2 in a county. A bidder can submit such a bid if there is both a C1 and a C2 license in the county, the bidder's processed demand for C1 equals 1, and the bidder's processed demand for C2 equals 0. By submitting a bid requesting to switch demand from C1 to C2 in a given county when the price of C1 is p, the bidder indicates that:

(1) When the price of C1 is less than p, the bidder is willing to purchase the C1 license but not the C2 license;

(2) When the price of C1 is p, the bidder is willing to purchase either the C1 license or the C2 license (but not both); and

(3) When the price of C1 is strictly greater than p and less than or equal to the clock price, the bidder is willing to purchase the C2 license but not the C1 license.

In (2) and (3) above, the bidder is willing to purchase the C2 license at any price associated with this round for the C2 license (that is, up to the clock price for C2).

Switch bid from C2 to C1 in a county. A bidder can submit such a bid if there is both a C1 and a C2 license in the county, the bidder's processed demand for C2 equals 1, and the bidder's processed demand for C1 equals 0. By submitting a bid requesting to switch demand from C2 to C1 in a given county when the price of C2 is p, the bidder indicates that:

(1) When the price of C2 is less than p, the bidder is willing to purchase the C2 license but not the C1 license;

(2) When the price of C2 is p, the bidder is willing to purchase either the C1 license or the C2 license (but not both); and

(3) When the price of C2 is strictly greater than p and less than or equal to the clock price, the bidder is willing to purchase the C1 license but not the C2 license.

In (2) and (3) above, the bidder is willing to purchase the C1 license at any price associated with this round for the C1 license (that is, up to the clock price for C1).

By submitting a switch bid from one license to another (in the same county), the bidder is guaranteed to have processed demand for exactly one of those licenses after the round.

2.2 Proxy Instructions and Proxy Bids

In Round 1, a bidder is allowed to submit a proxy instruction for any license for which it submits a bid in the round. For example, if the minimum opening bid for a given license is $1,000 and the bidder is willing to purchase that license at any price up to $1,800, the bidder can submit a bid for the license at the minimum opening bid and also enter a proxy instruction specifying that it is willing to bid for the license up to the price of $1,800.

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[4] The bidding system will not process the requested increase until bid processing reaches the price at which the bid was made, but depending upon demand for the license relative to its supply of one and depending upon which bids by other bidders to reduce demand for the license are applied, the posted price for the current round may be above or below the bid price of the requested increase. The posted price may be lower if, for example, applying the increase allows another bidder's requested decrease at a lower price to be applied.

In a round after Round 1, a bidder with processed demand for a license that wishes to maintain its demand at the round's clock price is allowed to submit a proxy instruction to reduce its demand for that license to zero at a price higher than the current round's clock price. For example, if a bidder has processed demand for a license with a clock price of $2,000, and the bidder is willing to purchase the license for a price up to $3,500, the bidder can submit a proxy instruction to reduce its demand for the license to 0 at $3,500. In a round after Round 1, a bidder will not be allowed to submit a proxy instruction for a license if its processed demand is 0 or if it submits a bid to change its demand for the license in the round.

If a proxy instruction has been submitted, the bidding system will automatically submit a proxy bid to maintain the bidder's demand for the license in every subsequent round as long as the clock price for the round is less than the proxy instruction price. In the first round in which the clock price is greater than or equal to the proxy instruction price, the bidding system will submit a proxy bid on behalf of the bidder to reduce the bidder's demand for that license to 0 at the proxy instruction price. This will be the highest price at which the system will submit a bid based on the proxy instruction.

In the case that a bid to reduce demand is not applied during bid processing, the bidding system will automatically generate a proxy instruction at the bid price and, in the following rounds, submit proxy bids on behalf of the bidder according to that proxy instruction. For example, suppose that the start-of-round price for a license is $10,000, the clock price is $12,000, and a bidder with processed demand for the license submits a bid to reduce its demand to 0 at price $11,500. If the bid is not applied during bid processing (e.g., because there were no other bids for the license in the round), in the following round the bidding system would submit a proxy bid on behalf of the bidder to reduce demand for the license to 0 at price $11,500.

A proxy bid (i.e., a bid that is submitted on behalf of the bidder based on a proxy instruction) is treated for purposes of bid processing and the activity rule like any other bid that is submitted by the bidder in the round.

In any round, a bidder can remove or modify any existing proxy instructions or proxy bids for the round by uploading a new bid file, including the modifications, which would replace any bids and proxy instructions previously submitted. The system would take the last bid file submission as that bidder's bids and proxy instructions.

Example 1 – Proxy Instruction at $140,000; Clock Prices Increase in Rounds 2 to 6: The minimum opening bid for a given license is $100,000. In Round 1, the bidder submits a bid for the license at the minimum opening bid and also submits a proxy instruction to reduce demand to 0 at price $140,000. This proxy instruction indicates that the bidder is willing to buy the license at any price up to $140,000. Suppose that the bidder does not submit any bids in the following rounds. Further suppose that, in Rounds 2, 3, 4, and 5, the aggregate demand for the license exceeds 1; thus, the clock price increases after each of those rounds. The following table shows the start-of-round price and the clock price for the license in Rounds 2 to 6 along with the proxy bid that will be submitted by the bidding system on behalf of the bidder in each of these rounds.

Round	Start-of-round Price	Clock Price	Proxy Bid
2	$100,000	$110,000	Bid to maintain demand at $110,000
3	$110,000	$121,000	Bid to maintain demand at $121,000
4	$121,000	$134,000	Bid to maintain demand at $134,000
5	$134,000	$148,000	Bid to reduce demand to 0 at $140,000
6	$148,000	$163,000	No Proxy Bid

We next consider a variation of Example 1 where the clock price for the license stops increasing after Round 4.

Example 2 – Proxy Instruction at $140,000; Clock Price Stops Increasing after Round 4: The minimum opening bid for a given license is $100,000. In Round 1, the bidder submits a bid for the license at the minimum opening bid and also submits a proxy instruction to reduce demand to 0 at price $140,000. Suppose that the bidder does not submit any bids in the following rounds.

In this example, we assume that the aggregate demand for the license exceeds 1 after Round 2, and that the aggregate demand drops to 1 in Round 3 at price $120,000. In Round 4, the start-of-round price is $120,000 and the clock price is $132,000. No other bidder bids for the license in the following rounds, so for each of the following rounds the start-of-round price is $120,000 and the clock price is $132,000. The following table shows the start-of-round price and the clock price for the license in Rounds 2 to 6 along with the proxy bid that will be submitted by the bidding system on behalf of the bidder in each of these rounds.

Round	Start-of-round Price	Clock Price	Proxy Bid
2	$100,000	$110,000	Bid to maintain demand at $110,000
3	$110,000	$121,000	Bid to maintain demand at $121,000
4	$120,000	$132,000	Bid to maintain demand at $132,000
5	$120,000	$132,000	Bid to maintain demand at $132,000
6	$120,000	$132,000	Bid to maintain demand at $132,000

Note that the system submits the same proxy bid in Rounds 4, 5 and 6. The bidding system will continue submitting a bid to maintain demand at the clock price as long as the clock price is below the proxy instruction price of $140,000. If there is no other bid for the license in the remainder of the auction, this bidder will win the license at price $120,000.

Example 3 – Proxy Instruction at $125,000; Clock Price Stops Increasing after Round 4: The minimum opening bid for a given license is $100,000. In Round 1, the bidder submits a bid for the license at the minimum opening bid and also submits a proxy instruction to reduce demand to 0 at price $125,000. This proxy instruction indicates that the bidder is willing to buy the license at any price up to $125,000. Suppose that the bidder does not submit any bids in the following rounds.

As in Example 2, we assume that the aggregate demand for the license exceeds 1 after Round 2, and that the aggregate demand drops to 1 in Round 3 at price $120,000. In round 4, the start-of-round price is $120,000 and the clock price is $132,000. No other bidder bids for the license in the following rounds, so for each of the following rounds the start-of-round price is $120,000 and the clock price is $132,000. The following table shows the start-of-round price and the clock price for the license in Rounds 2 to 6 along with the proxy bid that will be submitted by the bidding system on behalf of the bidder in each of these rounds.

Round	Start-of-round Price	Clock Price	Proxy Bid
2	$100,000	$110,000	Bid to maintain demand at $110,000
3	$110,000	$121,000	Bid to maintain demand at $121,000
4	$120,000	$132,000	Bid to reduce demand to 0 at $125,000
5	$120,000	$132,000	Bid to reduce demand to 0 at $125,000
6	$120,000	$132,000	Bid to reduce demand to 0 at $125,000

The bidding system will continue submitting a bid to reduce demand to 0 at the proxy instruction price of $125,000 as long as the proxy instruction price is within the price range for the round (and the bidder has processed demand for the license). If there is no other bid for the license in the remainder of the auction, this bidder will win the license at price $120,000. However, if another bidder bids for the license in a later round, then the proxy bid to reduce demand to 0 at $125,000 will be applied.

Example 4 – Bid to Reduce Demand is Not Applied and Becomes a Proxy Instruction: In Round 10, for a given license, the start-of-round price is $200,000 and the clock price is $220,000. There are two bidders with processed demand for the license. Bidder 1 submits a bid to reduce demand to 0 at price $202,000, which indicates that the bidder is willing to buy the license at any price up to $202,000. Bidder 2 submits a bid to reduce demand to 0 at price $218,000, which indicates that the bidder is willing to buy the license at any price up to $218,000. No other bidder bids for the license in the round. During the bid processing for Round 10, the bid of Bidder 1 is applied reducing the aggregate demand for the license to 1 (and setting the posted price at $202,000), whereas the bid of Bidder 2 is not applied. The bidding system will generate a proxy instruction to reduce the demand of Bidder 2 to 0 at price $218,000. Suppose that Bidder 2 does not submit any bids in the following rounds.

In Round 11, the start-of-round price is $202,000 and the clock price is $223,000. The bidding system will generate a proxy bid on behalf of Bidder 2 to reduce demand to 0 at $218,000. If there are no other bids for the license, this proxy bid will not be applied and the bidding system will enter the same proxy bid on behalf of Bidder 2 in the following round. Suppose that another bidder (say Bidder 3) bids for the license in Round 14. Then, the proxy bid to reduce the demand of Bidder 2 to 0 is applied, and the system does not submit a proxy bid on behalf of Bidder 2 in Round 15. This scenario is shown in the following table.

Round	Start-of-round Price	Clock Price	Proxy Bid
11	$202,000	$223,000	Bid to reduce demand to 0 at $218,000
12	$202,000	$223,000	Bid to reduce demand to 0 at $218,000
13	$202,000	$223,000	Bid to reduce demand to 0 at $218,000
14	$202,000	$223,000	Bid to reduce demand to 0 at $218,000
15	$218,000	$240,000	No Proxy Bid

2.3   Bidding Requirements

A bidder submits its bids for a round and any proxy instructions while the round is open for bidding. For a given license, a bidder may submit at most one bid and at most one proxy instruction in a round, subject to the requirements described below.

In the first round of the auction, a bidder may only submit a (simple) bid for a license at the minimum opening bid for that license and only for a quantity of 1. If the bidder submits a bid for a license at the minimum opening bid, the bidder can also submit a proxy instruction for a quantity of 0 at a price above the minimum opening bid.

For all subsequent rounds, a bidder may either submit a simple bid to maintain its demand for a license at the round's clock price or submit a bid (simple or switch) to change its demand for the license at a price that is greater than or equal to the start-of-round price and less than or equal to the clock price. The bid quantity must be either 1 or 0.

Switch bids are allowed only in counties with both a C1 license and a C2 license. A switch bid may be *either* from C1 to C2 *or* from C2 to C1. (A switch bid cannot involve a C3 license.) To submit a switch

bid, the bidder must have processed demand for the "from" license and must not have processed demand for the "to" license.

After the first round of the auction, a bidder may submit a proxy instruction for a license only if the bidder has processed demand for the license and is willing to buy the license at the round's clock price. To submit a proxy instruction for a license, the bidder must specify a price that is greater than this round's clock price and a quantity equal to 0. That is, the proxy instruction price indicates the price at which the bidder is willing to reduce its demand for the license to 0.

Each bid price and proxy instruction price specified by the bidder must be a multiple of $10, $100 or $1,000 according to the following requirements:

- A price below $10,000 must be a multiple of $10;

- A price between $10,000 and $100,000 (inclusive) must be a multiple of $100; and

- A price above $100,000 must be a multiple of $1,000.

In the first round of the auction, a bidder will *not* be allowed to submit a bid or a collection of bids if the bidder's submitted activity for the round would exceed the bidder's eligibility for the round. In any subsequent round, a bidder will *not* be allowed to submit a bid or collection of bids if the bidder's submitted activity for the round would exceed the bidder's *contingent bidding limit* for the round.[5] The bidder's contingent bidding limit for the round is equal to the contingent bidding percentage for the round times the bidder's eligibility for the round, rounded up to the nearest integer (see Section 3.3). This implies that, if a bidder's eligibility for the round is equal to 0, then the bidder will not be able to submit any bids.

3 Calculations for Bidding Information

3.1 Submitted Activity

When a clock round is open for bidding, the *submitted activity* of a bidder is calculated as the total number of bidding units associated with the licenses that the bidder indicates it is willing to buy at the clock price, given all bids that the bidder has submitted.[6] In Round 1, all licenses with bids are included in the submitted activity calculation. In a later round, a license is included in this calculation if *either* the bidder has processed demand for the license and has bid to maintain its demand at the round's clock price *or* the bidder has processed demand of 0 for the license and has submitted a bid to increase its demand to 1 in this round.

Example 5 – Calculation of Submitted Activity: License 1 has 10 bidding units and license 2 has 8 bidding units. For license 1, the start-of-round price is $5,000 and the clock price is $6,000. For license 2, the start-of-round price is $4,000 and the clock price is $4,800. Suppose that, after the previous round, the bidder has processed demand for each of these licenses. The bidder has submitted the following bids in the current bidding round:

- License 1: a simple bid to maintain demand for the license at the clock price.

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[5] Even though a bidder may be allowed to submit activity that exceeds its eligibility, the bidder's processed activity cannot exceed its eligibility. Therefore, if a bidder submits activity that exceeds its eligibility, some of its bids will not be applied during bid processing. See Sections 3.3, 5.3, and 8.1 for more information.

[6] The bidding system shows the submitted activity, as described here, during the bidding round. Processed activity and processed demand cannot be determined until after the round's bids have been processed, so will be made available to bidders after the round.

- License 2: a simple bid to reduce demand to 0 at price $4,500.

After the bidder has submitted these two bids, its submitted activity is 8 bidding units. That is, only license 1 is included in the submitted activity calculation. License 2 is not included because the bidder is not willing to buy license 2 at the clock price.

3.2 Required Activity

A bidder's required activity in round t is the minimum total number of bidding units associated with the bidder's processed demand that the bidder must have after the bid processing of round t in order to maintain the same eligibility in round $t + 1$.

The required activity of bidder i in round t is calculated by multiplying the activity requirement percentage for round t with the eligibility of bidder i in round t. The result is rounded down to the nearest integer. The activity requirement percentage may change from round to round, and will be set within a range of 90% and 100% inclusive. The initial activity requirement percentage will be 95%.

3.3 Contingent Bidding Limit

A bidder's *contingent bidding limit* for a round represents the maximum activity that the bidder can submit for the round. For Round 1, the contingent bidding limit of bidder i is equal to the bidder's initial eligibility.

For any round $t > 1$, the contingent bidding limit of bidder i is calculated by multiplying the contingent bidding percentage for round t with the eligibility of bidder i for round t. The result is rounded up to the nearest integer. The contingent bidding percentage may change from round to round, and will be set within a range of 100% and 140% inclusive.

Example 6 – Calculation of Contingent Bidding Limit: Consider a round $t > 1$. The contingent bidding percentage for round t is 120% and the eligibility of bidder i for round t is 156 bidding units. Then, the bidder's contingent bidding limit for round t is calculated as 120% of 156, which after rounding up to the nearest integer yields 188. That is, the bidder can submit bids with activity of up to 188.

The bidding system, however, will not apply bids that would result in the bidder having processed activity that exceeds its eligibility. Note also that the price point associated with a bid determines the order in which the bid will be processed. Therefore, a bidder submitting bids with activity that exceeds its eligibility — that is, bids not all of which can be applied — should indicate price points that reflect its preferences for the order in which it wishes its bids to be processed by the system. *See* Section 4.2 for the definition of price point.

Example 8 in Section 7.1 illustrates a scenario where the contingent bidding limit is used properly to address the potential for loss of bidding eligibility under some circumstances. Example 9 in Section 7.1 provides some case studies where the contingent bidding limit is not used properly.

3.4 Payment Information Available While the Round Is Open for Bidding

For the convenience of bidders, the bidding system will provide information about the financial exposure created by bids during the course of the auction.

The following notation is used in this section:

- $P_{t,l}$ denotes the clock price in round t for license l.

- BC_i denotes the bidding credit percentage of bidder i.

- L denotes the set of all licenses.

- $LC_{t,i}$ denotes the set of licenses that bidder i is willing to buy at the clock prices of round t, based on the bids it has submitted. In Round 1, this includes all the licenses for which the bidder has submitted bids. In a later round $t > 1$, a license is included in $LC_{t,i}$ if *either* the bidder has processed demand for the license and has bid to maintain its demand at the round's clock price *or* the bidder has processed demand of 0 for the license and has submitted a bid to increase its demand to 1 in this round.

- S denotes the set of all licenses in "small markets", that is, in counties located within any partial economic area (PEA) with a population of 500,000 or less.

- $RC_{t,i}$ denotes the requested commitment of bidder i in round t (defined in Section 3.4.1).

3.4.1 Requested Commitment

A bidder's *requested commitment* during a clock round t is the total bid amount calculated at the round's clock prices, given the bids that the bidder has submitted so far in round t. During the round, bids for the round will not yet have been processed, so the requested commitment is an estimate of a bidder's commitment, and the estimate is updated as the bidder submits its bids. The requested commitment of bidder i in a clock round t is calculated by summing the clock prices of all licenses that the bidder is willing to accept at the clock price, that is:

$$RC_{t,i} = \sum_{l \in LC_{t,i}} P_{t,l}$$

Example 7 – Calculation of Requested Commitment: For license 1, the start-of-round price is $5,000 and the clock price is $6,000. For license 2, the start-of-round price is $4,000 and the clock price is $4,800. Suppose that, after the previous round, bidder i has processed demand for each of these licenses. The bidder has submitted the following bids in the current bidding round:

- License 1: a simple bid to maintain demand for the license at the clock price.

- License 2: a simple bid to reduce demand to 0 at price $4,500.

By submitting these bids, the bidder indicates that (1) it is willing to purchase license 1 at the clock price of $6,000, and (2) it is not willing to purchase license 2 at the clock price of $4,800. Thus, the bidder's requested commitment is $6,000.

3.4.2 Bidding Credit Discounts on Requested Commitment

This section describes the calculations for requested commitment bidding credit discounts in a round t. All bidding credit discounts are rounded to the nearest dollar. Rounding is only done at the very end of a given calculation, that is, after performing any summations and/or minimizations in a formula.

Rural Service Provider Bidding Credit. If bidder i qualifies for the rural service provider bidding credit, then in round t,

Its *uncapped requested commitment discount* is:

$$BC_i \cdot RC_{t,i}$$

Its *requested commitment discount* is:

$$min\{\$10 \text{ million}, BC_i \cdot RC_{t,i}\}$$

This is equal to the bidder's requested commitment multiplied by its bidding credit percentage and then capped at $10 million.

Small Business Bidding Credit. If bidder i qualifies for the small business bidding credit, then in a clock round t,

Its *uncapped requested commitment discount in small markets* is:

$$BC_i \cdot \sum_{l \in S \cap LC_{t,i}} P_{t,l}$$

Note that the summation is across all licenses in small markets that the bidder is willing to buy at the clock prices. The uncapped requested commitment discount in small markets is calculated by multiplying the bidder's requested commitment in small markets with its bidding credit percentage.

Its *uncapped requested commitment discount* (across all markets) is:

$$BC_i \cdot RC_{t,i}$$

Its *requested commitment discount* (across all markets) is:

$$min \left\{ \$25 \text{ million}, BC_i \cdot \sum_{l \in LC_{t,i} \backslash S} P_{t,l} + min \left\{ \$10 \text{ million}, BC_i \cdot \sum_{l \in S \cap LC_{t,i}} P_{t,l} \right\} \right\}$$

This calculation first caps the bidder's discount in small markets at $10 million, then adds the bidder's discount from all other markets (*i.e.*, markets that are not subject to the small market bidding cap) and caps the sum at $25 million.

3.4.3 Requested Net Commitment

A bidder's *requested net commitment* is equal to its requested commitment minus its requested commitment discount.

3.5 Payment Information Available After the Round Has Been Processed

After bid processing for a round, the bidding system will provide payment information to the bidder based on its processed demands and the posted prices for the round. The calculations are similar to the corresponding calculations for requested commitment and bidding credit discounts that are conducted during a round (as described in Section 3.4), except that the posted price ($p_{t,l}$) is used instead of the clock price ($P_{t,l}$) and the set of licenses for which bidder i has processed demand after round t ($LP_{t,i}$) is used instead of the set of licenses that the bidder is willing to buy at the round's clock prices ($LC_{t,i}$).

In addition to the notation of Section 3.4, the following notation is used in this section:

- $p_{t,l}$ denotes the posted price of license l after round t.

- $LP_{t,i}$ denotes the set of licenses for which bidder i has processed demand after round t.

- $C_{t,i}$ denotes the commitment of bidder i after round t (defined in Section 3.5.1).

3.5.1 Commitment

The bidder's *commitment* after a round is a dollar value that is calculated from the bidder's processed demands and the posted prices after the bid processing of the round.

The commitment of bidder i after round t is given by the following formula:

$$C_{t,i} = \sum_{l \in LP_{t,i}} p_{t,l}$$

3.5.2 Bidding Credit Discounts on Commitment

This section describes the calculations for bidding credit discounts on a bidder's commitment after round t. All bidding credit discounts are rounded to the nearest dollar. Rounding is only done at the very end of a given calculation, that is, after performing any summations and/or minimizations in a formula.

Rural Service Provider Bidding Credit. If bidder i qualifies for the rural service provider bidding credit, then after round t,

Its *uncapped commitment discount* is:

$$BC_i \cdot C_{t,i}$$

Its *commitment discount* is:

$$min\{\$10 \text{ million}, BC_i \cdot C_{t,i}\}$$

Small Business Bidding Credit. If bidder i qualifies for the small business bidding credit, then after round t,

Its *uncapped commitment discount in small markets* is:

$$BC_i \cdot \sum_{l \in S \cap LP_{t,i}} p_{t,l}$$

Its *uncapped commitment discount* (across all markets) is:

$$BC_i \cdot C_{t,i}$$

Its *commitment discount* (across all markets) is:

$$min\left\{\$25 \text{ million}, BC_i \cdot \sum_{l \in LP_{t,i} \setminus S} p_{t,l} + min\left\{\$10 \text{ million}, BC_i \cdot \sum_{l \in S \cap LP_{t,i}} p_{t,l}\right\}\right\}$$

3.5.3 Net Commitment

A bidder's *net commitment* after round t is equal to its commitment after round t minus its commitment discount.

4   Processing Bids for a Clock Round

This section describes bid processing in the clock rounds. The purpose of bid processing is to determine, at the conclusion of a round of bidding, the processed demands for all bidders and the posted prices for all the licenses.

4.1   Missing Bids

For each license for which the bidder had processed demand in the previous round, if the bidder did not submit a bid for that license during the current round and does not have a proxy instruction in place, the bidder will be deemed to have submitted a simple bid for that license with a quantity of 0 at the start-of-round price. For example, if the start-of-round price for a particular license is $6,000 and a bidder with processed demand for that license did not submit a bid in this round for that license and does not have a proxy instruction in place, it will be deemed to have bid a quantity of 0 at $6,000. Note that this does not necessarily mean that a bidder will have processed demand of 0 at $6,000. The missing bid will be processed just as if the bidder submitted a simple bid for a quantity of 0 at $6,000.

4.2   Price Points

The *price point* indicates the percentage of the distance between the start-of-round price and the clock price. Specifically, the price point of a bid is calculated as the following ratio:

$$\text{price point} = \frac{\text{bid price} - \text{start-of-round price}}{\text{clock price} - \text{start-of-round price}}$$

The result of the calculation is rounded to 10 decimal places.

For example, the 0% price point refers to the start-of-round price, the 100% price point refers to the clock price, and the 50% price point refers to the average of the start-of-round price and the clock price. As another example, if the start-of-round price is $5,000 and the clock price is $6,000, the price $5,100 corresponds to the 10% price point, and the price $5,400 corresponds to the 40% price point.

4.3   Processed Demands

Bids to maintain demand are always applied during bid processing.

Bids to change demand are prioritized for processing in the following order: by price point (from lowest to highest) across all bids, and then by bid-specific pseudorandom number (from lowest to highest). The priority ordering of bids remains the same throughout the bid processing of a round (that is, only one pseudorandom number is associated with a given bid in a round).[7]

A simple bid to increase demand (from 0 to 1) is applied if it would not cause the bidder's processed activity to exceed its eligibility for the round.

A simple bid to reduce demand (from 1 to 0) is applied if it would not cause the aggregate demand for the license to drop to 0 (*i.e.*, if this is not the only bidder with processed demand for the license).

A switch bid is applied if it would not cause the aggregate demand for the "from" license to drop to 0.

The bid processing algorithm maintains a queue of all bids to change demand from the round that have not been applied. Whenever a bid is applied, the queue is re-tested to determine whether any bids in the queue can be applied. When a bid has been applied, it is removed from the queue; otherwise, it is kept in

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[7] Each pseudorandom number is drawn uniformly at random from the set $\{0, 1, 2, \ldots, 2^{40} - 1\}$.

the queue so that it may be applied later. The re-testing of the queue is repeated until no bids remaining in the queue can be applied. Then the next bid from the round is processed until (1) all bids from the round have been processed, and (2) no bids in the queue can be applied. At that point, proxy instructions are generated for any bids to reduce demand remaining in the queue (as described in Section 2.2), and then all bids remaining in the queue are discarded.

The demands of a bidder following the processing of the bids for the round are referred to as its processed demands.

4.4   Posted Prices

Once processed demands have been determined, the posted price for a license is set based on the aggregate demand for that license. The aggregate demand of a license is the number of bidders with processed demand for that license.

The posted price of each license is determined as follows:

-     If aggregate demand exceeds 1, the posted price equals the clock price for the round.

-     If aggregate demand equals 1 and at least one bid to reduce demand for the license was applied, the posted price equals the highest bid price among all bids to reduce demand for the license that were applied. That is, the posted price is the price at which a reduction caused aggregate demand to equal supply.

-     In all other cases, the posted price equals the start-of-round price (*i.e.,* the posted price of the previous round).

These rules ensure that the posted price of a license will not be higher than the price of any bid that requested a reduction for that license but was not applied *and* will not be lower than the price of any bid that requested a reduction for that license and was applied.

5   Stopping Rule

After the bids of a round have been processed, the stopping rule is met if, for every license, the aggregate demand is less than or equal to 1. If the stopping rule is met, the auction concludes. Otherwise, the auction proceeds with a new clock round.

6   Information Policy

After each clock round, the following information will be publicly available on the Public Reporting System for each license: the aggregate demand, the posted price of the last completed round, and the clock price for the next round. The identities of bidders bidding for a specific license will not be disclosed until after Auction 108 concludes.

Each bidder will have access to additional information related to its own bidding and bid eligibility. Specifically, after the bids of a round have been processed, the bidding system will inform each bidder of its processed demand for every license and its eligibility for the next round.

7 Setting Up the Next Round

If the bidding system determines that there is excess demand for at least one license, then the system sets up the next round. The system must calculate each bidder's eligibility for the next round based on the activity associated with the bidder's processed bids in the previous round. The bidding system also calculates the clock prices for the new round and, if there are any proxy instructions in place, generates the appropriate proxy bids for the round. This section provides the details of these calculations.

7.1 Processed Activity, Next Round Eligibility, and the Contingent Bidding Limit

A bidder's *processed activity* for a round is equal to the total number of bidding units associated with the bidder's processed demand after the bid processing of the round. Specifically, the processed activity of bidder i after round t is calculated as:

$$\sum_{l \in LP_{t,i}} b_l$$

Where:

-   $LP_{t,i}$ denotes the set of licenses for which bidder i has processed demand after round t.

-   b_l denotes the number of bidding units associated with license l.

An activity rule is used to require bidders to participate in each round of the auction. A bidder's eligibility in the first round is determined by the bidding units associated with its upfront payment.

A bidder's eligibility in subsequent rounds is calculated based on its eligibility in the previous round, its required activity (see Section 3.2), its processed activity, and the activity requirement percentage.

If the processed activity of bidder i after round t is greater than or equal to its required activity, then bidder i maintains its eligibility in the following round, that is, the bidder's eligibility for round $t + 1$ will equal the bidder's eligibility for round t.

Otherwise, the eligibility of bidder i for the round $t + 1$ is reduced and is set equal to the ratio of the bidder's processed activity for round t over the activity requirement percentage. The result is rounded up to the nearest integer.

Example 8 – Calculation of Eligibility: In a given round $t > 1$, the activity requirement percentage is 95% and the contingent bidding percentage is 120%. Consider a bidder with eligibility of 10,000 bidding units in the round. The following table shows the bidding units, start-of-round prices, and clock prices for licenses W, X, Y, and Z, as well as the bidder's processed demands after the previous round and its submitted bids in this round.

License	Bidding Units	Previous Round Processed Demand	Start-of-Round Price	Clock Price	Submitted Bids Quantity@Price (Price Point)
W	7,000	1	$80,000	$90,000	0 @ $81,000 (10%)
X	2,800	1	$30,000	$35,000	0 @ $31,000 (20%)
Y	10,000	0	$90,000	$100,000	1 @ $93,000 (30%)
Z	2,000	0	$20,000	$24,000	1 @ $22,000 (50%)

Based on the table above, the bidder has processed demand for licenses W and X after the previous round. In this round, the bidder has submitted bids to reduce its demand for licenses W and X, and to increase its

demand for licenses Y and Z. The bid to increase demand for license Y has higher priority than the bid to increase demand for license Z because it was submitted at a lower price point.

The bidder's processed activity in the previous round is 7,000 + 2,800 = 9,800. The bidder's submitted activity in the round is 10,000 + 2,000 = 12,000. The bidder will be allowed to submit these bids because the submitted activity does not exceed its contingent bidding limit for the round, which is 12,000 (that is, 120% of 10,000).

Bids to change demand are processed in increasing order of price point. This example assumes that no other bidder submitted a bid to change its demand in W, X, Y, or Z. The example considers two scenarios:

Scenario 1: There is excess demand in license W and in license X so that both of the bidder's bids to reduce demand are applied. The bid to reduce demand in W is considered first and is applied, because this scenario assumes that there is excess demand in W. As a result, the activity associated with the demand held by the bidder is 2,800. The bid to reduce demand in X is considered next and is applied, because this scenario assumes that there is excess demand in X. As a result, the activity associated with the demand held by the bidder is now 0. The bid processing algorithm will then consider the bid to increase demand in Y (because it has a lower price point than the bid to increase demand in Z). The bid to increase demand in Y is applied, because that does not cause the bidder's processed activity to exceed its eligibility. As a result, the activity associated with the demand held by the bidder is now 10,000. The bid to increase demand in Z is considered next but is not applied, because applying the bid would cause the bidder's processed activity to exceed its eligibility. Thus, the bidder's processed activity after the round is equal to 10,000. This means that the bidder maintains its eligibility at 10,000.

Scenario 2: There is excess demand in license X but not in license W so that the bid to reduce demand in X is applied but the bid to reduce demand in W is not. The bid to reduce demand in W is considered first but it is not applied, because this scenario assumes that there is no excess demand in W; thus, the bid is placed in the queue, and the activity associated with the demand held by the bidder continues to be 7,000 + 2,800 = 9,800. The bid to reduce demand in X is considered next and is applied, because this scenario assumes that there is excess demand in X. As a result, the activity associated with the demand held by the bidder is now 7,000. The bid processing algorithm will then consider the bid to increase demand in Y (because it has a lower price point than the bid to increase demand in Z). The bid to increase demand in Y is not applied, because applying it would cause the bidder's processed activity to become 7,000 + 10,000 = 17,000, which would exceed the bidder's eligibility of 10,000. The bid to increase demand in Z is considered next and is applied, because that does not cause the bidder's processed activity to exceed its eligibility (7,000 + 2,000 < 10,000). Then, the bidder's processed activity after the round is equal to 9,000 (less than its required activity of 9,500) and the bidder's eligibility in the next round is 9,474 bidding units (that is, 9,000/0.95 rounded up to the nearest integer).

As illustrated in this example, if a bidder submits activity that exceeds its eligibility, not all of its bids will be applied. Since bids are considered by the bidding system in order of price point, a bidder can prioritize its bids using price points, so that the bidding system applies any free eligibility first to the bidder's most preferred bids to increase demand. The highest priority bids should be associated with the lowest price points.

Example 8 illustrates a scenario where the contingent bidding limit is used properly to address the potential for loss of bidding eligibility under some circumstances: the bidder submits bids with activity that exceeds its eligibility and indicates price points that reflect its preferences for the order in which it wishes its bids to increase demand to be processed by the system.

Example 9 provides some case studies where the contingent bidding limit is not used properly.

Example 9 – Case Studies Where Contingent Bidding Limit Is Not Used Properly: For the purposes of this example, the contingent bidding percentage is 120% and the bidder's eligibility for the round is 10,000.

- Case study 1: All bids to increase demand are at the same price point. Consider a variation of Example 8 where both bids to increase demand (*i.e.,* the bids for licenses Y and Z) are at the corresponding clock prices (*i.e.,* at $100,000 and $24,000 respectively). Then, both bids have a price point of 100%, and the system will prioritize them based on random numbers. In Scenario 1 where both bids to reduce demand are applied, the bidding system might process the bid to increase demand for license Z first. If that bid is applied, then it is not possible to also apply the bid to increase demand for license Y. In that case, the bidder will only have processed demand for license Z, which perhaps was not the bidder's intention.

- Case study 2: Bid to increase demand cannot be applied under any circumstances. Consider a bidder that has processed activity for a single license (A) and submits a bid to maintain demand in A and another bid to increase demand in another license (B), as shown in the table below:

License	Bidding Units	Previous Round Processed Demand	Start-of-Round Price	Clock Price	Submitted Bids Quantity@Price (Price Point)
A	10,000	1	$90,000	$100,000	1 @ $100,000 (100%)
B	2,000	0	$20,000	$24,000	1 @ $22,000 (50%)

The bidder will be allowed to submit these bids with submitted activity of 12,000 since that equals the bidder's contingent bidding limit for the round (*i.e.,* 120% of 10,000). However, the bid to increase demand for license B will not be applied under any circumstances. The reason is that, since bids to maintain demand are always applied, the bid to maintain demand for license A is applied first, and therefore applying the bid to increase demand for license B would cause the bidder's processed activity to exceed its eligibility. This case study illustrates a scenario where a bidder submits a bid that is irrelevant because it cannot be applied under any circumstances.

- Case study 3: The bidder attempts to move its demand to a license with more bidding units and for which the bidder does not have sufficient eligibility. Consider a bidder with processed demand for a single license (A). The bidder submits a bid to reduce its demand in A from 1 to 0 and another bid to increase its demand in another license (C) from 0 to 1, as shown in the table:

License	Bidding Units	Previous Round Processed Demand	Start-of-Round Price	Clock Price	Submitted Bids Quantity@Price (Price Point)
A	10,000	1	$90,000	$100,000	0 @ $95,000 (50%)
C	11,000	0	$110,000	$120,000	1 @ $115,000 (50%)

In this case, the bidder wants to move its demand from license A to license C. However, the bidder does not have enough eligibility for license C. The bidder will be allowed to submit these bids with submitted activity of 11,000 since that does not exceed the bidder's contingent bidding limit for the round (*i.e.,* 120% of 10,000). However, the bid to increase demand for license C will not be applied under any circumstances because the bidding units for C exceed the bidder's

eligibility for the round. Thus, if the bid to reduce demand in A is applied, then the bidder's processed activity will be 0 and the bidder's eligibility for the next round will also be 0.

7.2   Clock Prices for the Next Round

The clock price of a license in the next round is calculated by incrementing the posted price from the previous round by a specified percentage.

Specifically, the clock price $P_{t,l}$ for license l in round t is calculated as:

$$P_{t,l} = (1 + y_t) \cdot p_{t-1,l}$$

Where:

- y_t denotes the increment percentage for round t. The increment percentage will be set within a range of 5% to 30% inclusive, and the initial increment percentage will be 10%. The increment percentage may change from round to round with advance notice.

- $p_{t-1,l}$ denotes the posted price of license l for round $t - 1$.

Results above $10,000 will be rounded up to the nearest $1,000; results below $10,000 but above $1,000 will be rounded up to the nearest $100; and results below $1,000 will be rounded up to the nearest $10.

OEA and WTB will retain the discretion to cap the increment if the total dollar amount of the increment (the difference between the clock price and the start-of-round price) would exceed a certain amount.

Note that the clock price calculation for the next round applies to every license, regardless of whether there is excess demand for the license.

7.3   Proxy Bids for the Next Round

Once the clock prices have been determined, the bidding system will determine the proxy bids that it will submit on behalf of the bidders. The proxy bids on behalf of a given bidder will be submitted by the bidding system at the beginning of the round. Any bids (including proxy bids) and any proxy instructions can be modified by the bidder during the round.

Consider a bidder with processed demand for a given license that has a proxy instruction in place for that license.

If the proxy instruction price is within the price range for the next round, that is, between the start-of-round price and the clock price inclusive, then the bidding system will generate a proxy bid to reduce the bidder's demand for the license to 0 at the proxy instruction price.

Otherwise, *i.e.,* if the proxy instruction price is greater than the next round's clock price, the bidding system will generate a proxy bid to maintain the bidder's demand at the clock price. In this case, the bidding system will inform the bidder that it also has a proxy instruction in place for future rounds.

Example 10 – Proxy Bid to Reduce Demand: For a given license, the start-of-round price is $100,000 and the clock price is $115,000. A bidder with processed demand for the license has a proxy instruction to reduce demand at $108,000. Then, the bidding system will submit a proxy bid to reduce the bidder's demand at $108,000.

Example 11 – Proxy Bid to Maintain Demand: For a given license, the start-of-round price is $100,000 and the clock price is $115,000. A bidder with processed demand for the license has a proxy instruction to reduce demand at $140,000. Then, the bidding system will submit a proxy bid to maintain the bidder's demand at $115,000 (the clock price). The bidding system will also inform the bidder that it has a proxy instruction to reduce demand at $140,000.

8 Final Payments and Per-License Prices

A bidder with processed demand for one or more licenses at the time the stopping rule is met will become the winning bidder for those licenses. The *final price* for a license is equal to the posted price for the final round, and the *final payment* of a winning bidder is equal to the net commitment of that bidder after the final round. See Section 3.5 for the definitions of commitment, commitment discount, and net commitment after a round.

Because the discount and the final payment for a winning bidder with a bidding credit apply on an aggregate basis, rather than for individual licenses, the bidding system will also calculate a net per-license price for each license won. Such individual prices may be needed in the event that a licensee subsequently incurs license-specific obligations, such as unjust enrichment payments.

For a license won by a bidder that does not qualify for a bidding credit, the net price is simply equal to the final price of the license.

To describe the net price calculation for a bidder that qualifies for a bidding credit, we use the following notation:

- $p_{T,l}$ denotes the final price for license l.

- $LP_{T,i}$ denotes the set of licenses for which bidder i has processed demand after the final round (*i.e.,* the set of licenses won by bidder i).

- $C_{T,i}$ denotes the commitment of bidder i after the final round.

- If bidder i qualifies for the small business bidding credit discount, $C_{T,i}^{SM}$ denotes the commitment of bidder i in small markets after the final round. That is, $C_{T,i}^{SM} = \sum_{l \in S \cap LP_{T,i}} p_{T,l}$, where S is the set of licenses subject to the small market bidding credit cap.

- $D_{T,i}$ denotes the commitment discount of bidder i after the final round.

A bidder i that qualifies for the small business bidding credit is considered to have exceeded the small market bidding credit cap if $BC_i \cdot C_{T,i}^{SM}$ rounded to the nearest integer is greater than \$10 million.

If bidder i qualifies for the rural service provider bidding credit *or* if the bidder qualifies for the small business bidding credit and did not exceed the small market bidding credit cap, then the net per-license price of a license l won by bidder i is determined by the following formula:

$$p_{T,l} - \frac{p_{T,l}}{C_{T,i}} \cdot D_{T,i}$$

That is, the bidding system calculates net prices by apportioning the bidder's discount to licenses in proportion to the final prices of the licenses that the bidder won.

Each license calculation is rounded down to the nearest dollar and then the slack due to rounding down is distributed to licenses (one dollar at a time) based on descending order of final prices. Ties are broken based on ascending lexicographic order of license ID. License ID is defined as "D" (which denotes 2017 census data reflecting county legal boundaries and names), followed by the five-digit FIPS code for the county, followed by a hyphen and the number representing the category. For example, if the FIPS code is 01003, then the license ID for the category 1 license would be D01003-1.

If bidder i qualifies for the small business bidding credit and it exceeded the small market bidding credit cap, then the \$10 million discount that applies to small markets is apportioned to licenses won by the bidder in counties subject to the small market bidding credit cap proportionally to the final prices of those

licenses. The remaining discount (*i.e.*, $D_{T,i} - \$10$ million) is apportioned among the licenses in counties not subject to the small market bidding credit cap proportionally to the final prices of those licenses.

- The net per-license price of a license l in a county that is subject to the small market bidding credit cap is determined by the following formula:

$$p_{T,l} - \frac{p_{T,l}}{C_{T,i}^{SM}} \cdot (\$10 \text{ million})$$

- The net per-license price of a license l in a county that is not subject to the small market bidding credit cap is determined by the following formula:

$$p_{T,l} - \frac{p_{T,l}}{C_{T,i} - C_{T,i}^{SM}} \cdot (D_{T,i} - \$10 \text{ million})$$

For each license, the calculation is rounded down to the nearest dollar. The slack due to rounding down is then distributed (one dollar at a time) to licenses based on descending order of final prices. Ties are broken based on ascending lexicographic order of license ID.

In the case of a small business that exceeded the small market bidding credit cap, the apportioning of discounts and the distribution of any slack is done separately for the licenses in small markets and for the licenses not in small markets.