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# US 600MHz Incentive Auction Forward and Reverse Auction Rules

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and **Jonathan Pike**

The “Incentive Auction” of 600MHz (UHF) bandwidth is the most ambitious spectrum auction ever proposed. Up to 144 MHz of “beachfront” radio frequencies could be repurposed from terrestrial broadcasting to mobile broadband. The process combines two separate but linked auctions: a **Reverse Auction**, which will identify a set of prices at which broadcasters are prepared to relinquish channels; and a **Forward Auction**, which will determine how much cellular operators are willing to pay to acquire the frequencies. The combined process determines not just the buyers and sellers but also the amount of spectrum to be cleared.

In this paper, **NERA Vice President Richard Marsden** and **NERA Analyst Jonathan Pike** describe the auction rules for the Reverse Auction and the Forward Auction.<sup>1</sup> There are up to eleven possible scenarios for clearing spectrum in the auction. The process will start with the largest possible clearing scenario, based on broadcaster participation. The Federal Communications Commission (FCC) will run the Reverse Auction to determine the cost of clearance, followed by the Forward Auction to determine if sufficient revenue can be raised to support the clearing scenario. The process continues for progressively smaller clearing until a solution, if any, is found.

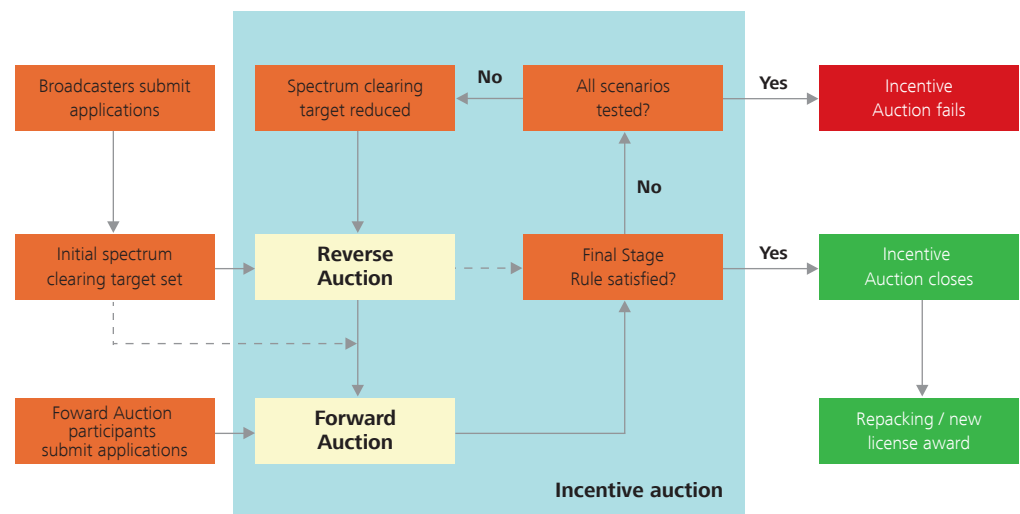
## How the Reverse and Forward Auctions Link Together

### Overview of Incentive Auction

*The Forward and Reverse Auctions are linked at the national level; there does not appear to be any direct linkage at the local area level.*

Both the Reverse and Forward Auctions are run over one or more stages, each linked to a scenario for clearing Ultra High Frequency (UHF) broadcast spectrum and repurposing it for cellular services. Each stage determines the prices necessary to persuade broadcasters to move or relinquish sufficient channels. The sum of the prices to be paid to station owners determines the revenue target for the Forward Auction for that stage. If the Forward Auction raises sufficient revenues (a condition referred to as the “final stage rule”), then the Incentive Auction closes; otherwise, the auction progresses to a new stage with a smaller clearing target. The overall process is illustrated in Figure 1.

Figure 1. **Overview of the Incentive Auction**



### Spectrum clearing scenarios

*According to a study by Kearns and Dworkin, a clearing target of 84 MHz would imply that just over 250 stations would need to be cleared nationally, including an average of 8-10 stations in some major metros, including New York, Philadelphia, Chicago, and San Francisco.<sup>2</sup>*

There are eleven distinct scenarios for spectrum to be cleared in the Reverse Auction, as illustrated in Figure 2. In each case, remaining broadcasters are repacked into existing 6MHz broadcast channels in the lower part of the UHF band, while a band plan based on paired 5+5 MHz blocks is created in the upper part of the UHF band.

The amount of UHF spectrum that could be cleared ranges from:

- a maximum of 144 MHz, which would clear UHF channels 27 upwards (scenario 12), and release 60+60 MHz for cellular mobile;
- down to 42 MHz, which would clear UHF channels 45 upwards (scenario 2) and release just 10+10 MHz for cellular mobile.

The same cellular band plan will be used nationwide, but it seems possible that some lower duplex lots could be unavailable in certain regions.

Cellular band plans greater than 30+30 MHz are complicated by the need for a carve-out in the lower duplex band to protect radio astronomy in channel 37.

Each clearing scenario corresponds to a potential stage in the auction. The first stage will feature the Initial Spectrum Clearing Target, which is the largest possible clearing scenario given broadcaster participation at opening prices. If the auction progresses, the FCC has discretion to skip scenarios.

Figure 2. Spectrum clearing scenarios and associated UHF band plans

Scenario #	MHz cleared	MHz sold	21 6MHz Broadcast channels	B New 5+5 MHz Cellular blocks	37 Radio Astronomy (protected)	7 Other cleared (MHz)
0	0	0	21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36		37	38 39 40 41 42 43 44 45 46 47 48 49 50 51
2	42	10+10	21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36		37	38 39 40 41 42 43 44 11 A B 11 A B
3	48	15+15	21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36		37	38 39 40 41 42 43 7 A B C 11 A B C
4	60	20+20	21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36		37	38 39 40 41 9 A B C D 11 A B C D
5	72	25+25	21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36		37	38 39 11 A B C D E 11 A B C D E
6	78	30+30	21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36		37	38 7 A B C D E F 11 A B C D E F
7	84	35+35	21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36		37	3 A B C D E F G 11 A B C D E F G
8	108	40+40	21 22 23 24 25 26 27 28 29 30 31 32 11 A B 3		37	3 C D E F G H 11 A B C D E F G H
9	114	45+45	21 22 23 24 25 26 27 28 29 30 31 7 A B C D 3		37	3 E F G H I 11 A B C D E F G H I
10	126	50+50	21 22 23 24 25 26 27 28 29 9 A B C D E F 3		37	3 G H I J 11 A B C D E F G H I J
11	138	55+55	21 22 23 24 25 26 27 11 A B C D E F G H 3		37	3 I J K 11 A B C D E F G H I J K
12	144	60+60	21 22 23 24 25 26 7 A B C D E F G H I J 3		37	3 K L 11 A B C D E F G H I J K L

## The Reverse Auction

### Reverse Auction participants

All full power and low power (Class A) licensees are eligible to participate in the Reverse Auction. This includes broadcasters in both the UHF and Very High Frequency (VHF) bands. Even though the VHF band is not being cleared, VHF broadcasters could be paid to vacate their channel if a UHF broadcaster is willing to move into the band. Even broadcasters that do not participate may have to change channels as part of the repacking process; however, they are guaranteed to be relocated in their current band.

### Broadcaster bid options and opening prices

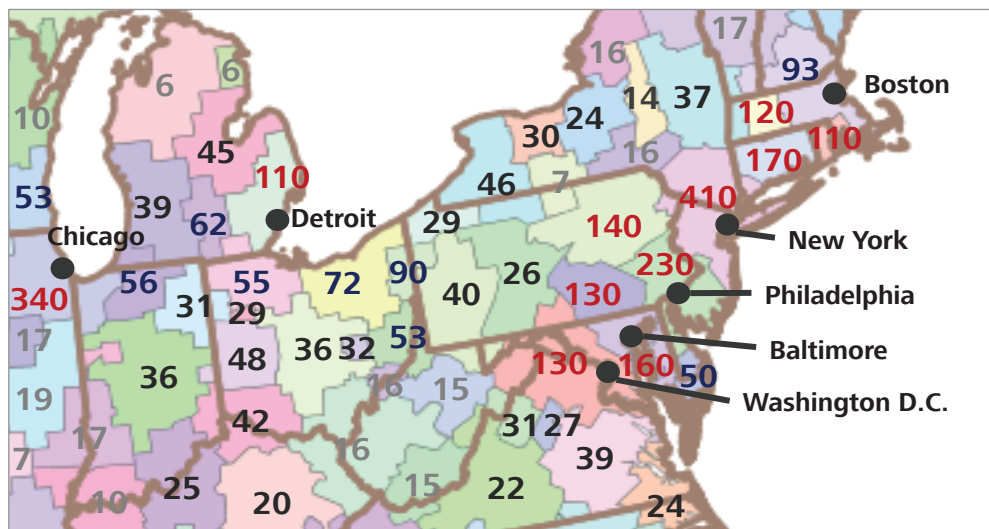
Prior to the auction, each bidder will be presented with a set of bid options. A bid option may include an offer to relinquish a channel (i.e., stop terrestrial broadcasting) or move to a different band. Options to move band will depend on the broadcaster’s current location: UHF broadcasters may offer to move to the Upper VHF or Lower VHF bands; and Upper VHF broadcasters may offer to move to the Lower VHF band. Channel sharing deals are also permitted but must be agreed outside the auction.

It appears that the FCC will use very large opening bids in the most congested broadcast DMAs to induce as much participation from these broadcasters as possible.

Markets that surround densely populated metropolitan areas are often valued higher than isolated large markets. For example, the median compensation for a broadcaster in Hartford-New Haven, CT DMA is US\$170 million, compared to just US\$45 million in Houston.

An opening price will be associated with each bid option; this is the maximum amount of money that the bidder could receive for that option. These prices will be based on a scoring mechanism, which the FCC says will be based on “objective factors, such as location and potential for interference with other stations.”<sup>3</sup> Opening prices have not been announced, but the FCC has published indicative estimates of potential payments to UHF stations for relinquishing their channels by designated market area (DMA).<sup>4</sup> The highest prices are projected for broadcasters based in major metro areas, such as Chicago, Los Angeles, and New York, and nearby markets, such as Wilkes Barre-Scranton-Hazleton. As an illustration, see how higher prices are clustered around the New York and Philadelphia DMAs in Figure 3. The wide range in prices both across and, in some cases, within DMAs implies that scoring will vary hugely between stations and will be closely correlated with local scarcity of UHF channels and population-based interference.

Figure 3. **FCC estimates of high-end compensation to broadcasters by DMA in northeast USA (US\$ million)**

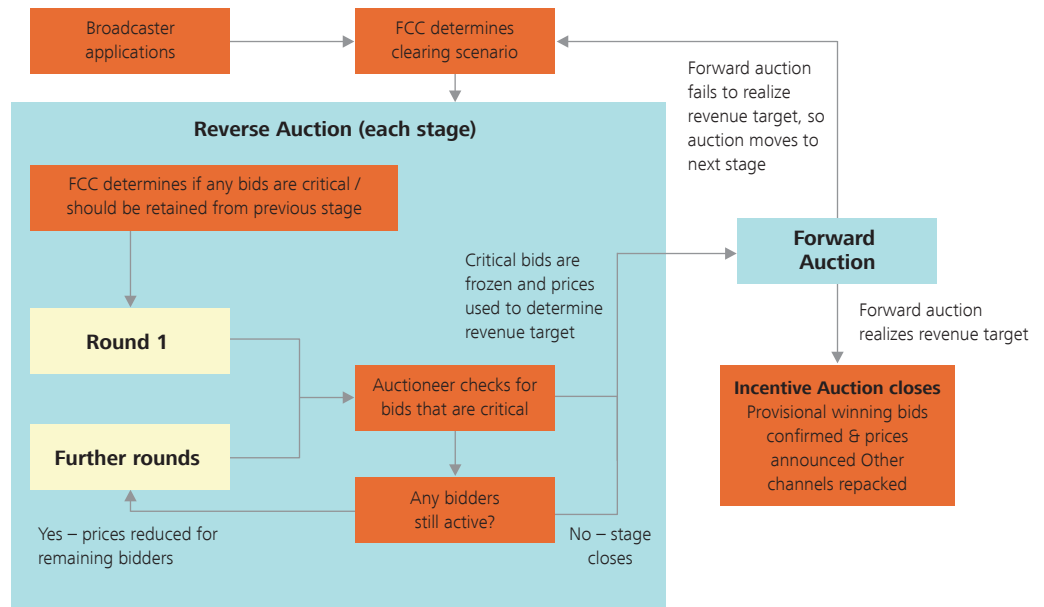


Numbers are median value estimates by DMA for payments to high-power broadcasters in US\$ million for relinquishing UHF channels. Color scheme: Red \$100m+, Blue \$50m+, Black \$20m+, Gray <\$20m

### The bidding process

The Reverse Auction will use a descending clock auction format and takes place over one or more stages (one for each clearing scenario as required). Our interpretation of the multiple-round procedure for each stage is illustrated in Figure 4.

Figure 4. **Structure of the Reverse Auction (multi-round descending clock format)**



The detailed auction rules will be set out in the Procedures Public Notice, scheduled for release in Q1 2015. We anticipate the following approach:

*The activity rules have not been clarified but it seems likely that bidders will only be allowed to bid on one option in each round and will be restricted in their ability to move between bid options.*

- In each round, broadcasters will be presented with prices for up to three bid options to relinquish or move channels. Bidders indicate whether they are willing to accept a bid option at that price.
- At the end of each round, the Auctioneer will identify stations that have become critical to the current clearing scenario, meaning that if they exited they could no longer be repacked in their current band. Any such bids will be frozen at their current price (think of them as provisional winning bids). Stations that were active at the round price but are not yet critical can bid again in the next round at a lower price.

*Like opening bids, the way bid decrements are applied across broadcasters could have a big impact on outcome, both in terms of which channels are cleared and the prices that broadcasters receive.*

- For price reductions, we expect the FCC to set a common, nationwide clock price in each round, with unique prices for each station determined by multiplying the clock price with each station's "score". It is unclear if a station's "score" will remain constant throughout the auction, or be adjusted in response to FCC predictions on how important a station is to the current repacking scenario. A constant score would mean common percentage decrements while a dynamic process could support wide variance, possibly within as well as between DMAs. The FCC may also apply special rules in certain DMAs where capacity is limited by cross-border interference agreements with Canada and Mexico. In these cases, prices may continue being reduced even if there is no excess supply, so as to avoid such stations benefiting unduly from greater scarcity of spectrum in these areas.

*Intra-round bidding has a crucial role in the Reverse Auction, making it feasible to run fewer rounds and use larger bid decrements, and thus move the auction along at a desirable pace.*

- If a bidder decides it is not willing to accept the new price for a bid option, it can submit an “intra-round bid” (minimum acceptable price) between the current and previous price. Intra-round bids may also be used to determine switch points between bid options. This approach gives broadcasters flexibility to express their full value for relinquishing spectrum or moving band.
- The auction continues in this way over multiple rounds until a point is reached when all remaining bids have been frozen because they are critical to the clearing scenario. The provisional winning prices for each remaining station are an input into the revenue target for the Forward Auction for that clearing scenario.

*The repacking process across the lower 48 states is complex but some rules of thumb apply: for example, if one station is deemed critical, then other stations with the same broadcast footprint must also be critical.*

Arguably, the most complex part of the auction is the process for determining when stations become critical to a clearing scenario. This requires the FCC to run an algorithm to test whether or not it is still feasible—if a particular station is allowed to exit—to repack it along with all other stations that did not participate or have already exited the auction. If a station can be repacked, they must continue bidding (or may exit). If a station cannot be repacked, they are critical and will be bought out.

*The pricing rule is supposed to minimize incentives for bidders to drop out of the auction early, above their real exit value, in the hope of getting a better price.*

The FCC has also stated that broadcaster payments will be determined using a “threshold pricing” approach. Instead of paying broadcasters their lowest accepted bid, they will be paid at a level equivalent to when they became critical to the clearing scenario, based on the exit prices of other bidders. In auction theory, this is known as a “second price” model, an approach that should encourage participants to bid straightforwardly based on valuation. It remains unclear how exactly the FCC will apply the repacking algorithm and associated pricing rule on a round-by-round basis.

*Even if a broadcaster’s price is frozen, they are not guaranteed any payment unless and until the Forward Auction clears in the same stage.*

### **What happens if there is a new bidding stage?**

In the event that the Forward Auction fails to realize sufficient revenues to support a particular clearing scenario, the Reverse Auction will restart but with a reduced clearing scenario. As a result, some bids that had been frozen will no longer be needed. Presumably, before restarting the auction, the FCC will re-run its algorithm for each station under the new clearing target to determine if the bidder should remain frozen. If a station is no longer deemed critical given the reduced spectrum demand, the bidder will once again face descending prices.

### **Payments to winning bidders**

Each winning bidder in the Reverse Auction will receive a payment equal to the “second price” calculated for them, which must be no less than their final bid amount. Although prices for each retained bid must be calculated at the end of each stage, so as to determine the Forward Auction revenue target, they will only apply to bidders if the clearing scenario is successful.

## Forward Auction

### Overview of the Forward Auction

*The success of the Forward Auction depends on aggregate revenues nationwide; there is no link between the funds raised in individual areas and the clearance of broadcast spectrum in that area.*

Forward Auction rounds always follow the corresponding rounds of the Reverse Auction for the relevant stage and clearing scenario. In a departure from previous cellular spectrum awards, which used the simultaneous multiple round (SMR) auction format, the FCC will use an Ascending Clock Auction format. Under this approach, geographic licenses are grouped together into categories and sold on a generic basis. Aggregate revenues across all categories have to achieve the clearing price in order to support the corresponding clearing scenario and end the Incentive Auction.

### Geographic license structure

*PEAs are a hybrid of the Economic Area (EA) and local area (RSA / MSA) licensing regimes. Some PEAs may yet be merged to reduce the number of categories.*

The available spectrum will be divided into up to 416 geographic areas, based on the new Partial Economic Area (PEA) licensing regime. Within each PEA, licenses will be grouped into one or more categories, each containing a number of equivalent 'generic' 5+5 MHz licenses. The number of licenses available depends on the clearing scenario. A bidder that wins more than one generic license in a category will presumably be guaranteed to receive a corresponding range of specific contiguous frequencies.

*Using generic licenses greatly simplifies bidding.*

To minimize value differences between specific frequency lots, the FCC will mandate interoperability across the whole band. In principle, this could mean that there will be just one category of license per PEA, an approach that would simplify the bidding process.

### Spectrum reservation

*In practice, only AT&T and Verizon will be ineligible to bid for reserved spectrum, as they are the only companies with sufficiently large low frequency holdings.*

In a departure from recent auctions of US cellular spectrum, the FCC has proposed restrictions on the spectrum that operators can acquire in the auction. Up to 30 MHz will be reserved in each PEA for "reserve-eligible bidders" who currently have less than 45 MHz of sub-1 GHz spectrum in that PEA. The maximum amount of reserved spectrum depends on the spectrum available in each stage, as illustrated in Figure 5.

Figure 5: **How reserved spectrum varies with the clearing scenario**

Clearing scenario #	12	11	10	9	8	7	6	5	4	3	2
Spectrum Available (MHz)	120	110	100	90	80	70	60	50	40	30	20
Maximum Unreserved Spectrum	90	80	70	60	50	40	40	40	30	20	10
Maximum Reserved Spectrum	30*	30*	30*	30*	30*	30*	20	10	10	10	10

\*May be reduced to 20 MHz if only one reserve-eligible bidder is still bidding at the price point when the reserve applies.

*The unusual complexity of the reservation rules appears to be driven by the FCC's desire to ensure that a clearing scenario does not fail owing to lack of demand from bidders other than AT&T and Verizon.*

*If prices progress at a different pace across PEAs, reserve-eligible bidders may be eliminated from some PEAs but become protected elsewhere when the trigger point is reached. This may encourage regional bidders to bid out of area.*

*The relative level of opening bids and eligibility points across regions could have a big impact on outcome, as it may affect which PEAs clear first and whether they do so before or after the reserve price trigger is met.*

Even within a stage, the amount of reserved spectrum may vary depending on aggregate prices and the level of demand from reserve-eligible bidders. Spectrum will only be reserved from a point, called the "spectrum reserve trigger", where gross revenue across all PEAs is sufficient to ensure the clearing scenario can be met. If, at this point, demand in a region from reserve-eligible bidders is below the maximum, then the reserve for that region will be reduced accordingly. Furthermore, for scenarios where a 30 MHz reservation applies, this will be reduced to 20MHz if only one reserve-eligible bidder remains.

These rules complicate the otherwise simple approach to price increments in an ascending clock auction. Within each PEA category, the same price increments will apply to all lots up to the point where the "spectrum reserve trigger" is achieved. Beyond this point, prices for any reserved spectrum will be frozen as soon as demand from reserve-eligible bidders falls below maximum reserve spectrum for that stage. Meanwhile, the price of unreserved spectrum in the same PEA will continue to rise as long as overall demand exceeds supply. This implies that a reserve-eligible bidder could find itself with de facto winning bids on reserved spectrum but still be competing for additional unreserved spectrum in the same area.

### **Opening bids and eligibility points**

As in previous spectrum auctions, the FCC is expected to announce opening bid levels and eligibility points for each license. All licenses within a category will have the same price and eligibility weighting. Historically, the FCC has set both opening bids and eligibility proportional to the population in the license area. However, the FCC's consultants have raised the possibility of variations to this approach, for example weighting prices and eligibility towards major cities based on an analysis of past auction results.

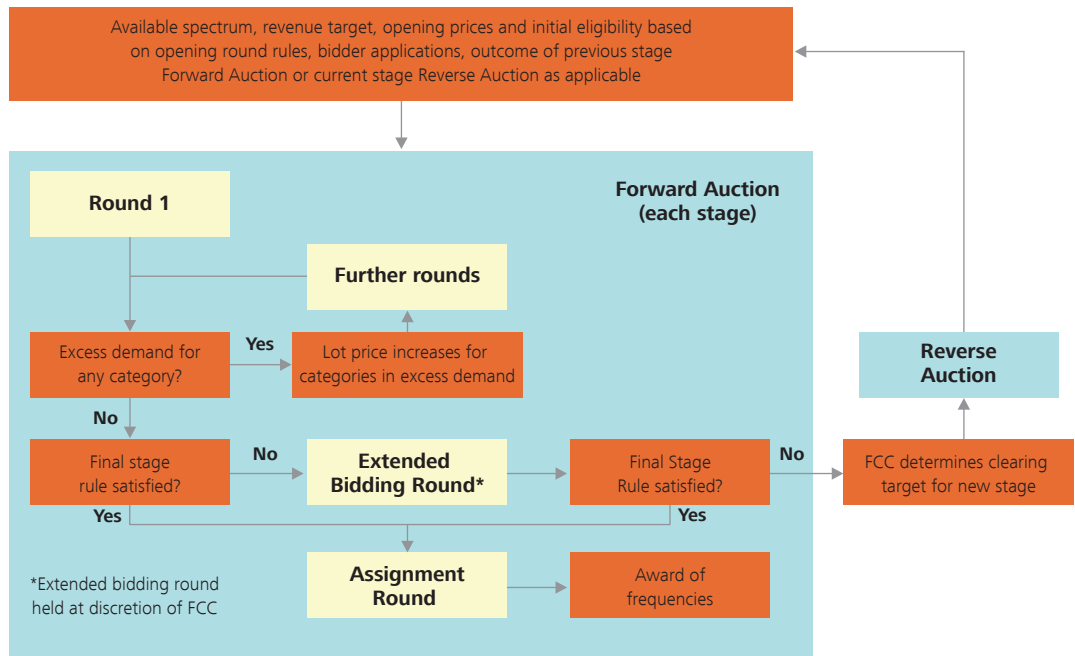
As with previous auctions, we expect each bidder will start the auction with a number of eligibility points determined by their initial deposit. This in turn will presumably be based on an application that specifies demand for a number of licenses in specific PEAs. Each bidder's activity in the auction will be constrained by their initial eligibility.

### **The bidding process**

The expected bidding process using the ascending clock auction format is illustrated in Figure 6.



Figure 6. **Overview of the bidding process for the Forward Auction**



The FCC’s June 2014 Report and Order provides little new information about the bidding process, but based on material published by the FCC’s consultants, our understanding is that the auction will likely proceed as follows:

- **First Round:** Each bidder specifies the number of licenses it wishes to acquire in each category (PEA) at the opening prices. A bidder may be active in multiple PEAs, but each bid is independent. Bidding for all categories will be conducted simultaneously.
- **Subsequent Rounds:** Prices for categories where aggregate demand exceeded supply in the previous round will be increased by a price increment. Price increments will be determined by the FCC and the percentage increase may vary across categories. Each bidder that was active in the previous round will have the opportunity to place new bids at the new round prices.
- **Activity rules:** The scope for bidders to make new bids and switch between categories will be constrained by activity rules, based on an eligibility point regime. Each bidder’s eligibility will be based on the sum of eligibility points associated with the licenses that they were active on in the previous round. As a general rule, bidders can only maintain or reduce their aggregate activity; they cannot increase it.

*Observe that the prices of all licenses in a category rise if there is excess demand. This is true regardless of the level of excess demand (although the FCC has discretion to use lower percentage bid increments for lower levels of excess demand).*

*The option to retain bids is necessary to protect the auction from sudden drops in revenue. However, it may expose bidders to aggregation risk. In the absence of any provision for package bidding, a bidder attempting to drop demand in or switch away from a PEA could find itself with partially retained demand. This risk is similar to an SMR auction, when bidders may become stranded on an unwanted subset of their demand.*

- **Retained bids.** There are no standing high bids in a clock auction. Bidders are typically free to switch demand from one category to another, and to reduce or increase demand in any category, provided they have sufficient eligibility. However, there may be rules enabling the FCC to retain bids at the individual lot level and deny switches between PEAs in case this would otherwise result in deficient demand and lower auction revenues.
- **Intra-Round Bidding:** When a bidder drops demand in a region, it may be obliged to specify a price point for each unit dropped, whether or not this is being switched to other PEAs. The default price point would be the previous round price, but the bidder may alternatively submit an “intra-round bid” for each unit of demand. An intra-round bid must be at a price that is greater than the previous round price and less than the current round price.
- **Final Round:** Normal bidding ends when there is a round in which there is no excess demand for any category, but the auction stage could be prolonged if the Final Stage Rule is not met.
- **Extended bidding round:** If the Final Stage Rule is met, bidding will stop and the auction will proceed to the Assignment Round. However, if the rule is not met, the FCC may initiate an extended bidding round, in which bidders will have the opportunity to increase their bids, in the hope that this enables the scenario to clear.

### Assignment Round

*The Assignment Round is necessary because licenses in the main stage of the Forward Auction are awarded on a generic basis. It is a new procedure in the US but has been widely used in other countries.*

Once the Incentive Auction concludes, an Assignment Round will take place to determine the specific frequencies in each PEA that each winning bidder will be issued. The Assignment Round provides an opportunity for bidders to express any preferences they may have for specific frequency positions within each PEA. Based on precedent from similar processes in other countries, a single round sealed bid may be used with each bidder guaranteed contiguous spectrum within (but not across) PEAs. A first price (pay your bid) or second price (pay the opportunity cost of denying others) rule could be applied.

### What happens if there is a new bidding stage?

*It is ambiguous what use if any the FCC will make of extended bid round offers in case the auction goes to a new stage.*

In the event that the Forward Auction fails to realize sufficient revenues to support a particular clearing scenario, the auction will move to a new stage with reduced spectrum available. The Forward Auction will resume once the new stage of the Reverse Auction has been completed. We suppose that bidding would resume at prices from the end of the last clock round (but not the extended round if there was one). As the number of lots in each PEA will be reduced, categories where demand previously equaled supply would now have excess demand, so price increments would resume.

### Payments by winning bidders

*The Greenhill book published by the FCC cites evidence that Forward Auction proceeds could approach US\$45 billion.<sup>5</sup>*

Each winning bidder must make a payment equal to the sum of their winning bids for individual licenses in the Forward Auction and any additional payments due for successful bids in the Assignment Round.

## Notes

- <sup>1</sup> Based on a review of the Incentive Auction Report and Order, GN Docket No. 12-268, June 2, 2014, and other documents published on the FCC website ([www.fcc.gov](http://www.fcc.gov)).
- <sup>2</sup> Michael Kearns and Lili Dworkin, A Computational Study of Feasible Repackings in the FCC Incentive Auctions, University of Pennsylvania, June 2014.
- <sup>3</sup> FCC, Incentive Auction Report and Order at para. 450.
- <sup>4</sup> Incentive Auction Opportunities for Broadcasters, Prepared for the FCC by Greenhill, October 2014.
- <sup>5</sup> Incentive Auction Opportunities for Broadcasters, Prepared for the FCC by Greenhill, October 2014.

## NERA's Auctions Practice

NERA Economic Consulting ([www.nera.com](http://www.nera.com)) is a global firm of experts dedicated to applying economic, finance, and quantitative principles to complex business and legal challenges. For over half a century, NERA's economists have been creating strategies, studies, reports, expert testimony, and policy recommendations for government authorities and the world's leading law firms and corporations.

Our global Auctions Practice is at the forefront of developments in spectrum auction design and bidding strategies. Our team have advised governments and bidders on dozens of spectrum auctions around the world.

Our skill set includes:

- An exceptional track record in developing bid strategies that help our clients secure their spectrum targets at low prices relative to competitors
- Experience with designing and implementing all major auction formats, including sealed bid, SMR, clock and package bid auctions
- Valuation of 4G spectrum portfolios
- Online bidding software for running or simulating auctions
- Visualization tools for tracking bids, monitoring payment exposure and identifying optimal bids

## About the Authors

**Richard Marsden**, a Vice President based in New York City, leads NERA's spectrum policy and auction advisory work. Over the last 15 years, he has advised bidders or governments in more than 45 spectrum auctions in the Americas, Asia, Africa and Europe. He was a key member of the design team that pioneered the use of package auctions, including the CCA, for the UK, Dutch and Danish spectrum regulators. Recently, he has focused on developing and executing bid strategies for bidders in 4G spectrum auctions.

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## About NERA

NERA Economic Consulting ([www.nera.com](http://www.nera.com)) is a global firm of experts dedicated to applying economic, finance, and quantitative principles to complex business and legal challenges. For over half a century, NERA's economists have been creating strategies, studies, reports, expert testimony, and policy recommendations for government authorities and the world's leading law firms and corporations. We bring academic rigor, objectivity, and real world industry experience to bear on issues arising from competition, regulation, public policy, strategy, finance, and litigation.

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