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# US 600MHz Incentive Auction Reverse Auction Rules

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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.

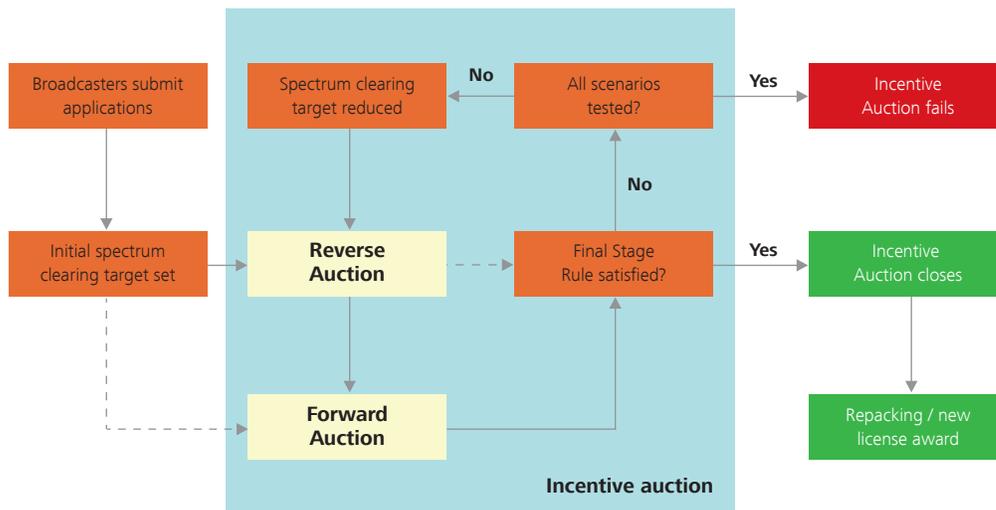
In this paper, **NERA Vice President Richard Marsden** and **NERA Analyst Jonathan Pike** describe the auction rules for the **Reverse Auction**<sup>1</sup>. For the first time in a spectrum auction context, the FCC will use a **descending clock auction** format, in which prices are progressively lowered until the number of channels that broadcasters are willing to move or relinquish supports a clearing scenario. The most complex part of the process is the repacking algorithm, which – at each price point in the auction – is used to determine if an offer by a broadcast station is critical to the relevant clearing scenario.

The Forward and Reverse Auction are linked at the national level; there is no direct linkage between clearance of channels and availability of cellular spectrum in any particular city or local area.

### Overview of the Reverse Auction

The Reverse Auction takes place over one or more stages, each linked to a scenario for clearing 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 for that stage meets the “final stage rule” (i.e. it raises sufficient revenues), 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



### Eligibility to participate in the auction

All full power and Class A licensees are eligible to participate in the Reverse Auction. This includes broadcasters in both the UHF band and the VHF band. Even though the VHF band is not being cleared, it may be desirable for a VHF broadcaster to vacate or share a channel, so as to make room for other broadcasters moving from the UHF band. Even broadcasters that do not participate or exit the auction may have to change channel as part of the repacking process; however, they are guaranteed to be relocated to equivalent spectrum (i.e. a UHF broadcaster would stay in the UHF band and an upper VHF broadcaster would stay in the upper VHF band).

Channel sharing must be pre-agreed, as it will not be a bid option during the auction.

Two broadcast stations that serve similar or identical population footprints may also make an offer to share a channel. Such stations are required to execute a channel sharing agreement prior to the application deadline. Only the station that would be relinquishing spectrum is required to participate in the auction; the other station is not. A station can share a channel with another station in the UHF or VHF band, regardless of their current location.

### Broadcaster bid options and opening prices

*The rules do not appear to allow for the possibility that two stations may both want to relinquish at opening bids but be willing to channel share as a fall back.*

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.

*The setting of opening bids could make or break the incentive auction, as they will impact broadcaster participation and affect relative drop out points.*

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 will be specific to each bidder and bid option, and will be based on "...objective factors, such as location and potential for interference with other stations." Broadcasters that operate in the same band and from the same broadcast location will receive identical options and opening prices.

*Prices are unlikely to be set until much closer to the auction. They could be controversial given potential to create relative winners and losers in terms of prices paid to broadcasters.*

To participate in the auction, eligible broadcasters must submit an application. This must include a binding offer to accept at least one bid option at the opening prices. After all applications have been received, the FCC will run the bids through a computer algorithm to determine the largest clearing scenario that could be achieved. This is the Initial Spectrum Clearing Target.

### Spectrum clearing scenarios

*According to a recent study by Kearns and Dworkin<sup>2</sup>, a spectrum 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.*

There are eleven distinct scenarios for spectrum to be cleared in the Reverse Auction, ranging from a maximum of 144 MHz, which would clear UHF channels 27 upwards (scenario 12), down to 42 MHz, which would clear UHF channels 45 upwards (scenario 2). These scenarios are illustrated in Figure 2.

The first scenario to be tested in the auction will be the Initial Spectrum Clearing Target. The Reverse Auction will set a revenue target for that scenario. If bidders in the Forward Auction do not collectively offer enough money to meet the revenue target, then the process will be repeated for successive smaller scenarios until a solution is found or the auction fails. The FCC has discretion to skip some 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

### Prohibition on collusion

*The anti-collusion rules imposed on broadcasters are unusually strict (more so than the Forward Auction). They could create challenges for affiliated channels or those planning to channel share.*

Once applications have been submitted, all eligible broadcasters are prohibited from communicating with any Reverse or Forward Auction participants regarding bids or bidding strategy (an exception is made for stations that share a common controlling interest). This prohibition includes broadcasters who are not participating in the auction. The FCC says that such rules are necessary to prevent identification of participating broadcasters, consistent with its promise that the identities of Reverse Auction participants will stay confidential for two years.

### 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). The multiple-round procedure for each stage is illustrated in Figure 3.

*It is ambiguous if bidders will be allowed to bid on multiple options or just one option in each round, but they will presumably be restricted in their ability to move between bid options. The rules may allow the Auctioneer to deny switches between options.*

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

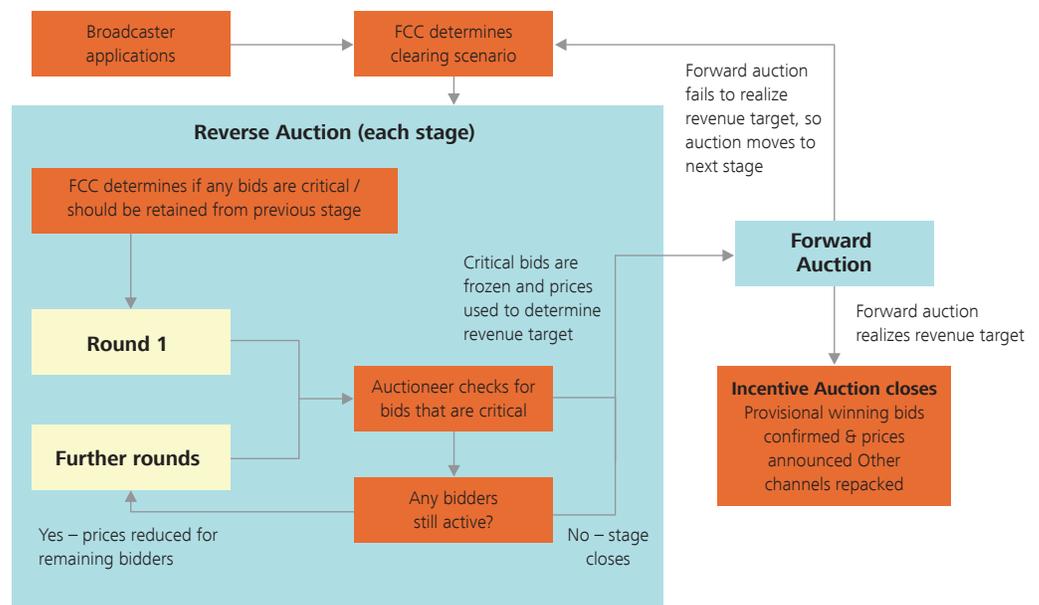
- In each round, broadcasters will be presented with prices for up to three bid options to relinquish or move channels. Bidders indicate whether they are willing to accept a bid option at that price.
- At the end of each round, the Auctioneer will identify bids that have become critical to the current clearing scenario. 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 have not yet been identified as critical will have the opportunity to continue bidding in the next round. The price of their bid options will be reduced by a bid decrement.

Like opening bids, the relative level of bid decrements used for each broadcaster and each bid option could have a big impact on outcome, both in terms of which channels are cleared and the prices that broadcasters receive.

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.

- No guidance has been provided as to how the FCC will set bid decrements, but it is likely the methodology will be more sophisticated than the simple percentages used in some past spectrum auctions. For example, smaller decrements may be used for stations and associated bid options thought more likely to become critical based on their potential to cause interference and the current evolution of the auction.
- 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 associated bid amounts are an input into the revenue target for the Forward Auction for that clearing scenario.

Figure 3. **Structure of the Reverse Auction (multi-round descending clock format)**



### Identifying bids that are critical to the clearing scenario

The repacking process across the lower 48 states is complex but some simple rules do apply: for example, if one station is deemed critical, then all other stations broadcasting in the same band and from the same location must also be critical.

The most complex part of the auction is the process for determining when bids become critical to the clearing scenario. This requires the FCC to run a bespoke 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. The algorithm takes into account the required geographic and frequency separations between stations necessary to prevent unacceptable interference and maintain broadcast service quality. The FCC may have to run the algorithm many times after each round, and this may be computationally demanding.

*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.*

*Although the process for running repeat repacking algorithms may seem obscure, it will play a crucial role in determining outcomes and prices, and may make or break gaming incentives for participants.*

*The hierarchy between bids established in the previous stage will presumably be applied again to determine how and what bids are carried over into the new stage.*

*We do not expect the FCC to announce any prices until the end of the Incentive Auction, as doing so between stages could reveal information about the level of supply.*

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.

The FCC has not yet announced how it intends to use the algorithm and apply the associated pricing rule. There are a number of possible approaches. One key decision the FCC will have to make is whether to identify the price at which bids become critical at the end of each round or delay this until the end of the Reverse Auction. The latter approach has the advantage that it may greatly reduce the number of times the algorithm needs to be run after each bidding round, thus speeding up the auction. However, this may also mean that some bidders keep bidding at prices below their final payment.

Another decision is how to prioritize between bidders that submit intra-round exit bids in the same round, given there is no common price across channels. Establishing a clear ranking of all such bids is a necessary step for systematically running the algorithm to determine which bids are deemed critical and at what price. We suppose that bids may be ranked according to their intra-round bid level as a proportion of their bid decrement, with ties perhaps broken in favor of channels having a higher interference score.

### **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 bid under the new scenario to determine if it should remain frozen. If a bid was previously frozen at an exit price, then that bid option would end. For any other bids no longer deemed critical, the clock will be restarted and 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 revenue target for the Forward Auction, they will only apply to bidders if the clearing scenario is successful. The aggregate value of the winning prices will be a subset of the total revenues from the Forward Auction, with the balance used to fund other initiatives, such as the public safety network, FirstNet.

## **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.

## 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.

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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.

**Jonathan Pike** is an Analyst in NERA's Auctions Practice and is based in New York City. He has particular expertise in developing proprietary auction software to assist mobile operators during spectrum auctions. Jonathan's experience includes on-site support for bidders in 4G auctions in Australia, Canada, Czech Republic, Switzerland and the UK.

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