Auction 103 Clock Phase Technical Guide

Revision History

Date	Section	Description
July 11, 2019	3.4.3	Corrected an error in Example 6 (changed $22 million to $24 million)
September 6, 2019	6	Corrected a formula on page 22 from $\sum_{r \in R} p_{t,r} \cdot \sum_{i \in B} d_{t,i,r}$ to $\sum_{r \in R} p_{t,r} \cdot \min(S_r, \sum_{i \in B} d_{t,i,r})$

1 Introduction

This technical guide details the bidding procedures for the first phase — the clock phase — of Auction 103 as described in the *Auction 103 Procedures Public Notice*.[1] The *Assignment Phase Technical Guide* describes the bidding procedures for the second part of Auction 103 — the assignment phase.

For the clock phase, a product is the pairing of a PEA and a license category. There are two license categories in this auction: Category M/N which consists of blocks in the Upper 37 GHz and 39 GHz bands, and Category P which consists of blocks in the 47 GHz band. The supply of a product is the number of blocks in the category in the PEA available in the auction. The supply of Category M/N blocks in a PEA will be determined by the reconfiguration process, which concludes with the Initial Commitments of 39 GHz incumbents,[2] and in each PEA there will be up to 24 Category M/N blocks. The supply of Category P blocks is equal to 10 for all PEAs.

The clock phase will consist of a series of timed bidding rounds. In the first round, bidders will indicate their demands at the opening prices, or minimum opening bids. After the first round and before each later round, the bidding system will announce a *clock price* for the next round. During the round, bidders will submit bids indicating demand for generic blocks in a license category in a PEA, at a price they specify that is equal to or greater than the *posted price*[3] of the previous round and equal to or less than the clock price. After each bidding round closes, the bids are processed. Bid processing determines the quantity of a bidder's requested demand that is applied (the *processed demand*), and the posted price of each product for the round. If, after the bids are processed, there is no excess demand for blocks in any category in any PEA, the clock phase of the auction will end and the *final clock phase price* for each product will be equal to the posted price of the last round. Otherwise, the auction will continue with a new clock round.

The final clock phase prices will determine the incentive payment for each incumbent 39 GHz licensee that made an Initial Commitment to relinquish either a partial block or all its licenses. The auction will implement a *net revenue requirement* based on auction bids that will assure that auction proceeds are

[1] *See Incentive Auction of Upper Microwave Flexible Use Service Licenses in the Upper 37 GHz, 39 GHz, and 47 GHz Bands for Next-Generation Wireless Services; Notice and Filing Requirements, Minimum Opening Bids, Upfront Payments, and Other Procedures for Auction 103; Bidding in Auction 103 Scheduled to Begin December 10, 2019*, Public Notice, FCC 19-63 (July 11, 2019) (*Auction 103 Procedures Public Notice*).

[2] *See Reconfigured 39 GHz Incumbent Holdings; Initial Commitment Options and Timeline; Preparation for Incentive Auction of Upper Microwave Flexible Use Service Licenses in the Upper 37 GHz, 39 GHz, and 47 GHz Bands (Auction 103),* Public Notice, DA 19-503 (WTB/OEA June 5, 2019).

[3] The posted price of Round 1 is equal to the minimum opening bid.

sufficient to cover all incentive payments owed. If the net revenue requirement has been met when the clock phase concludes, then the auction will proceed with the assignment phase. Otherwise, the auction will end, and no new licenses will be assigned.

Section 2 describes the bidding rules. Section 3 describes the calculations for the bidding information shown to bidders. Section 4 describes the types of bids bidders can submit. Section 5 describes how bids are processed after a round. Section 6 describes how the system checks whether the net revenue requirement has been met, and Section 7 describes the closing conditions. Section 8 describes how the system sets up the next round if the closing conditions are not met at the end of a round.

2 Bidding

A bidder in the auction indicates in each round its demand for blocks of the products it desires at current prices. When submitting a bid, the bidder specifies a quantity and a price. The price can be the previous round's posted price, the current round's clock price, or any price in between (an "intra-round bid"). In each round, bidders may submit multiple bids, including up to five bids for the same product. For example, a bidder that begins a round with processed demand of 4 units for a product might submit one bid to reduce its demand for that product from 4 to 3 at a price of $5,500 and another bid to reduce its demand for the product from 3 to 2 at a price of $5,800.

In order to give bidders flexibility to express their demands, the auction includes two types of bids: simple bids and switch bids. Section 4 provides detailed explanations and examples of these bid types and how the bidding system will process them.

2.1 Bidding Rules

In the first round of the auction, a bidder may only submit a bid for a product at the opening price (or minimum opening bid) for that product. For all subsequent rounds, a bidder may either submit a bid to maintain its demand for a product at the round's clock price or submit a bid to change its demand for the product at a price that is greater than or equal to the previous round's posted price for that product and less than or equal to the current round's clock price for that product.

In every round, a bidder may only bid for a quantity that is greater than or equal to 0 and less than or equal to the supply for that product.

Starting in round 2, a bidder may submit up to five bids for the same product in a round. For example, a bidder that begins a round with processed demand of 4 units for a product might submit one bid to reduce its demand for that product from 4 to 3 at a price of $5,500 and another bid to reduce its demand for the product from 3 to 2 at a price of $5,800. As another example, a bidder that begins a round with processed demand of 24 units could submit up to 5 bids, but will *not* be allowed to submit six bids for the product, such as the following: one bid to reduce its demand for that product from 24 to 23 at a price of $5,100, another bid to reduce its demand for that product from 23 to 20 at a price of $5,150, another bid to reduce its demand for that product from 20 to 18 at a price of $5,200, another bid to reduce its demand for that product from 18 to 10 at a price of $5,300, another bid to reduce its demand for that product from 10 to 8 at a price of $5,400, and another bid to reduce its demand for that product from 8 to 5 at a price of $5,420,

A bidder will *not* be allowed to submit a bid or collection of bids if the bidder's *activity* for the round would exceed its *current eligibility*.

A bidder may only submit one of the two types of bids for a given product: simple bids or switch bids. For example, if a bidder submits a simple bid for product A, then it cannot submit a switch bid that involves product A in the same round.

A switch bid can be *either* from Category M/N to Category P *or* from Category P to Category M/N within the same PEA.

A bidder may *not* submit two different bids that involve the same product at the same price. For example, the bidder cannot submit a simple bid for 2 blocks of product A and a simple bid for 0 blocks of product A both at the same price.[4]

A bidder may *not* submit two bids for the same product that involve the same quantity at different prices. For example, the bidder cannot submit a simple bid for 2 blocks of product A at a price of $1,050 and a simple bid for 2 blocks of product A at a price of $1,070 in the same round.

All of the bids submitted by a bidder in a round for a product must be *one-directional* in terms of price. That is, if all of the bids submitted by a bidder in a round for a product are put in ascending order by price, the corresponding quantities must all either increase or decrease starting from the bidder's processed demand from the previous round. The algorithm that determines *one-directionality* is described below.

2.2 Algorithm for One-Directionality

The following algorithm illustrates how one can check one-directionality for a bidder with respect to a given product r. Let A denote the set of bids that the bidder has just requested to submit, and B denote the set of bids that the bidder has already submitted in this round. This section describes how to check one-directionality when the set $A \cup B$ contains at least two bids that involve product r.

If the set of bids $A \cup B$ includes at least one switch bid where product r is the "to" product, then one-directionality for product r is satisfied if and only if all bids in $A \cup B$ that involve product r are switch bids with r as the "to" product. See Section 4.2 for details on switch bids.

The remainder of this section describes how to check one-directionality when all bids involving product r are simple bids or are switch bids with r as the "from" product. The algorithm looks at all bids for product r in A and B. It ranks them in price order, then checks the direction of the change and validates that all bids at higher prices maintain the same direction.

- Let A_r consist of all bids in A that involve product r. Each element of A_r is represented by the pair (price, quantity for product r).
- Similarly, let B_r consist of all bids in B that involve product r. Each element of B_r is represented by the pair (price, quantity for product r).
- Let S denote the union of A_r, B_r and the following element: (posted price of previous round for product r, the bidder's processed demand from previous round for product r)
- Rank all elements of S in ascending order of price, and let q be the corresponding vector of quantities. That is, $q(1)$ is the processed demand from the previous round, $q(2)$ is the quantity associated with the lowest-price bid for product r in $A \cup B$, etc. Let N be the number of elements in q.
- Check whether one of the following conditions holds:

  (i) $q(k) > q(k-1)$ for $k = 2, 3, \ldots, N$.

  (ii) $q(k) < q(k-1)$ for $k = 2, 3, \ldots, N$.

  If either (i) or (ii) is satisfied, then the bids in A are one-directional with the bids in B and the bidder's processed demand from the previous round for product r. If the bids in A are one-

[4] This avoids having to randomly select which of the bidder's bids to process first.

directional with the bids in B and the bidder's processed demand from the previous round for all products, then the system allows the bidder to submit the bids in A. Otherwise, the bids in A are not submitted.

Example 1: Suppose that the bidder's processed demand for product r from the previous round is 4, and the posted price is $5,000. In the current round, the clock price is $6,000. The bidder has already submitted the bids $B_r = \{(\$5{,}300, 2), (\$5{,}400, 0)\}$ for product r in this round. The bidder is now trying to submit the bids $A_r = \{(\$5{,}100, 3), (\$5{,}200, 1)\}$ for product r. Then,

$$S = \{(\$5{,}000, 4), (\$5{,}100, 3), (\$5{,}200, 1), (\$5{,}300, 2), (\$5{,}400, 0)\}$$

The following table shows the prices and quantities of the elements of S, ranked in order of price:

k	Price	$q(k)$
1	$5,000	4
2	$5,100	3
3	$5,200	1
4	$5,300	2
5	$5,400	0

Observe that $q(2) < q(1)$ but q(4) $> q(3)$. Thus, the bidder will not be allowed to submit the bids in A_r.

3 Calculations for Bidding Information

In the following sections, R denotes the set of all products.

Moreover, the notation x^+ is used to denote the maximum between x and 0. That is, $x^+ = \max(x, 0)$.

3.1 Activity

When a clock round is open for bidding, the *activity* of a bidder is calculated as the total number of bidding units associated with the demand the bidder indicates it is willing to accept at the clock price, given all bids that the bidder has submitted.[5] In other words, the activity of bidder i in round t is:

$$\sum_{r \in R} q_{t,i,r} \cdot b_r$$

Where:

- $q_{t,i,r}$ denotes the requested demand of bidder i for product r at the clock price of round t, given all bids that bidder i has submitted so far in this round. In particular, if all the bids that are submitted by bidder i for product r are applied during bid processing, then its processed demand will be $q_{t,i,r}$.
- b_r denotes the number of bidding units associated with product r.

[5] The bidding system provides the activity calculation, 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 at that time.

At the beginning of a round, *i.e.*, before the bidder has submitted any bids in this round, the bidder's activity is equal to 0.

Example 2: Product A has 10 bidding units and product B has 8 bidding units. For product A, the clock price is \$6,000, and the previous round's posted price is \$5,000. For product B, the clock price is \$4,800, and the previous round's posted price is \$4,000. Suppose that bidder i has submitted the following bids in the current bidding round:

- Product A: a simple bid for 4 blocks at price \$5,500, and a simple bid for 2 blocks at price \$5,700. (See Section 4.1 for description of simple bids.)
- Product B: a simple bid for 2 blocks at price \$4,500.

After the bidder has submitted these three bids, its activity is: $(2 \cdot 10) + (2 \cdot 8) = 36$ bidding units.

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 should have after the bid processing of round t in order to maintain the same eligibility in round $t+1$. The bidder's required activity in round t is calculated according to the following formula:

$$Required\ Activity(t) = Eligibility(t) \cdot ActivityRequirement,$$

rounded down to the nearest integer.

Where:

- $Eligibility(t)$ denotes the bidder's eligibility in round t.
- $ActivityRequirement$ denotes the activity requirement. This is a percentage (up to 100%) set by the Commission.

3.3 Payment Information Available While the Round is Open for Bidding

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

The following notation is used in this section:

- $q_{t,i,r}$ denotes the requested demand of bidder i for product r at the clock price of round t, given all bids that bidder i has submitted so far in this round. In particular, if all the bids that are submitted by bidder i for product r are applied during bid processing, then its processed demand will be $q_{i,r}$.
- $P_{t,r}$ denotes the clock price in round t for product r.
- $\{MN, j\}$ denotes the Category M/N product in PEA j and thus $P_{t,\{MN,j\}}$ denotes the clock price in round t for Category M/N in PEA j.
- $\{P, j\}$ denotes the Category P product in PEA j and thus $P_{t,\{P,j\}}$ denotes the clock price in round t for Category P in PEA j.
- w_j denotes the weighted MHz-pops of PEA j per block.
- $v_{i,j}$ denotes the relinquished weighted MHz-pops of bidder i for PEA j (in the 39 GHz band), given the incumbent's Initial Commitment and Round Zero decisions.

- BC_i denotes the bidding credit percentage of bidder i.
- R denotes the set of all products.
- TM denotes the set of all markets, that is, $TM = \{1,2, \dots ,416\}$.
- SM denotes the set of all *small markets* (*i.e.*, markets subject to the small market bidding cap).[6]
- S denotes the set of all products in small markets.
- $RC_{t,i}$ denotes the requested commitment of bidder i in round t (defined in Section 3.3.1).
- $MIP_{t,i}$ denotes the maximum incentive payment of bidder i in round t (defined in Section 3.3.2).

3.3.1 Requested Commitment

A bidder's *requested commitment* during a clock round t is the total gross bid amount calculated at the round's clock prices, given the bids that the bidder has submitted so far in round t.[7] This calculation does not take incentive payments, if any, into account; it concerns only the bidder's obligations based on its bids. During the round, bids for the round have not yet been processed, so the requested commitment is an estimate of a bidder's commitment, which is updated as bids are submitted. The requested commitment of bidder i in a clock round t is calculated according to the following formula:

$$RC_{t,i} = \sum_{r \in R} q_{t,i,r} \cdot P_{t,r}$$

At the beginning of a round, *i.e.*, before the bidder has submitted any bids in this round, the bidder's requested commitment is equal to 0.

Example 3: For product A, the clock price is $6,000, and the previous round's posted price is $5,000. For product B, the clock price is $4,800, and the previous round's posted price is $4,000. Suppose that bidder i has submitted the following bids in the current bidding round:

- Product A: a simple bid for 4 blocks at price $5,500, and a simple bid for 2 blocks at price $5,700. (See Section 4.1 for a description of simple bids.[8])
- Product B: a simple bid for 2 blocks at price $4,500

By submitting these bids, the bidder indicates that it is willing to buy 2 blocks of product A up to and including the clock price of $6,000 per block, and 2 blocks of product B up to and including the clock price of $4,800 per block. After submitting these three bids, the bidder's requested commitment is:

$$(2 \cdot \$6{,}000) + (2 \cdot \$4{,}800) = \$21{,}600$$

3.3.2 Maximum Incentive Payment (applicable only to incumbents)

For the convenience of an incumbent that chose to relinquish all its licenses and bid for licenses in the auction, the bidding system will provide an estimate of its incentive payments based on a round's clock

[6] Markets that are subject to the small market bidding credit cap are those PEAs with a population of 500,000 or less, which corresponds to PEAs 118–416, excluding PEA 412. *See Auction 103 Procedures Public Notice* at Section II.H.3 (Caps on Bidding Credits).

[7] Note that a bidder's requested commitment may change when the bidder submits or changes its bids.

[8] For example, a simple bid for 2 blocks at a price of $5,700 indicates that at a price of $5,700 up to the clock price of $6,000, the bidder demands 2 blocks.

prices. During a clock round, the bidding system will display the maximum incentive payment that an incumbent will have if the current round is the final clock round. This estimate is a maximum because it is based on the round's clock prices. If the current round is the final clock round, the actual incentive payment will be based on the round's posted prices, which may be lower than the clock prices. If the auction continues with more clock rounds, the incumbent's incentive payment may increase further. An incumbent will receive an incentive payment only if the net revenue requirement is met during the clock phase of the auction.

An incumbent's *maximum incentive payment* during a clock round t is the total gross incentive payment amount calculated at the round's clock prices, given the quantities that the incumbent is relinquishing in each market (based on Round Zero decisions). During the round, the round's posted prices have not yet been determined, so the incentive payment information shown to the bidder is just an estimate. The maximum incentive payment of bidder i in a clock round t is calculated according to the following formula:

$$MIP_{t,i} = \sum_{j=1}^{416} \frac{v_{i,j}}{w_j} \cdot P_{t,\{MN,j\}}$$

This is the sum, across all PEAs, of the Category M/N clock price for PEA j multiplied by the incumbent's relinquished quantity in weighted MHz-pops for the PEA divided by the weighted MHz-pops of the PEA.

The system will first calculate the summation shown above and then round the result to the nearest dollar.

An incumbent's maximum incentive payment amount that is displayed by the system during a round depends only on the round's clock prices and the incumbent's relinquished holdings. It does not depend on the bids that the incumbent submits for the round. Thus, unlike the requested commitment amount for a round, the maximum incentive payment amount will not change if the bidder changes its bids during the round.

Note that if the bidder is not an incumbent, then it has not relinquished any holdings nor will it receive an incentive payment in this auction. The bidding system will not show any incentive payment information to such a bidder.

3.3.3 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.

Non-Incumbent with Rural Service Provider Bidding Credit. If bidder i qualifies for the rural service provider bidding credit and is not an incumbent in the 39 GHz band, then in round t,

Its *uncapped requested commitment discount* is:

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

Its *capped 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.

Incumbent with Rural Service Provider Bidding Credit. If bidder i is an incumbent in the 39 GHz band that qualifies for the rural service provider bidding credit, then in round t,

Its *uncapped requested commitment discount* is:

$$BC_i \cdot \left(RC_{t,i} - MIP_{t,i}\right)^+$$

Its *capped requested commitment discount* is equal to the minimum of $10 million and the bidder's uncapped requested commitment discount:

$$min\left\{\$10 \text{ million}, BC_i \cdot \left(RC_{t,i} - MIP_{t,i}\right)^+\right\}$$

That is, the incumbent receives a discount only on its net cash payment for new licenses, and its overall discount is capped at $10 million. If the bidder's maximum incentive payment for the round is greater than or equal to the bidder's requested commitment, then the bidder's capped requested commitment discount is equal to 0.

Non-Incumbent with Small Business Bidding Credit. If bidder i qualifies for the small business bidding credit and is not an incumbent in the 39 GHz band, then in a clock round t,

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

$$BC_i \cdot \sum_{r \in S} q_{t,i,r} \cdot P_{t,r}$$

Note that the summation is across all products in small markets. 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 *capped requested commitment discount* (across all markets) is:

$$min\left\{\$25 \text{ million}, BC_i \cdot \sum_{r \in R \setminus S} q_{t,i,r} \cdot P_{t,r} + min\left\{\$10 \text{ million}, BC_i \cdot \sum_{r \in S} q_{t,i,r} \cdot P_{t,r}\right\}\right\}$$

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.

Incumbent with Small Business Bidding Credit. If bidder i is an incumbent in the 39 GHz band that qualifies for the small business bidding credit, then in a clock round t,

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

$$BC_i \cdot \left(\sum_{r \in S} q_{t,i,r} \cdot P_{t,r} - \sum_{j \in SM} \frac{v_{i,j}}{w_j} \cdot P_{t,\{MN,j\}} \right)^+$$

Note that the first summation is across all products in small markets and represents the bidder's requested commitment in small markets, whereas the second summation is across all small markets and represents the bidder's maximum incentive payment in small markets. The uncapped requested commitment discount in small markets is positive only if the requested commitment in small markets exceeds the maximum incentive payment in small markets.

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

$$BC_i \cdot \left(RC_{t,i} - MIP_{t,i}\right)^+$$

Its *capped requested commitment discount* (across all markets) is equal to the minimum of the following two quantities:

i.

$$BC_i \cdot \left(RC_{t,i} - MIP_{t,i}\right)^+; \text{ and}$$

ii.

$$min\left\{ \$25 \text{ million}, BC_i \cdot \left(\sum_{r \in R \setminus S} q_{t,i,r} \cdot P_{t,r} - \sum_{j \in TM \setminus SM} \frac{v_{i,j}}{w_j} \cdot P_{t,\{MN,j\}} \right)^+ + min\left\{ \$10 \text{ million}, BC_i \cdot \left(\sum_{r \in S} q_{t,i,r} \cdot P_{t,r} - \sum_{j \in SM} \frac{v_{i,j}}{w_j} \cdot P_{t,\{MN,j\}} \right)^+ \right\} \right\}$$

The first quantity is simply the bidder's uncapped requested commitment discount; this considers the bidder's requested commitment and maximum incentive payment across all markets together and does not take into account any caps. The second quantity considers the bidder's discount in small markets and non-small markets separately. 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.

3.3.4 Requested Net Commitment

A bidder's *requested net commitment* is equal to its requested commitment *minus* its maximum incentive payment (applicable only for incumbents in the 39 GHz band) *minus* its capped requested commitment discount.

A bidder's requested net commitment will be negative if its incentive payment for its relinquished licenses exceeds its obligation for new licenses.

3.4 Payment Information Available After the Round has been Processed

After bid processing for a round, the bidding system will then provide payment information based on the processed demands and the posted prices for the round. The calculations are similar to the corresponding

calculations for requested commitment and maximum incentive payment that are conducted during a round (as described in Section 3.3), except that the bidder's processed demand ($d_{t,i,r}$) is used instead of the bidder's requested demand at the clock price ($q_{t,i,r}$), and a product's posted price ($p_{t,r}$) is used instead of the product's clock price ($P_{t,r}$).

In addition to the notation of Section 3.3, the following notation is used in this section:

- $d_{t,i,r}$ denotes the processed demand of bidder i for product r after round t.
- $p_{t,r}$ denotes the posted price of product r after round t.
- $C_{t,i}$ denotes the commitment of bidder i after round t (defined in Section 3.4.1).
- $IP_{t,i}$ denotes the incentive payment of bidder i after round t (defined in Section 3.4.2).

3.4.1 Commitment

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

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

$$C_{t,i} = \sum_{r \in R} d_{t,i,r} \cdot p_{t,r}$$

3.4.2 Incentive Payment (applicable only to incumbents)

The incentive payment of bidder i after round t is calculated based on the round's posted prices according to the following formula:

$$IP_{t,i} = \sum_{j=1}^{416} \frac{v_{i,j}}{w_j} \cdot p_{t,\{MN,j\}}$$

The system will first calculate the summation shown above and then round the result to the nearest dollar.

In contrast to the maximum incentive payment that is shown to a bidder when a round is open for bidding (defined in Section 3.3.2), the incentive payment shown to a bidder after a round is not a "maximum", because it is calculated based on the round's posted prices (not the clock prices).

3.4.3 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.

Non-Incumbent with Rural Service Provider Bidding Credit. If bidder i qualifies for the rural service provider bidding credit and is not an incumbent in the 39 GHz band, then after round t,

Its *uncapped commitment discount* is:

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

Its *capped commitment discount* is:

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

Incumbent with Rural Service Provider Bidding Credit. If bidder i is an incumbent in the 39 GHz band who qualifies for the rural service provider bidding credit, then after round t,

Its *uncapped commitment discount* is:

$$BC_i \cdot \left(C_{t,i} - IP_{t,i}\right)^+$$

Its *capped commitment discount* is:

$$min\left\{\$10 \text{ million}, BC_i \cdot \left(C_{t,i} - IP_{t,i}\right)^+\right\}$$

Example 4: Bidder i is a 39 GHz incumbent that qualifies as a rural service provider with a bidding credit percentage of 15%. The bidder relinquished 1.1 block equivalents in given PEA X, that is, $\frac{v_{i,X}}{w_X} = 1.1$. After round t, bidder i has processed demand of 2 blocks of Category P in PEA Y, that is, $d_{t,i,\{P,Y\}} = 2$. The posted price for Category M/N in PEA X is $p_{t,\{MN,X\}} = \$20$ million and the posted price for Category P in PEA Y is $p_{t,\{P,Y\}} = \$15$ million. Then, for this round, the bidder's commitment is \$30 million and its incentive payment is \$22 million. Thus, the bidder's capped commitment discount is:

$$min\{\$10 \text{ million}, (15\%) \cdot (\$30 \text{ million} - \$22 \text{ million})^+\} = \$1.2 \text{ million}$$

Thus, the bidder's net commitment is $\$30 \text{ million} - \$22 \text{ million} - \$1.2 \text{ million} = \$6.8 \text{ million}$

Non-Incumbent with Small Business Bidding Credit. If bidder i qualifies for the small business bidding credit and is not an incumbent in the 39 GHz band, then after round t,

Its *uncapped commitment discount in small markets* is:

$$BC_i \cdot \sum_{r \in S} d_{t,i,r} \cdot p_{t,r}$$

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

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

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

$$min\left\{\$25 \text{ million}, BC_i \cdot \sum_{r \in R \setminus S} d_{t,i,r} \cdot p_{t,r} + min\left\{\$10 \text{ million}, BC_i \cdot \sum_{r \in S} d_{t,i,r} \cdot p_{t,r}\right\}\right\}$$

Incumbent with Small Business Bidding Credit. If bidder i is an incumbent in the 39 GHz band that qualifies for the small business bidding credit, then after round t,

Its *uncapped commitment discount in small markets* is:

$$BC_i \cdot \left(\sum_{r \in S} d_{t,i,r} \cdot p_{t,r} - \sum_{j \in SM} \frac{v_{i,j}}{w_j} \cdot p_{t,\{MN,j\}} \right)^+$$

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

$$BC_i \cdot \left(C_{t,i} - IP_{t,i} \right)^+$$

Its *capped commitment discount* (across all markets) is equal to the minimum of the following two quantities:

i.
$$BC_i \cdot \left(C_{t,i} - IP_{t,i} \right)^+; \text{ and}$$

ii.
$$min \left\{ \$25 \text{ million}, BC_i \cdot \left(\sum_{r \in R \setminus S} d_{t,i,r} \cdot p_{t,r} - \sum_{j \in TM \setminus SM} \frac{v_{i,j}}{w_j} \cdot p_{t,\{MN,j\}} \right)^+ + min \left\{ \$10 \text{ million}, BC_i \cdot \left(\sum_{r \in S} d_{t,i,r} \cdot p_{t,r} - \sum_{j \in SM} \frac{v_{i,j}}{w_j} \cdot p_{t,\{MN,j\}} \right)^+ \right\} \right\}$$

The first quantity is simply the bidder's uncapped commitment discount; this considers the bidder's commitment and incentive payment across all markets together and does not take into account any caps. The second quantity considers the bidder's discount in small markets and non-small markets separately. 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.

Example 5: Bidder i is a 39 GHz incumbent. The bidder qualifies for the small business bidding credit with a bidding credit percentage of $BC_i = 25\%$. The bidder relinquished 1 block equivalent in PEA X and, after round t, the posted price for Category M/N in PEA X is $p_{t,\{MN,X\}} = \$20$ million. Thus, the incentive payment of bidder i after round t is $IP_{t,i} = \$20$ million. After round t, bidder i has processed demand of 1 block for Category M/N in PEA Y and the posted price for Category M/N in PEA Y is $p_{t,\{MN,Y\}} = \$20$ million. Thus, the bidder's commitment after round t is $C_{t,i} = \$20$ million. Suppose that PEA Y is a small market and PEA X is not. Then, the bidder's capped commitment discount after round t is equal to 0, because that is the minimum of:

i. $(25\%) \cdot (\$20 \text{ m} - \$20 \text{ m})^+ = 0$; and
ii. $min\{\$25\ m, (25\%) \cdot (0 - \$20 \text{ m})^+ + min\{\$10 \text{ m}, (25\%) \cdot (\$20 \text{ m})^+\}\} = \$5 \text{ m}$

In this example, the bidder's capped commitment discount is equal to its uncapped commitment discount. Even though the bidder's commitment exceeds its incentive payment in small markets (which results in the second quantity being positive), the bidder does not get a discount in this example, because its overall commitment does not exceed its overall incentive payment.

Example 6: Bidder i is a 39 GHz incumbent. The bidder qualifies for the small business bidding credit with a bidding credit percentage of $BC_i = 25\%$. The following table shows the bidder's relinquished quantities as well as the posted prices and the bidder's processed demands after round t.

PEA	Small Market?	Block Equivalents Relinquished ($v_{i,j}/w_j$)	Posted Price ($p_{t,i,r}$)	Requested Demand at Clock Price ($d_{t,i,r}$)
X	No	1.1	M/N: \$40 million	M/N: 0 blocks
			P: \$12 million	P: 2 blocks
Y	Yes	0	M/N: \$15 million	M/N: 4 blocks
			P: \$10 million	P: 4 blocks

The bidder's incentive payment after round t is calculated based on the round's posted prices and is equal to $IP_{t,i} = \$44 \text{ million}$. The bidder's commitment after round t is

$$C_{t,i} = 2 \cdot (\$12 \text{ m}) + 4 \cdot (\$15 \text{ m}) + 4 \cdot (\$10 \text{ m}) = \$124 \text{ m}$$

Suppose that PEA Y is a small market and PEA X is not. Then, the bidder's capped commitment discount after round t is the minimum of:

i. $(25\%) \cdot (\$124 \text{ m} - \$44 \text{ m})^+ = \$20 \text{ m}$; and
ii. $min\{\$25 \text{ m}, (25\%) \cdot (\$24 \text{ m} - \$44 \text{ m})^+ + min\{\$10 \text{ m}, (25\%) \cdot (\$100 \text{ m})^+\}\} = \$10 \text{ m}$

Thus, the bidder's capped commitment discount is \$10 million. Note that, in this example, the bidder's commitment exceeds its incentive payment by \$80 million, resulting in an uncapped commitment discount of \$20 million (in i). However, because the bidder's commitment for small markets exceeds its incentive payment for small markets by \$100 million corresponding to a discount of \$25 million, that discount needs to be capped by the \$10 million small markets cap (in ii). Thus, the bidder's capped commitment discount is lower than its uncapped commitment discount.

3.4.4 Net Commitment

A bidder's *net commitment* after round t is equal to its commitment after round t *minus* its incentive payment (applicable only for 39 GHz incumbents) *minus* its capped commitment discount.

4 Bid Types

There are two types of bids:

Simple Bids: These bids indicate a desired quantity of a product at a price. During processing, if it is not possible to apply the simple bid in its entirety, it may be applied partially.[9]

Switch Bids: These bids allow a bidder to request to switch its demand for a quantity of a product from one category of generic blocks to another category within the same PEA. Switch bids may be applied partially, but the increase in demand in the "to" category will always match in quantity the reduction in the "from" category.

Below, a more detailed explanation is provided along with examples to illustrate each of these bid types and how the bidding system will process them.

4.1 Simple Bids

In Round 1, bidders will submit simple bids to indicate their initial demands for blocks in a category in a geographic area in which they are qualified to bid. In subsequent rounds, they may wish to reduce, increase, or maintain those demands using simple bids.

A *simple bid requesting to reduce demand* to a quantity q for a product r at price p in a round indicates that:

(1) At all prices above p and less than or equal to the clock price (or the next price at which the bidder submitted a bid, if the bidder submitted multiple bids for the product), the bidder is willing to buy an exact quantity equal to q; and

(2) At price p, the bidder is willing to buy any quantity between q and its previous demand for product r.[10]

By submitting one (or more) *simple bid(s) requesting to increase demand* for a product r at one (or more) price(s) in a round, the bidder indicates that at all prices associated with this round (*i.e.*, prices that are greater than or equal to the last round's posted price and less than or equal to the clock price) it is willing to buy any quantity that is greater than or equal to its processed demand and less than or equal to the maximum quantity that it specifies in a bid for product r.[11]

A *simple bid to maintain a quantity* equal to the bidder's processed demand for a product r at the round's clock price indicates that the bidder is willing to buy a quantity equal to the previous round's processed

[9] Bids requesting a reduction in demand may not be fully applied if the reduction would cause the demand for blocks in the category to fall below the supply. Simple bids requesting an increase in demand may not be fully applied if that would cause the bidder's activity to exceed its eligibility. *See Auction 103 Procedures Public Notice* at Section IV.B.4 (Changing Demand, Bid Types, and Bid Processing).

[10] The bidder's previous demand for product r is either equal to its processed demand from the previous round or, if the bidder has submitted a simple bid at a price below p for product r, the quantity in the bid for product r with the highest price below p.

[11] The bidding system will not process the requested increase until bid processing reaches the price point at which the bid was made, but depending upon demand for the product relative to its supply and upon which bids to reduce demand for the product 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 point to be applied.

demand at all prices in this round up to and including this round's clock price. Intra-round bids to maintain demand are not permitted.[12]

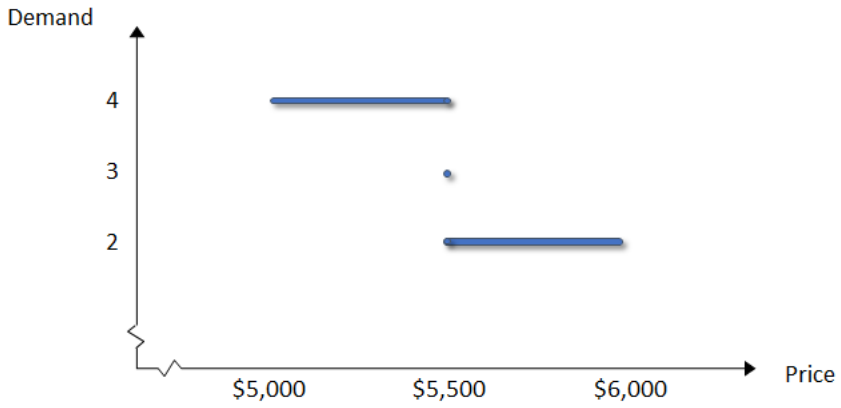
Example 7: Bidder Submits a Simple Bid Requesting to Reduce Demand to 2 Blocks at $5,500

Suppose that after the bids of the previous round are processed, the bidder's processed demand for a product is 4 blocks and the posted price is $5,000. In the current round, the clock price is $6,000, and the bidder submits a single simple bid for the product requesting to reduce its demand to 2 blocks at price $5,500.

To the bidding system, this bid means the following:

- If the price is below $5,500, the bidder is willing to purchase 4 blocks.
- If the price is exactly $5,500, the bidder is willing to purchase 2, 3, or 4 blocks.
- If the price is above $5,500, the bidder is willing to purchase only 2 blocks.

The graph below illustrates how the bidding system interprets this simple bid:



If a simple bid is partially applied, then the processed demand of the bidder is a quantity that is strictly between the bidder's processed demand before the simple bid was applied and the quantity that the bidder specified in the bid.

When the bidding system processes the bids at price $5,500, the simple bid will be applied fully, partially, or not at all depending on the level of excess demand at that point in the bid processing.

(a) If demand exceeds supply by more than 2 blocks, the bid is fully applied. The bidder will hold 2 blocks.

(b) If demand exceeds supply by exactly 2 blocks, the bid is also fully applied. The bidder will hold 2 blocks.

(c) If demand exceeds supply by only 1 block, the bid is partially applied. The bidder will hold 3 blocks.

[12] A bidder cannot submit a bid to maintain its demand at a price below the round's clock price. Bids made at intra-round price points are used to indicate the price point at which the bidder's requested demand changes from its processed demand from the previous round, or if the bidder requested a change at a lower intra-round price in the round, from its requested demand at the next lowest price point.

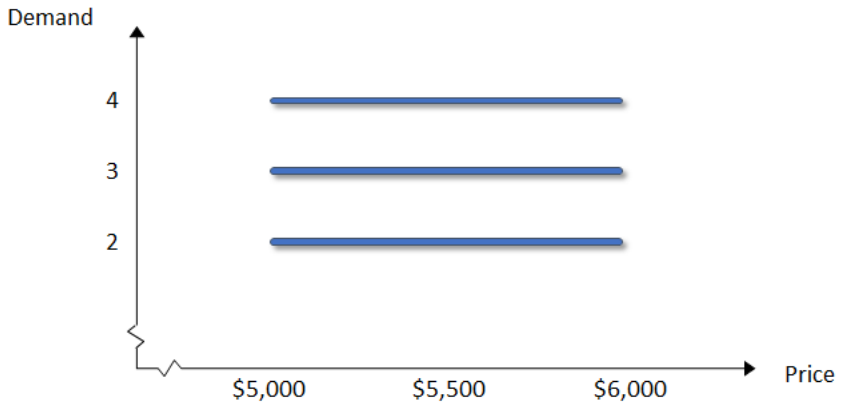
(d) If demand does not exceed supply, the bid is not applied. The bidder will continue to hold 4 blocks.

Using the same bid, if no other bidder has submitted a bid requesting to change its demand for this product, then:

- In case (a), the posted price will be equal to $6,000.
- In cases (b) and (c), the posted price will be equal to $5,500.
- In case (d), the posted price will be equal to $5,000.

Example 8: Bidder Submits a Simple Bid Requesting to Increase Demand to 4 Blocks at $5,500

Suppose that, after the bids of the previous round are processed, the bidder's processed demand for a product is 2 blocks and the posted price is $5,000. In the current round, the clock price is $6,000, and the bidder submits a single simple bid for the product requesting to increase its demand to 4 blocks at price $5,500. This means that for all prices p such that $\$5{,}000 \leq p \leq \$6{,}000$, the bidder is willing to buy 2, 3, or 4 blocks. The corresponding demand graph is shown in the following figure:



4.2 Switch Bids

A *switch bid* is a request to move demand for up to n blocks in a given PEA from one category to another category. For instance, a bidder can request to switch 2 blocks from Category M/N to Category P in a given PEA. Switch bids may be applied partially or in full.

For each switch bid, the bidder specifies the "from" product as well as a price p and a quantity q for the "from" product. If the "from" product is the Category M/N (respectively, P) product in a PEA, then the "to" product is the Category P (respectively, M/N) product in that PEA. The bidder does not specify a quantity or a price for the "to" product. In processing the switch bid, the bidding system will determine the maximum number of blocks by which demand in the "from" category can be reduced (such that demand does not fall below supply) and will then switch an equal number of blocks to the "to" category.

Such a bid indicates that:

(1) At all prices that are strictly greater than p and less than or equal to the clock price (or the next price at which the bidder submitted a bid involving the "from" product), the bidder is willing to buy an exact quantity of q of the "from" product;

(2) At price p, the bidder is willing to buy any quantity between q and its previous demand for the "from" product;[13] and

(3) The bidder is willing to buy up to a quantity of $d_t + (d_f - q)$ of the "to" product at the clock price, where d_t and d_f denote the bidder's previous demand for the "to" and "from" products respectively before the switch bid is applied. [14]

Regardless of whether a bid to switch n blocks from product A to product B is fully or partially applied, if the processed demand of the bidder for product A is reduced by m blocks, then the processed demand of the bidder for product B is increased by m blocks, where $1 \leq m \leq n$. A switch bid for 1 block cannot be partially applied.

Example 9: Bidder Submits a Switch Bid for 2 Blocks from Category M/N to Category P at $5,500

Suppose that after the bids of the previous round are processed, the bidder's processed demand is 4 blocks in Category M/N and 0 blocks in Category P in some PEA, and the posted price of the Category M/N product in that PEA is $5,000. In the current round, the clock price for the Category M/N product in that PEA is $6,000, and the bidder submits a single switch bid involving that PEA requesting to switch its demand by 2 blocks from Category M/N to Category P at price $5,500.

To the bidding system, this bid means the following:

- If the price of Category M/N is below $5,500, the bidder is willing to purchase 4 Category M/N blocks.
- If the price of Category M/N is exactly $5,500, the bidder wishes to switch demand from Category M/N to Category P by up to 2 blocks.

Note that the bidder does not specify a quantity or a price for Category P blocks in its bid. By submitting the bid, the bidder indicates a willingness to purchase up to 2 blocks of Category P at the current clock price.

When the bidding system processes the bids at price $5,500, this switch bid will be applied fully, partially, or not at all depending on the level of excess demand at that point in the bid processing:

- If demand exceeds supply by 2 or more blocks in Category M/N, the bid is fully applied. The bidder will then hold 2 blocks in Category M/N and 2 blocks in Category P.
- If demand exceeds supply by only 1 block in Category M/N, the bid is partially applied. The bidder then will hold 3 blocks in Category M/N and 1 block in Category P.
- If demand does not exceed supply, the bid is not applied at all. The bidder will continue to hold 4 blocks in Category M/N and none in Category P.

In all cases, the bidder's total processed demand across the categories is still 4. However, a switch bid may be applied partially in the sense that the number of blocks that are switched from Category M/N to Category P may be smaller than the maximum number of blocks that the bidder was willing to switch, depending on whether it is possible to reduce the bidder's demand for Category M/N.

[13] The bidder's previous demand for the "from" product is either equal to its processed demand from the previous round or, if the bidder has submitted a switch bid at a price below p involving that product, the quantity in the bid involving that product with the highest price below p.

[14] The bidder's previous demand for the "to" product is either equal to its processed demand from the previous round or, if the bidder has submitted another switch bid involving that product, the quantity that has already been applied for this product during bid processing at the point this switch bid is considered.

5 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 products. This section provides a definition of *price points* and the details of how bid processing is done in a clock round.

5.1 Missing Bids

For each product for which the bidder had positive processed demand in the previous round, if the bidder did not submit a bid for that product during the current round, it will be deemed to have bid a simple bid for that product with a quantity of 0 at a price equal to the previous round's posted price. For example, if the previous round's posted price for a particular product is $6,000 and the bidder does not submit a bid in this round for that product, 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 receive 0 blocks at $6,000. The missing bid will be processed just as if the bidder submitted a simple bid for 0 blocks at $6,000. All missing bids are subject to the same checks as those submitted by a bidder.

5.2 Price Points

The *price point* indicates the percentage of the distance between the posted price of the previous round and the clock price of the current round. For example, the 0% price point refers to the previous round's posted price, the 100% price point refers to the clock price, and the 50% price point refers to the average of the previous round's posted price and the clock price of this round. As another example, if the previous round's posted price is $5,000 and the clock price of this round is $6,000, the price $5,100 corresponds to the 10% price point, and the price $5,500 corresponds to the 50% price point.

5.3 Acceptable Bids

Acceptable bids are ones that can be applied in full or in part when they are considered during bid processing after the round.

No bid will be applied that reduces the aggregate demand for blocks in a product below the available supply. As a result of this restriction, some bids that request a reduction in the number of blocks in a product demanded by a bidder may not be applied in their entirety.

A bid that requests an increase in the number of blocks in a product demanded by a bidder will not be applied in its entirety if that would cause the bidder's processed activity to exceed its eligibility for the round.

The following sub-sections describe the circumstances under which a bid is applied either fully or partially.

5.3.1 Fully Acceptable Bids

A bid is *fully acceptable* if, at the time it is considered during processing, the following conditions both hold:

(a) If the bid were applied in its entirety, the total number of bidding units associated with the bidder's demand would not exceed the bidder's eligibility in the current round;

(b) If the bid were applied in its entirety, it would not cause the aggregate demand to be less than the supply for that product.

Only bids that are fully acceptable will be applied in their entirety during bid processing.

5.3.2 Partially Acceptable Bids

A bid is *partially acceptable* if, at the time it is considered during processing, it is not fully acceptable and the following conditions both hold:

(a') If the bid were applied *partially*, the total number of bidding units associated with the bidder's demand would not exceed the bidder's eligibility in the current round; and

(b') If the bid were applied *partially*, it would not cause the aggregate demand to be less than the supply for that product.

Examples of fully and partially applied bids are provided in Section 4.

5.4 Processed Demands

For processing bids after each round, bids are prioritized in the following order: price point (from lowest to highest) across all bids, and then a 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).

The bid processing algorithm described here maintains a *queue* of all bids from the round that have not been applied in their entirety.[15] The highest-priority bid that has not yet been considered is processed. The algorithm checks whether the bid is fully acceptable using the most-recently-determined aggregate demand and the bidder's eligibility for the round.[16] If the bid is fully acceptable, then it is applied (in its entirety). If the bid is not fully acceptable, then it is placed in the queue. The algorithm then checks whether the bid is partially acceptable using the most-recently-determined aggregate demand. If the bid is partially acceptable, then it is partially applied (to the maximum extent possible).

Whenever a bid is applied either partially or in its entirety, the queue is re-tested to determine whether any bids in the queue have become fully acceptable and whether any have become partially acceptable; if so, the highest-priority fully acceptable or partially acceptable bid is applied. When a bid has been applied in its entirety, it is removed from the queue; otherwise, it is kept in the queue so that the remaining part may be applied later. The re-testing of the queue is iterated until no bids remaining in the queue are fully acceptable and none are partially acceptable. Then the next bid from the round is processed, until (1) all bids from the round have been processed, (2) no bids in the queue are fully acceptable, and (3) no bids in the queue are partially acceptable. At that point, 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*.

Example 10: Suppose that at the beginning of the round the bidder's processed demand for product A is 4 blocks and the bidder has submitted a simple bid for 0 blocks of product A. If the bid is not fully acceptable (because applying the bid in its entirety would lead to excess supply for product A), but it is possible to apply 1, 2, or 3 blocks of the reduction without creating excess supply for product A, then 3

[15] The implementation does not necessarily require a queue, but this description is used here for expository ease.

[16] Note that a bid may be found not acceptable because of insufficient bidding eligibility if another bid submitted by the bidder, requesting a reduction, is not processed due to insufficient aggregate demand, thereby not freeing up bidding units needed to support the requested bid to increase demand for another product. This can occur even when the bidder's activity overall does not exceed its eligibility.

blocks of the reduction will be applied. The bid for a quantity of 0 blocks for product A will be placed in the queue, so that the reduction of the remaining one block may be applied later, if conditions permit after other bids have been processed.

Example 11: There are three bidders (bidders 1, 2 and 3). At the beginning of the round, bidder 1 has 3 blocks of processed demand, bidder 2 has 2 blocks of processed demand and bidder 3 has 1 block of processed demand. Thus, the aggregate demand for product A at the beginning of the round is 6 blocks. The supply for product A is 5 blocks. The following bids are submitted in the round:

- Bidder 1 has submitted a simple bid to reduce its demand for A to 0 blocks at price $1,500.
- Bidder 2 has submitted a bid to increase its demand to 3 blocks at price $1,800.
- Bidder 3 has submitted a simple bid to maintain its demand of 1 block at the clock price.

The bid processing works as follows:

- The simple bid of bidder 1 is processed first because it is at the lowest price point. It is not fully acceptable (because it would lead to excess supply), but it is partially acceptable. One block of the reduction is applied, and the bid for a quantity of 0 blocks is placed in the queue.
- At this point there is no excess demand for product A, and the processed demand of bidder 1 is 2 blocks.
- The bid of bidder 2 is processed, creating 1 unit of excess demand for product A. The simple bid of bidder 1 in the queue is considered and a reduction of an additional 1 block is applied. Bidder 1's bid for a quantity of 0 blocks remains in the queue.
- Bid processing ends (and the bid in the queue is discarded), and the bidders' processed demands for product A are:
    - Bidder 1: 1 block
    - Bidder 2: 3 blocks
    - Bidder 3: 1 block

5.5 Posted Prices

Let $P_{t,r}$ denote the clock price for product r in round t. After the bids of a clock round t have been processed, the *posted price* $p_{t,r}$ for product r in round t is set as follows:

- If aggregate demand (evaluated using the processed demands) exceeds supply, the posted price will be set equal to the clock price for the round ($p_{t,r} = P_{t,r}$).
- If aggregate demand (evaluated using the processed demands) is equal to the supply and at least one bid that included a reduction in the quantity demanded of that product was applied (either entirely or partially), the posted price ($p_{t,r}$) will be set to be equal to the product price associated with the bid that has the highest price for product r among all bids from round t that included a reduction in demand for the product and that were applied (either entirely or partially). That is, the *posted price* will be the price at which a reduction caused demand to equal supply.
- If either of the following two conditions holds:
    - The aggregate demand (evaluated using the processed demands) is less than the supply[17]
    - The aggregate demand (evaluated using the processed demands) is equal to the supply and no bid that included a reduction in quantity for that product was applied (either as a whole or partially)

[17] For example, because of insufficient demand at the opening prices.

Then the posted price will be set to be equal to the posted price of the previous round ($p_{t,r} = p_{t-1,r}$).

These rules ensure that the posted price of a product will not be higher than the price of a simple bid or a switch that requested a reduction for that product and was not applied (either entirely or in part).

Therefore, in Example 11 in Section 5.4, the posted price is $1,500.

6 Checking the Net Revenue Requirement

Once the bids for the round have been processed, if the net revenue requirement has not been met in a previous round, the system will check whether the net revenue requirement has been met in this round. The net revenue requirement is met if the auction proceeds, adjusted to take into account the discounts for bidding credits, are sufficient to cover all incentive payments for incumbents that elected to relinquish either all their licenses or only a partial block.

If, after a round, aggregate demand is less than or equal to supply for all products, then this round is the final clock round and, in the event that the net revenue requirement is met, each bidder will win its processed demand for the round. In this case, the system will determine that the net revenue requirement has been met if the sum, over all bidders, of a bidder's commitment minus its capped commitment discount is greater than or equal to the sum of incentive payments across all bidders. Note that commitments and incentive payments are based on the posted prices of the round (see Section 3.4).

If, after a round, aggregate demand exceeds supply for at least one product, then this round is not the final clock round and thus winning bidders are not known when the net revenue requirement is evaluated. In this case, bidding credits are incorporated with a worst-case calculation. In particular, the system will calculate two lower bounds for the proceeds net of bidding credit discounts and will use the larger of the two to determine whether the net revenue requirement has been met.

The following notation is used in this section:

- $d_{t,i,r}$ is the processed demand of bidder i for product r after round t.
- $p_{t,r}$ is the posted price for product r after round t.
- S_r is the supply of product r.
- BC_i is the bidding credit percentage of bidder i.
- $IP_{t,i}$ is the incentive payment of bidder i after round t (defined in Section 3.4.2 and applicable only to incumbents).
- I is the set of 39 GHz incumbents that relinquished licenses (including incumbents not bidding in the auction for new licenses).
- R is the set of all products.
- B is the set of bidders.

The first lower bound (LB_1) considers each product separately and does not take into account bidding credit caps. For this lower bound, the proceeds of a product will be calculated as the lowest possible proceeds that could be expected given the bidders that currently have positive processed demand for that product and their associated bidding credits. Thus, the calculation will consider the proceeds that would result if, for products with excess demand, blocks are first assigned to bidders with larger bidding credits.

Now consider product r and suppose that there are m bidders with processed demand for the product.

If aggregate demand for product r is less than or equal to the product's supply, then the proceeds for product r after round t are calculated as:

$$\delta_{t,r} = p_{t,r} \cdot \sum_{i=1}^{m} (1 - BC_i) \cdot d_{t,i,r}$$

If the aggregate demand for the product exceeds the product's supply, then the m bidders with positive processed demand for product r are ordered in decreasing order of bidding credit percentages. Let k be the minimum number such that $\sum_{i=1}^{k} d_{t,i,r} \geq S_r$. Then, each bidder from 1 through $k-1$ is assigned its processed demand, bidder k is assigned any remaining supply up to its processed demand, and each bidder $k+1$ through m is not assigned any blocks in the worst-case proceeds calculation.

The estimated worst-case proceeds from product r after round t are calculated as:

$$\delta_{t,r} = p_{t,r} \cdot \sum_{i=1}^{k-1} (1 - BC_i) \cdot d_{t,i,r} + p_{t,r} \cdot (1 - BC_k) \cdot \min\left(d_{t,k,r},\ S_r - \sum_{i=1}^{k-1} d_{t,i,r} \right)$$

The first lower bound is then calculated as the sum of the estimates across products, that is,

$$LB_1 = \sum_{r \in R} \delta_{t,r}$$

The second lower bound (LB_2) on the proceeds net of bidding credit discounts does not consider the bidding credit percentages of bidders bidding for a specific product. Instead, it is based on the gross proceeds and the caps on the total amount of bidding credit discounts that may be awarded to bidders. Specifically, LB_2 will be calculated as the gross proceeds *minus* 25 million times the number of small businesses with non-zero eligibility after round t *minus* 10 million times the number of rural service providers with non-zero eligibility after round t. Note that the gross proceeds after a round are equal to $\sum_{r \in R} p_{t,r} \cdot \min(S_r, \sum_{i \in B} d_{t,i,r})$.

The net revenue requirement is satisfied if:

$$\max(LB_1, LB_2) \geq \sum_{i \in I} IP_{t,i}$$

Note that the right-hand side in the condition above considers the incentive payments for all incumbents, regardless of whether the incumbent is participating in the auction.

After each round, bidders will be informed about whether the net revenue requirement has been met. If the net revenue requirement has not been met, bidders will be informed about the shortfall, that is, $\sum_{i \in I} IP_{t,i} - \max(LB_1, LB_2)$, rounded up to the nearest $1 million. The Public Reporting System will announce whether the net revenue requirement has been met after a round but will not provide information about the shortfall in the case that the net revenue requirement has not been met.

Example 12: Calculation of worst-case proceeds from a product with excess supply

The aggregate demand for product p after round t is $D_{t,r} = 20$, and the product's supply is $S_r = 24$. There is excess supply of 4 blocks. There are two bidders with positive processed demand for product r: Bidder 1 has processed demand $d_{t,1,r}$ = 12 and a bidding credit percentage of 25%, and Bidder 2 has

processed demand $d_{t,2,r}$ = 8 and does not qualify for a bidding credit. The posted price of product r after round t is $p_{t,r} = 10$.

To compute the estimated worst-case proceeds from product r, assume that:

- Bidder 1 is assigned 12 blocks (its processed demand)
- Bidder 2 is assigned 8 blocks (its processed demand)

That is, $\delta_{t,r} = 10 \cdot (1 - 25\%) \cdot 12 + 10 \cdot 8 = 170$

Example 13: Calculation of worst-case proceeds from a product with excess demand

Consider a product with supply of 10 blocks. There are 4 bidders each with a processed demand of 4 for that product. Bidders 1 and 2 have a bidding credit percentage of 25%, Bidder 3 has a bidding credit percentage of 15%, and Bidder 4 does not qualify for a bidding credit. The posted price is $p_{t,r} = 100$.

To compute the estimated worst-case proceeds from product r after round t, assume that:[18]

- Bidder 1 is assigned 4 blocks (its processed demand)
- Bidder 2 is assigned 4 blocks (its processed demand)
- Bidder 3 is assigned 2 blocks (the minimum of its processed demand and the number of available blocks given blocks assigned to Bidders 1 and 2)
- Bidder 4 is not assigned any blocks

That is,

$$\delta_{t,r} = 100 \cdot (1 - 25\%) \cdot 4 + 100 \cdot (1 - 25\%) \cdot 4 + 100 \cdot (1 - 15\%) \cdot 2 = 770$$

Note that in this example all 10 blocks are assigned, because there is no excess supply.

The calculations for the worst-case proceeds from a product will be rounded down at the bidder product level to the nearest $1. In particular, in computing $\delta_{t,r}$, the estimated worst-case proceeds from product r, the calculations will be done in following way. The quantity $p_{t,r} \cdot (1 - BC_i) \cdot d_{t,i,r}$ is computed for every bidder i and each of these numbers is rounded down to the nearest dollar.[19] The summation of these numbers (across all bidders with positive processed demand for the product) will give the worst-case net proceeds from the product.

7 Checking Closing Conditions

After bid processing, the bidding system will determine if the closing conditions for the auction have been met or if bidding will continue with a new clock round.

If there is no excess demand for any product, the clock phase of the auction will close. If the net revenue requirement has been met at the conclusion of the clock phase, then the auction will proceed with the assignment phase. In this case, the final clock phase price of a product will be set to be equal to the product's posted price for the last round. However, if the net revenue requirement has not been met at the conclusion of the clock phase, then the auction will end without assigning any new licenses.

[18] Note that processed demand is assigned to bidders in decreasing order of bidding credit percentage.

[19] In the case of a product with excess demand, the quantity $p_{t,r} \cdot (1 - BC_k) \cdot \min\left(d_{t,i,r},\ S_r - \sum_{i=1}^{k-1} d_{t,i,r}\right)$ for bidder k will also be rounded down to the nearest dollar.

8 Setting Up the Next Round

If the bidding system determines that there is excess demand for at least one product, 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 clock prices for the new round must also be calculated. This section provides the details of these calculations.

8.1 Processed Activity and Next Round Eligibility

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 bidder's processed activity after round t is calculated as:

$$ProcActivity(t) = \sum_{r \in R} d_{t,i,r} \cdot b_r$$

Where:

- R denotes the set of all products.
- $d_{t,i,r}$ denotes the processed demand of bidder i for product r after round t.
- b_r denotes the number of bidding units associated with product r.

An activity rule is used to require bidders to participate in each round of the auction. A bidder's *eligibility* in round 1 of the auction 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 processed activity, and the activity requirement. Specifically, after any clock round t, the bidder's eligibility for the next round $t + 1$ is set to be equal to:

$$min\left\{ Eligibility(t), \frac{ProcActivity(t)}{ActivityRequirement} \right\},$$

rounded up to the nearest integer.

Where:

- $Eligibility(t)$ denotes the bidder's eligibility in round t
- $ActivityRequirement$ denotes the activity requirement. This is a percentage (up to 100 percent) set by the Commission.

8.2 Clock Prices for Next Round

A product's clock price in the next round is calculated as the product's posted price from the previous round multiplied by an increment.

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

$$P_{t,r} = (p_{t-1,r}) \cdot (1 + y)$$

Where:

- y denotes the percent increment for round t.
- $p_{t-1,r}$ denotes the posted price for product r after round $t-1$.

The result will be rounded up using the Commission's standard rounding procedures for auctions: 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.

Note that this calculation applies to every product, irrespective of whether the product is in excess demand.