BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON D.C. 20554

In the Matter of	)	
	)	
Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions	)	GN Docket No. 12-268
	)	

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INTRODUCTION AND SUMMARY

AT&T welcomes the opportunity to engage with the Commission on the details of this critical spectrum-reallocation initiative. The stakes are as high as the issues are complex. "[S]pectrum is the oxygen that ultimately sustains the mobile revolution,"[1] and freeing up more of it is critical to U.S. economic growth and technological leadership. This is the last spectrum auction of comparable scope that the Commission will conduct for many years, and the decisions the Commission makes here will have economic and technological consequences lasting a generation.

The Commission should therefore focus sharply on the central factor that distinguishes this auction proceeding from all others. In a typical auction, unlike this one, the Commission first defines the frequency blocks it commits to clear and simply asks carriers to bid for those blocks. If the auction rules are suboptimal, less money is deposited into the Treasury, but consumers nonetheless reap the benefits of greater bandwidth for mobile broadband applications. In *this* auction, by contrast, the Commission must persuade a variety of auction participants to satisfy the statutory auction-closing criteria for any target level of spectrum: namely, forward-auction revenues must exceed winning reverse-auction bids plus administrative and estimated repacking costs.[2] If they fall short of that benchmark, the Commission will have to settle for less cleared spectrum, and in the worst-case scenario, the auction could fail altogether.

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1 Prepared Remarks of Chairman Julius Genachowski, Telecommunications Industry Association 2011 Summit, at 2 (May 19, 2011), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-306768A1.pdf.

2 *See* Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, Tit. VI, § 6403(c)(2), 126 Stat. 156, 227-228 (Feb. 22, 2012) ("Spectrum Act") (codified at 47 U.S.C. § 1452(c)(2)).

That fact has profound consequences for the decisions the Commission makes in establishing a band plan, designing the forward and reverse auctions, establishing the ground rules for participation, and creating mechanisms for efficient repacking. Those decisions will determine not only how much money changes hands, and not only whether spectrum goes promptly to providers able to extract the most value from it, but also *how much spectrum* is available to such providers and their customers in the first place. Suboptimal decisions would not only reduce revenues, but deprive consumers of the primary benefit that Congress sought to achieve in the Spectrum Act: reallocating as much spectrum as possible for mobile broadband services. In Chairman Genachowski's words, this incentive auction is the Administration's "single biggest initiative to free up beachfront spectrum and address the spectrum crunch," and the Commission's first goal should be to "maximize[e] the amount of spectrum freed up."[3]

The Commission should thus take all steps needed to make this auction succeed, in the sense that the auction will meet the statutory closing conditions for the maximum possible amount of freed-up spectrum. As discussed below, the Commission has already set the stage for success by developing innovative approaches to managing the complexity inherent in this process, including its proposals for "extended families" of cleared spectrum blocks and for bidding on "generic categories" of interchangeable

[3] *See* Notice of Proposed Rulemaking, *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, 27 FCC Rcd 12357, 12547 (2012) ("NPRM") (statement of Chairman Genachowski); *see also* FCC, *Connecting America: The National Broadband Plan*, at 81 (2010) ("The broadband spectrum needs of the U.S. are growing as it is becoming more difficult to identify large swaths of spectrum—both federal and commercial—that can be reclaimed for auction. . . . Given the practical challenges of reallocation, the FCC needs to create new incentives for incumbent licensees to yield to next-generation users.").

spectrum. As the Commission recognizes, however, the NPRM's proposals are properly viewed as starting points in the discussion rather than as finished solutions in their own right. In that spirit, AT&T proposes that the Commission build on those proposals in the following respects.

Band plan. In principle, AT&T supports the Commission's basic "extended families" concept, which provides for carefully coordinated blocks of uplink and downlink spectrum across different markets depending on how much spectrum can be freed up in each. This concept is a key innovation that will allow the Commission to reallocate the greatest amount of usable spectrum while accommodating the twin realities that different amounts of spectrum will be cleared in different geographic markets and that mobile technologies cannot feasibly support a proliferation of widely disparate band plans from one location to the next. AT&T also agrees with some of the other principles underlying the Commission's proposal. For example, AT&T supports using five-megahertz building blocks, creating a significant amount of paired spectrum, and limiting the size of guard bands to what is technically necessary to avoid interference.

That said, after engaging in a detailed engineering analysis and consulting with its vendors, AT&T believes that certain aspects of the NPRM's proposal would raise significant practical concerns that would devalue the spectrum and increase the risk of partial or complete auction failure.

One key set of concerns relates to the unique interference challenges the NPRM's proposed band plan would pose. *First*, the proposed placement of television stations in the "duplex gap"—the spectrum between paired uplink and downlink blocks—would create a risk of substantial intermodulation interference in a variety of downlink frequencies, not only in the 600 MHz band itself, but also in other bands such as the PCS ("Personal Communications Service") band. *Second*, the NPRM's proposal would place uplink spectrum in certain frequencies where a handset's transmissions would cause harmonics-related interference for the same handset's PCS and EBS/BRS ("Educational Broadband Service/Broadband Radio Service") downlink frequencies. Both forms of interference would dampen bidding for 600 MHz spectrum by increasing the risk of impaired handset performance, whether on the 600 MHz band or on other frequencies that the handset could otherwise use in combination with the 600 MHz band.

Third, because the NPRM's proposal relies so heavily on varying the number of cleared uplink blocks from market to market, depending on how much spectrum is cleared in each market, it would exacerbate the risk of co-channel interference. For example, if Channel 48 is cleared in City A but not neighboring City B, a high-power station operating in Channel 48 in City B might well interfere with base-station receivers on the same channel in City A. Such co-channel interference might arise under any band plan with variable market-by-market clearing targets, but the NPRM's proposal would magnify the risk by creating more incremental, and thus more frequent, market-by-market variation than is necessary.

It is unlikely that any of these three forms of interference could be sufficiently and efficiently alleviated through the use of filters, guard bands, or similar techniques. In contrast, ordinary adjacent-channel interference *can* be fully mitigated through the use of such techniques, but in this respect, too, the Commission's proposed band plan requires some refinement. The NPRM proposes guard bands of just six megahertz to separate any given TV station from mobile broadband uses, including downlink operations. Although that amount would be sufficient for TV stations transmitting at 50 kW or below, a much wider guard band would be needed to protect downlink spectrum from harmful adjacent-channel interference caused by higher-power stations. One solution to this challenge lies in the repacking process: that is, in reassigning TV stations transmitting at 50 kW (or below) to slots adjacent to downlink-protecting guard bands so that those guard bands can be limited to six megahertz.

Two additional related characteristics of the Commission's proposal—the large size of the duplex gap and the location of all downlink blocks below Channel 37—would also create implementation problems by materially increasing the size of the antennas needed for devices and base stations in a 600 MHz network. That in turn would require the use of bulkier devices, and it would prevent carriers from using many existing cell sites for 600 MHz operations and make it more difficult to find new cell sites that can accommodate the larger antennas. It would also greatly complicate the deployment of MIMO ("multiple input/multiple output") technologies, which increase the efficiency of spectrum use. Alternatively, carriers that end up with lower 600 MHz spectrum could avoid the logistical burdens of larger antennas by settling for suboptimally sized antennas—for example, smaller antennas that are optimized for use in the *upper* 600 MHz band. But carriers could take that step only at the expense of degraded performance. Either way, bidders will attach substantially less value to spectrum on the lower end of the 600 MHz band than the higher. And because the paired downlink spectrum under the NPRM's proposal would all fall below Channel 37, paired blocks under that proposal would all have a lower value than they would have under an alternative that places paired downlink spectrum above Channel 37.

In light of these interference and implementation issues, AT&T proposes below an example of a modified band-plan framework that would retain some of the NPRM proposal's key characteristics but would reduce the size of the duplex gap, avoid placing television stations in that gap, place as much mobile broadband spectrum as possible in the higher frequency blocks of the 600 MHz band, and make certain other adjustments. This alternative would minimize interference concerns and avoid the need for larger handset and base-station antennas. And in every market in which twelve or more television stations are cleared, AT&T's alternative would make available (depending on the details of implementation) as much spectrum for mobile broadband use as the NPRM's proposal—and often more. AT&T has developed this alternative in consultation with other industry participants and offers it here not as a formal proposal, but merely as an illustration of how the Commission can improve upon the NPRM's proposed band plan. AT&T looks forward to working with the Commission and other stakeholders on the potential for further refinements.

Forward auction: generic bidding categories. AT&T supports both the use of an ascending clock auction and, to help manage complexity, the Commission's proposal for bidding on "'generic' categories of licenses, such as paired or unpaired licenses, in a geographic area." NPRM ¶ 56. That said, the Commission should carefully define the categories of generic licenses so that each category contains only truly interchangeable spectrum blocks of similar value. For example, if some blocks within a category have a much lower value than others, bidders will reduce their bids to hedge against the exposure risk of ending up with inferior spectrum blocks. The question is thus how best to reconcile two goals: (1) keeping the number of generic categories small and (2) ensuring comparability of spectrum assets within each category. The Commission can best achieve these objectives by defining separate bidding categories for paired and unpaired spectrum and, within the broader class of unpaired spectrum, distinct bidding categories for each discrete "grouping" of supplemental downlink blocks (*i.e.*, each market-variable set of contiguous blocks allocated for supplemental downlink uses). Designating distinct groupings of unpaired spectrum for bidding purposes is necessary because some of those groupings will be more valuable than others, depending on their frequency locations and, just as important, on the relative number of markets nationwide in which each such grouping will be cleared.

Forward auction: package bidding and spectrum contiguity. The Commission should follow through on its proposal to permit a forward-auction participant to place "a single, all-or-nothing bid amount that would apply to a group of licenses, such as . . . the same block in multiple geographic areas." NPRM ¶ 62. Such package bidding is necessary to capture the large complementarities that regional and national carriers will derive from offering service on the same 600 MHz bands across multiple geographic areas. Indeed, in the *absence* of package bidding, bidders might exit the forward auction early to avoid the classic exposure risk of "winning" a hodgepodge of scattered spectrum assets that lack much of the value they would have presented had they been part of a seamless geographic package. That exposure risk would thus suppress forward-auction participation and increase the risk of auction failure.

In their attached white paper, Professors Che, Haile, and Kearns propose a package-bidding solution that, without introducing undue complexity, will allow forward-auction participants to express the substantial value of geographic complementarities. Under their approach, a forward-auction participant could bid on individual EAs or on one or more permissible geographic packages. To avoid intractable computational problems, the Commission would strictly define the set of permissible package bids in a fully nested hierarchy. For example, the Commission could specify that a permissible geographic package must consist of all EAs in an MEA, of all MEAs in an REA, or of all REAs within the United States. An EA and a larger package including that EA would be treated as separate objects for bidding purposes, yet no spectrum would be set aside for packages; instead, all bidders would participate in the same ascending clock auction for the same underlying spectrum. A package bidder would win spectrum in all EAs within its geographic package if the total price it offers for the spectrum in that package exceeds the sum of the bids that would otherwise prevail in the absence of that bidder's package bid. This proposal would neither favor nor disfavor package bidders as compared to bidders for individual EAs. Instead, it would pick winners solely on the basis of which combination of bids expresses—and can be presumed to produce—the greatest economic value for consumers.

Beyond the complementarities a bidder can derive from procuring *some* 600 MHz blocks throughout a multi-EA region, a bidder can also derive substantial additional value from rights both to *the same* frequency blocks from one EA to the next ("horizontal contiguity") and to *adjacent* frequency blocks within any given EA ("vertical contiguity"). The Commission should establish clear assignment rules that will provide winning bidders with contiguous spectrum to the maximum extent possible, thereby inducing forward-auction participants to express those complementarities in the form of higher bids for generic spectrum. To the extent the rules do not specify complete assignment outcomes, the Commission should allow for supplemental bids during a subsequent "assignment phase." But it should minimize the importance of that phase in order to increase bidding in the main (generic) phase and thus permit a prompt determination of whether the revenue conditions for a given channel-clearing target have been met.

Reverse auction. The major purpose of the reverse auction is to reveal some or all of the supply curve for potentially reallocated spectrum: *i.e.*, the prices at which various broadcasters would agree to cede the spectrum rights needed to satisfy a range of channel-clearing targets. The key design question is *how much* of that supply curve the reverse auction should reveal up front, before the forward-auction is conducted.

Under one approach, advocated in the Auctionomics proposal attached to the NPRM, the reverse auction would obtain only enough information from broadcasters to determine the revenue requirement for a single spectrum-clearing target at a time.[4] Each time the descending clock reached a price level where just enough broadcasters would cede spectrum rights that the Commission could clear a target amount of spectrum, the Commission would stop the reverse auction, convene the forward auction, and see whether forward-auction bidding has met the statutory revenue requirement for that spectrum-clearing target. If not, the Commission would have to call the broadcasters back for a new round of reverse-auction bidding at a lower spectrum-clearing target and begin the cycle anew. Broadcasters would thus have to reconvene each time the forward-auction results fall short of the statutory revenue benchmark, and the forward auction

4 *See* Paul Migrom, Lawrence Ausubel, Jon Levin, and Ilya Segal, *Incentive Auction Rules Option and Discussion*, at 3 (Sept. 12, 2012) ("Auctionomics Proposal").

would pause for each new round of the reverse auction, including computation of repacking alternatives at the lower spectrum-clearing target.

As Professors Che, Haile, and Kearns explain, this proceeding is more likely to succeed if the Commission chooses a different approach designed to reveal at the outset as much of the supply curve as needed to show what the aggregate revenue requirements would be for all potentially applicable channel-clearing targets. In their attached analysis, they thus propose a "single-pass reverse auction" that closely resembles the Auctionomics approach except in one critical respect: it would ask broadcasters to indicate, *before* the forward auction is held, whether or not they would cede specified spectrum rights at progressively lower price levels.

The single-pass format is clearly preferable for the reasons that Professors Che, Haile, and Kearns explain. Among its other benefits, this format would greatly simplify auction participation for broadcasters by enabling the Commission to adjust the spectrum-clearing target as necessary to ensure satisfaction of the statutory auction-closing conditions *without* any need to reconvene the broadcasters (and interrupt the forward-auction bidding) each time the forward-auction results fall short of revenue requirements. The single-pass approach would thus avoid the repeated, unpredictable, and potentially lengthy delays endemic to the Auctionomics approach. A modified single-pass approach could also improve the *substantive outcomes* of the repacking analysis if, as might well happen, the Commission finds either that sequential ("greedy") repacking analyses are computationally infeasible to conduct in real time or that they would produce an unacceptable loss of repacking efficiency. If it makes either finding, the Commission could combine the single-pass approach with proxy bidding (as described below) to produce more efficient, *non*-sequential repacking outcomes—and thus more cleared spectrum for mobile broadband.

Finally, there is no compelling reason, either conceptual or practical, to favor the Auctionomics format of repeatedly alternating forward and reverse bidding. The NPRM suggests (¶ 40) that it may be preferable to seek price information for only one channel-clearing target at a time on the theory that some broadcasters might be deterred from participating if they are required to "determine an exact bid at the beginning of an auction." But under *any* bidding format, broadcasters would have to expect that, within a constrained time period, they might well need to make multiple offers to cede their spectrum rights at successively lower price levels, either because excess supply remains or because the auction-closing conditions have not yet been met. Broadcasters would thus have to make at least rough station-value determinations at the outset of bidding even under the Auctionomics approach.

Coordinating the forward and reverse auctions. The Commission should adjust its proposal for coordinating the forward and reverse auctions to ensure that the latter auction does not, in effect, stop too soon. The NPRM anticipates that, for any given channel-clearing target, bidding in the reverse auction will stop when excess supply is eliminated, and bidding in the forward auction will stop when excess demand is eliminated. The NPRM then provides that, "[i]f the closing conditions are met, the incentive auction process would end. If not, we continue running *the forward auction* to see if the closing conditions can be met." ¶ 67 (emphasis added).

In fact, the Commission should look to additional bidding in *both* the forward auction *and* the reverse auction in these circumstances to maximize the odds of meeting the closing conditions for a given channel-clearing target rather than settling for some lesser target. On the forward-auction side, even once the ascending clock has just eliminated excess demand, the remaining bidders may nonetheless be willing to pay somewhat higher prices for the same spectrum assets if necessary to meet the closing conditions. By the same token, on the reverse-auction side, even once the descending clock has just eliminated excess supply, the remaining broadcasters may nonetheless be willing to accept somewhat lower prices to cede the same spectrum rights if necessary to meet the closing conditions. The Commission should not acquiesce in a less ambitious channel-clearing target until after it has tested both possibilities. That fact presents another reason to conduct a single-pass reverse auction, which (when combined with intra-round bidding) will provide the Commission up front with the detailed pricing information needed to make that judgment on the reverse-auction side.

Repacking. The efficiency of the Commission's repacking solutions will be critical to the success of the overall auction, and the Commission should thus avoid placing any undue constraints on its repacking discretion. First, it should avoid any artificial geographic constraints. In particular, it should account for the daisy-chain effects of its co-channel separations policies by assessing repacking options from a region-wide (and potentially nationwide) perspective rather than a local one. Second, the Commission should also avoid reading into the operative legislation any unnecessary *legal* constraints on efficient repacking. The statute requires the Commission to "make all reasonable efforts to preserve . . . the coverage area and population served" of each licensee. The modifier "reasonable" is critical to interpretation of this mandate, and giving it effect may be necessary to free up substantial amounts of additional spectrum.

Third, the Commission should try to structure the repacking process to distinguish between TV stations that currently transmit above 50 kW (up to the maximum of 1 MW) and those that operate at 50 kW or below. The stations in the latter category pose less severe interference challenges to mobile downlink operations than higher-power stations do. In the repacking process, therefore, the Commission should assign those reduced-power stations to channels adjacent to guard bands protecting mobile broadband downlink spectrum. That step will enable the Commission to limit the size of those guard bands to six megahertz (in contrast to the much wider guard bands that would be needed for a higher-power station) and, in turn, will allow the Commission to maximize the amount of spectrum that it can reallocate to mobile broadband uses.

Fourth, the Commission should provide as much advance information as possible about how it will structure the repacking process to maximize the value of the spectrum reallocated to mobile broadband uses. Only then can it ensure that forward-auction participants will express that increased value in their bids. The Commission should thus establish clear repacking algorithms up front and make them fully available to the public.

No restrictions on auction participation. Finally, the Commission should reject any proposal to restrict the participation of particular carriers in these auctions on the basis of their existing spectrum holdings. Instead, if a winning bidder's acquisition of new spectrum would bring its total holdings in a market to a level that is determined to threaten competition, that licensee should be free to choose which spectrum it will divest to remedy the perceived anticompetitive harm. But excluding well-capitalized carriers from fully participating in this auction would undermine forward-auction competition, suppress bid levels, and threaten outright auction failure.

DISCUSSION

I. THE COMMISSION SHOULD ADOPT A BAND PLAN DESIGNED TO EXTRACT MAXIMAL VALUE FROM THE AVAILABLE SPECTRUM

A. General Observations

This auction can succeed only if the Commission's band plan is sound. Yet this auction presents the most complex band-plan challenge the Commission has ever faced. Unlike in prior auctions, the Commission cannot know in advance how much spectrum will be available for auction or exactly where that spectrum will be located, and the answers to both questions will likely vary by market. The band plan must be flexible enough to accommodate these unknowns while minimizing interference and implementation problems. As the NPRM recognizes, moreover, the band plan should provide bidders with as much advance information as possible so that they can make informed business decisions. As in the other contexts discussed throughout these comments, minimizing uncertainty and risk will be critical to ensuring robust forward-auction participation and, in turn, the overall success of this proceeding.

The NPRM takes an innovative approach to this difficult challenge, and AT&T agrees with key features of the NPRM's proposed band plan. But other features of that plan would present serious and avoidable interference risks and other implementation challenges. In Section I.B below, we discuss these concerns in detail; we then turn, in Section I.C, to an alternative proposal that illustrates one way in which the Commission could build on key attributes of the NPRM's proposal while avoiding some of the pitfalls. We begin, however, by identifying three core principles that should inform any band-plan design.

- ***Principle 1: The band plan should accommodate market-by-market variations in cleared spectrum, but it should balance that objective against the need to avoid undue interference and other implementation problems*.**

The amount of UHF spectrum that TV stations agree to relinquish will inevitably vary by market. The Commission can address that reality in one of two basic ways: it can limit the available spectrum nationwide to the lowest-common-denominator markets with the fewest cleared spectrum blocks, or it can build a more flexible band plan that accommodates this variation by clearing spectrum in some markets that will remain uncleared in others. As the NPRM suggests, the latter approach is clearly preferable to the lowest-common-denominator alternative because it is the only way to maximize the amount of spectrum available for mobile broadband services, even though it will obviously increase auction complexity and create engineering challenges.

Although AT&T would configure cleared spectrum somewhat differently, AT&T also agrees with the NPRM's insight that spectrum should be allocated in a way that will create as much market-by-market consistency as feasible in the placement of downlink spectrum, both paired and unpaired. As the Commission understands, each incremental increase in market-by-market variation in cleared downlink spectrum will present a trade-off in the form of new interference challenges in markets with less cleared spectrum. Carriers with 600 MHz holdings subject to such variation will need to respond by adding multiple filters to their devices, with corresponding increases in both costs and handset size.

Consider the following simplified example of a band plan with two defined groupings of supplemental downlink blocks, one of which (Grouping 1) is cleared in all markets, and the other of which (Grouping 2) is cleared only in some:

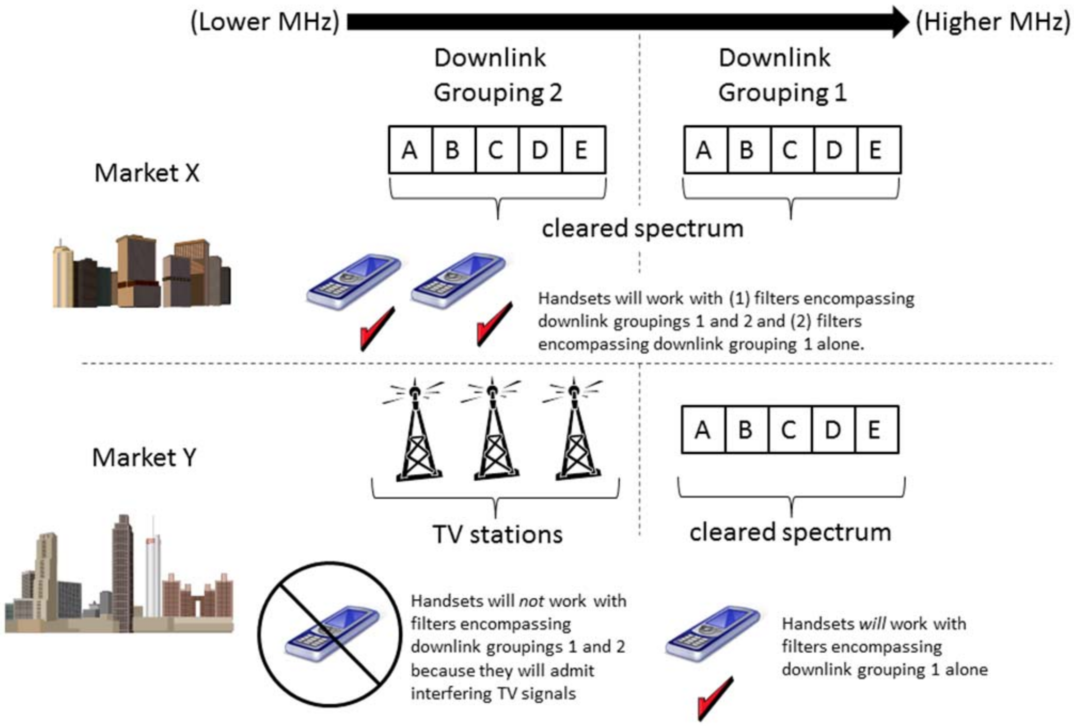

Figure 1: Effects of market-by-market variation in cleared downlink spectrum

In this example, a carrier that obtains one block apiece in Grouping 1 and Grouping 2, and wishes to use both in as many markets as possible, will need to install two filters in its mobile devices. It will need one filter that allows the device to exploit all available spectrum when a customer is in Market X (and other markets where both groupings are cleared). And it will need another filter that avoids overwhelming the handset with blocking interference from TV stations when the customer travels to Market Y (and any other market where Grouping 1 is cleared and Grouping 2 is not). And all else held equal, the more filters a mobile device contains, the bulkier and more expensive the device will be.

Again, this is not a reason to *eliminate* market-by-market variation in downlink spectrum; that approach would leave spectrum on the table by limiting the available spectrum nationwide to the lowest-common-denominator markets with the fewest cleared spectrum blocks. But it is a reason to limit the number of different *increments* in market-by-market variation by defining fewer groupings (contiguous downlink blocks) that are cleared in some markets but not others.[5] The fewer such groupings there are, the fewer the filters that will be needed for a handset to make full use of all cleared downlink spectrum from market to market while avoiding interference from the remaining TV broadcasters.

The ultimate challenge lies in finding an optimal balance among three key objectives: (1) minimizing the number of passband filters that any given carrier must install in its handsets to accommodate market-by-market downlink variations, while (2) maximizing the spectrum that will be allocated to mobile broadband in any given market; and (3) configuring the uplink and downlink bands to avoid undue interference and other implementation problems. The NPRM's proposal accounts for the first two objectives by minimizing variation in downlink spectrum while maximizing variation in *uplink* spectrum. As discussed below, however, that approach would simultaneously thwart the third objective by creating the risk of major interference problems and requiring

[5] An extreme example illustrates the hazards of having too much market-by-market variation in downlink groupings. Suppose that the Commission were to clear Channels 42-45 for downlink in Market A; Channels 43-45 in Market B; Channels 44-45 in Market C; and Channel 45 alone in Market D. In each case, the uncleared channels would remain occupied by full-power TV stations. If a carrier installed a handset filter that allowed signals into the handset from all four of these groupings, TV-station interference would overwhelm the handset in every market except Market A and thus make the 600 MHz spectrum unusable. Yet any handset filter that avoids that problem by keeping out signals in certain of these groupings would exclude those signals even in markets where the channels have been cleared and the signals are dedicated to mobile broadband.

unnecessarily large antennas, and it should thus be adjusted to promote all three objectives rather than just the first two.

As the NPRM notes, the first objective—minimizing the number of passband filters—raises a related question about how wide a given set of adjacent downlink blocks can be while remaining supported by the same passband filter. NPRM ¶¶ 168-71. With current technology, device duplexers can effectively support a passband that is about four percent of the center frequency being used. *See* Jeffrey Reed and Nishith Tripathi, *The 600 MHz Spectrum Auction: An Analysis of the Band Plan Framework*, at 8-9 (Jan. 25, 2013) ("Reed/Tripathi Analysis") (attached as Exh. A). As a result, the maximum passband size for 600 MHz spectrum is about 25 megahertz. *Id.* Interference-related implementation concerns also counsel in favor of keeping passbands in this range. *Id.* at 9. The Commission should thus define sets of contiguous downlink blocks of 25 megahertz (five five-megahertz blocks) or less, enabling the industry to use a single passband (and a single duplexer) for any block within such a set.

- ***Principle 2: The band plan should balance the need for paired spectrum against the need to avoid interference and implementation problems.***

As a general matter, AT&T agrees with the Commission's goal to pair spectrum blocks "wherever possible." NPRM ¶ 125. Today, almost all LTE providers use Frequency Division Duplexing ("FDD") technologies and thus need separate, dedicated uplink and downlink spectrum to provide LTE service.[6] The band plan should

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[6] AT&T also agrees with the NPRM's proposal to license the 600 MHz spectrum in five-megahertz blocks. NPRM ¶ 128. As the Commission notes, 3G FDD technologies today typically use 5x5 blocks of paired uplink and downlink spectrum, and the industry typically uses five-megahertz blocks to configure LTE networks. As discussed below, the forward auction should be designed to permit carriers to obtain contiguous blocks of

accommodate this reality by designating the entire 600 MHz spectrum for FDD operations and should set aside a substantial amount of paired spectrum in as many markets as feasible. The Commission should also reject any proposal to permit Time Division Duplexing ("TDD") operations in the 600 MHz band. *Cf.* NPRM ¶¶ 183-84. As the industry's experience with the 700 MHz band shows, such mixed use would expose FDD and TDD operations to substantial co-channel and adjacent-channel (and potentially intermodulation) interference problems.

Although it will be important to set aside substantial paired spectrum for FDD in as many markets as feasible, the benefits of paired spectrum must be weighed against various technological realities, and the NPRM's proposed band plan draws several of these trade-offs into sharp relief, as discussed in greater detail below. First, although the NPRM's proposal would create paired spectrum by generally designating a new paired uplink block for each additional five-megahertz of spectrum cleared in a market, it would do so at the price of placing up-to-one-megawatt TV stations in the duplex gap, a literally unprecedented arrangement that could create interference problems in the designated 600 MHz downlink blocks (among others). *See* Section I.B.1, *infra*. Second, in markets where fourteen or more stations are cleared, the NPRM's approach would require the use of Channels 42-46 for additional uplink blocks, and that step would create harmonics-related interference for handsets simultaneously using both the 600 MHz and other receive bands such as PCS and EBS/BRS. *See id.* Third, by maximizing market-by-market variability in the amount of uplink spectrum, the NPRM's proposed band plan

adjacent spectrum, which would permit carriers to aggregate two or more five-megahertz blocks into ten-megahertz (or larger) blocks if that better suits their business plans. *See* Section II, *infra*.

would increase the risk that television stations operating in one market will create co-channel interference with base stations using cleared uplink spectrum in geographically proximate markets. *See id.* Last but not least, the NPRM's related proposal to relegate all downlink spectrum to below Channel 37 would increase the costs and engineering challenges of 600 MHz deployment by requiring larger antennas than would otherwise be necessary. *See* Section I.B.2, *infra*. In short, the Commission needs to balance the objective of greater paired spectrum against the reality that band plans maximizing paired spectrum may create more-than-offsetting technological problems that would impair the overall value of the 600 MHz band.

Moreover, in evaluating that tradeoff, the Commission should recognize the value of supplemental downlink spectrum. The Commission did just that in its recent *AWS-4 Order*, where it concluded that power restrictions that reduced the capacity of certain uplink spectrum are a necessary price for ensuring that adjacent downlink spectrum is free of interference.[7] The tradeoff here is even more stark. On the one hand, in an effort to create additional uplink spectrum, the Commission could cause interference problems that reduce the capacity and usability of downlink spectrum. On the other hand, it could avoid that interference and create fully usable supplemental downlink spectrum. The latter course is clearly preferable, particularly given that mobile broadband today uses more downlink than uplink spectrum. We discuss all of these issues in greater detail below.

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[7] Report and Order and Order of Proposed Modification, *Service Rules for Advanced Wireless Services in the 2000-2020 MHz and 2180-2200 MHz Bands et al.*, WT Docket No. 12-70 *et al.*, ¶ 80 (rel. Dec. 17, 2012).

- ***Principle 3: The size of guard bands should be sufficient to protect against interference but no larger, and any unlicensed uses within those guard bands should be subject to appropriate limits to avoid interference with mobile broadband operations.***

The Spectrum Act directs the Commission to conduct a forward auction to "assign[] licenses for the use of the spectrum that the Commission reallocates." Spectrum Act § 6403(c)(1)(A). It authorizes the Commission to "permit the use of [any] … guard bands for unlicensed use," but it provides that those guard bands must be "no larger than is technically reasonable to prevent harmful interference [with] licensed services," and it further directs that "[t]he Commission may not permit any use of a guard band that the Commission determines would cause harmful interference to licensed services." *Id.* § 6407(b), (c) & (e). The questions are (1) how wide the guard bands should be, and (2) what operational limits the Commission should impose on any unlicensed uses to avoid "harmful interference to licensed services."

The first question requires the Commission to balance two objectives: keeping the guard bands large enough to avoid undue interference,[8] while keeping them small enough that as much 600 MHz spectrum as possible will be cleared for licensed mobile broadband uses (as Congress directed). The optimal solution will vary depending on whether the TV station on the other side of a given guard band from a mobile broadband

[8] Electromagnetic signals typically are concentrated in a specified bandwidth but, on either side, create extraneous energy that can interfere with operations in adjacent channels. No filter can fully block signals centered on frequencies that are very close to those that the filter is designed to let in, and the stronger those signals are, the farther away they can be while still creating adjacent-channel interference. Reed/Tripathi Analysis at 15-16. For example, if a filter's passband extends from 580 to 605 MHz, it will not fully block a powerful signal centered at, say, 610 MHz.

licensee is transmitting at the highest power level authorized for any broadcaster (one megawatt) or at some substantially lower power level.

According to analysis performed by AT&T and several of its vendors, a six-megahertz guard band—the size proposed in the NPRM—would be insufficient to protect mobile broadband devices against downlink interference from a 1 MW TV station. Indeed, according to AT&T's vendors, a significantly larger guard band would be required if the television station adjacent to the guard band (opposite downlink spectrum) is operating at 1 MW, which is a common power output for TV stations and the highest power level currently authorized for any TV station. Reed/Tripathi Analysis at 16, 27.[9] One way to reduce the size of the guard bands would be to use the repacking process to fill TV channels adjacent to guard bands with stations that are already operating at power levels much lower than 1 MW—for example, 50 kW or below. *Id.* at 27.[10] This approach would best carry out the statutory mandate: it would prevent interference as a technical matter, and it would maximize the amount of spectrum available at auction for mobile broadband use.

As to the second question, to the extent the Commission permits unlicensed uses in the guard bands, it should heed Congress's prohibition on "any use of a guard band that the Commission determines would cause harmful interference to licensed services." Spectrum Act, § 6407(e). In particular, the Commission should adopt appropriately low

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[9] By contrast a six-megahertz guard band *may* be sufficient to protect uplink operations because the filters used at base stations can better protect against adjacent-channel interference, though AT&T is continuing to analyze this issue in conjunction with its vendors.

[10] In the top 30 markets, there are currently television stations operating at power levels significantly below 1 MW. Reed/Tripathi Analysis at 27.

power limits and controls on out-of-band-emissions for any unlicensed uses that are permitted in these guard bands.

B. Several Components of the Commission's Proposed Band Plan Raise Significant Interference and Implementation Concerns

Although the Commission's proposed band plan has a number of innovative and useful features that AT&T believes should be part of the final band plan, it would also create the risk of significant interference and implementation problems. That risk and the resulting uncertainty about the usefulness of the 600 MHz spectrum would chill forward-auction participation and substantially devalue this spectrum for carriers and consumers alike.[11] In this section, we discuss the technological basis for these concerns before turning, in Section I.C, to some proposed solutions. For ease of reference, we reproduce here the NPRM's proposal (at ¶ 142) for a band plan with "extended families":

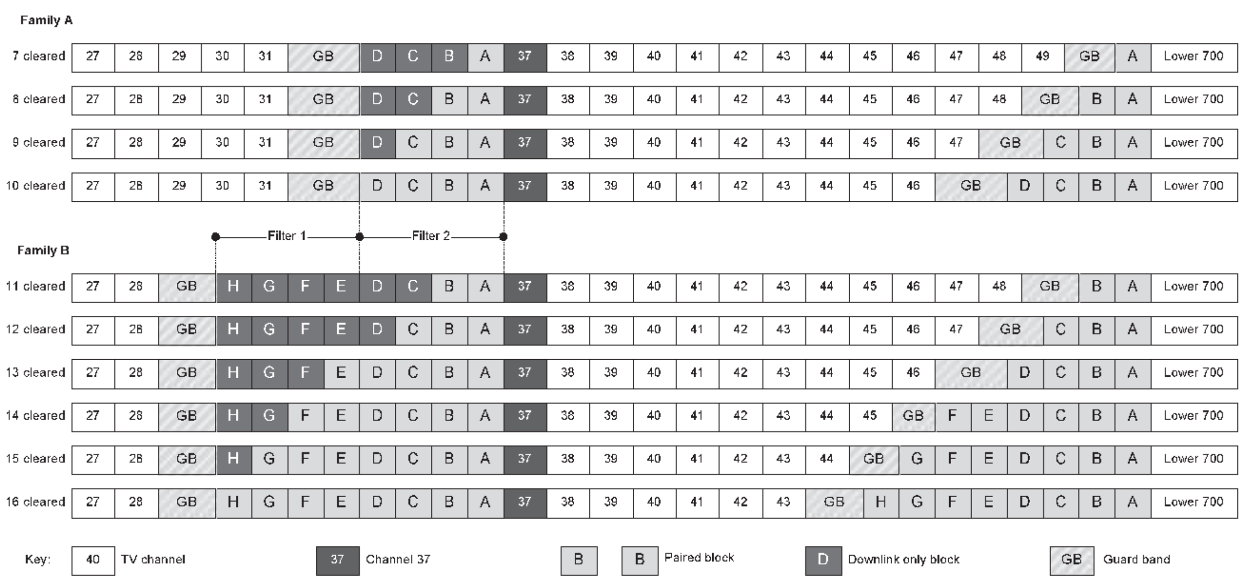

Fig. 2: NPRM's basic band plan proposal

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[11] These problems would also create significant challenges for international harmonization because they would likely deter other countries from adopting the same band plan. Reed/Tripathi Analysis at 24-25.

1. ***Interference Concerns***

Aspects of the Commission's proposed band plan could create substantial interference with mobile operations—in the 600 MHz band itself and in the 700 MHz, PCS, and EBS/BRS bands as well. As discussed below, it is unlikely that these interference concerns could be satisfactorily mitigated using guard bands, filters, or other technological cures. At the very least, great uncertainty about the efficacy and costs of any mitigation measures would depress participation in the forward auction and would therefore threaten this spectrum-clearing initiative.

These interference concerns arise from three aspects of the proposed band plan: (1) the placement of television stations in the duplex gap; (2) the placement of uplink spectrum in the 643-667 MHz frequencies (which overlap current Channels 42-46); and (3) the unusually high likelihood that spectrum cleared in one market will be uncleared and occupied by high-power TV stations in geographically proximate markets. We discuss each concern in turn.

Intermodulation interference from television stations in the duplex gap. The NPRM's proposed band plan would place television stations in the duplex gap—that is, in the spectrum between paired uplink and downlink blocks. That arrangement would be problematic. In particular, placing TV stations in the duplex gap, particularly stations broadcasting at power levels as great as 1 MW, would create the risk of intermodulation interference for the 600 MHz band (among other bands), resulting in degraded network performance.

Intermodulation interference arises when signals from two or more sources combine to produce new signals ("intermodulation products") that fall within a device's receive frequencies. *See* Reed/Tripathi Analysis at 11. Under the NPRM's proposed band plan, intermodulation products would arise from the combination of (1) television signals in the duplex gap with (2) the signals created by certain components of a mobile device's transmitter. *Id.*[12] In other words, a device's *uplink* transmissions, when mixed with broadcast signals, will create interference on the same device's *downlink* frequencies.

Moreover, under the NPRM's proposal, many television stations would operate in the duplex gap, and these stations could produce multiple intermodulation products. Many of these unwanted signals would fall squarely within the downlink frequencies on which mobile devices would receive transmissions, and they would thus degrade the device's performance on those frequencies. Reed/Tripathi Analysis at 13-14. In addition, the intermodulation products would often overlap, and the total power level of the interference at a given frequency would be the sum of the power levels of the overlapping intermodulation products falling within that frequency. *Id.* at 12-13. Thus, even if each intermodulation product might be relatively weak in isolation, the cumulative strength of those products could be much higher. *Id.*.

In short, as Professors Reed and Tripathi observe, placement of multiple television stations in the duplex gap could cause substantial interference in the 600 MHz, 700 MHz, *and* PCS receive bands and substantially degrade mobile operations in those bands. *Id.* at 13. As they further explain, there is a substantial risk that this interference

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[12] The signals in question include not only the primary frequency on which the transmitters are authorized to operate, but also harmonics of those signals: *i.e.*, additional signals that arise at multiples of the primary frequency. For example, a signal at 100 MHz will produce harmonics at 200 MHz, 300 MHz, etc. Reed/Tripathi Analysis at 12.

could not be satisfactorily mitigated through the use of filters and guard bands. Although those techniques are sometimes sufficient to alleviate intermodulation interference that originates from a *single* broadcast source, they could be inadequate for that purpose where, as here, such interference arises from *multiple* broadcast sources. *Id.* at 14-15.

To begin with, as Professors Reed and Tripathi explain, some transmitter components lie "outside" a device's filter, and the filter therefore cannot prevent or attenuate even broadcast signals outside the passband frequencies from reaching those components and creating intermodulation products. *Id*. Moreover, guard bands cannot completely stop broadcast signals from reaching transmitter components (either outside or inside the filter) and thus creating intermodulation products. *Id.* at 14. To be sure, a guard band of sufficient size can *reduce* the magnitude of intermodulation interference. Moving a TV station from Channel 48 to Channel 47 and establishing a guard band at Channel 48 may help attenuate the TV station's signal before it reaches a device transmitter operating on Channel 49 and thereby reduce the strength of the resulting intermodulation product. Although such intermodulation products might be manageable if there were only one problematic broadcast source, the NPRM's proposed band plan would place many TV stations in the duplex gap. Even if a guard band attenuates each *individual* intermodulation product, that multiplicity of TV signals would create multiple overlapping products, and the signal level of those products would be cumulative. Thus, under the NPRM's proposed band plan, the interference might be highly disruptive no matter where the guard bands are placed or require inefficiently wide guard bands.[13]

[13] Quite apart from intermodulation interference, the NPRM's proposal to employ guard bands as narrow as six megahertz would also, as discussed, cause ordinary

Harmonics from the placement of uplink spectrum. The Commission's proposed band plan would place uplink spectrum in five-megahertz blocks starting in the 693-698 MHz range and work downward, potentially to 667 MHz and below, depending on how many stations are cleared in given markets. A key problem with that plan is that, if a device makes uplink transmissions in frequencies between 643-667 MHz (which overlap with current television Channels 42-46), it will also transmit harmonics (multiples of the primary transmission frequencies) that will fall within the receive frequencies in the PCS band (1930-1990 MHz) and within the EBS/BRS band (2.5 GHz). Reed/Tripathi Analysis at 17. These harmonics could degrade the performance of that device if it is being used to operate simultaneously in the relevant 600 MHz and PCS (or EBS/BRS) frequencies and that risk would further impair the value of the underlying 600 MHz frequencies. *Id.* at 17-18. The industry already has analogous experience with this phenomenon: in some circumstances, harmonics resulting from the use of 700 MHz frequencies have significantly degraded throughput and useful capacity for devices using both 700 MHz and AWS-1 (Band 4) spectrum. *Id.*

Co-channel interference to base stations from TV stations in adjacent areas. The FCC's proposed band plan also creates a significant risk of co-channel interference to base stations in one area from TV stations operating on the same channels in neighboring areas. Consider the simplified example illustrated in the following diagram:

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adjacent-channel interference for downlink operations adjacent to high-power (up to 1 MW) TV stations. *See* Reed/Tripathi Analysis at 15-16. This concern arises both at the top of the NPRM's proposed downlink bands (where only the six megahertz of Channel 37 is situated between TV stations and downlink spectrum) and at the bottom.

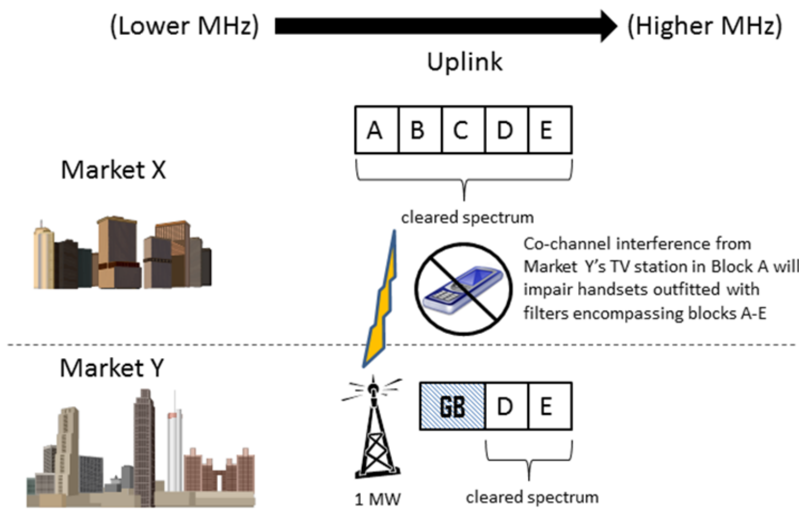

Fig. 3: Co-channel interference between adjacent markets

In this scenario, a 1 MW television station in Market Y is broadcasting on the same frequencies assigned to uplink operations in neighboring Market X (uplink blocks A and B) and is thus threatening interference with Market X base stations receiving signals in those frequencies. Reed/Tripathi Analysis at 18. Such co-channel interference is potentially most severe in the Northeast, where urban areas are spaced particularly close to one another.

To be sure, any band plan that creates variability in the number of channels cleared per market may suffer from this problem to some degree. But the NPRM's proposal would be particularly susceptible to such co-channel interference because, by design, it would maximize market-by-market disparities in the designation of uplink blocks. Although the extent and locations of co-channel interference would not be known until after the auction and repacking process are completed, the risk of such interference would suppress forward-auction bidding, and the interference that did materialize would reduce the capacity and usability of the 600 MHz spectrum.

*   *   *

The various interference problems created by the NPRM's proposed band plan could reduce the effective capacity of multiple spectrum bands and inflict a variety of practical harms on wireless providers. Reed/Tripathi Analysis at 19-20. Most obviously and directly, they could degrade the utility of the 600 MHz spectrum itself. Yet both intermodulation and harmonic interference could also subject carriers with 600 MHz spectrum to additional harms in *other* bands. For example, such interference could impair a provider's ability to aggregate PCS blocks as supplemental downlink together with paired 600 MHz spectrum because its 600 MHz uplink transmissions might well interfere with its supplemental PCS downlink transmissions. *Id.*.[14]

It is not possible at this stage to estimate the full extent of the interference-related impairment that the NPRM's band-plan proposal would create. Among other things, the industry has no real-world experience with cumulative interference problems of the sort described above, and any empirical analysis of the actual magnitude of interference would depend on various unknowns, such as the number of stations that would be cleared and how many would operate in the duplex gap. That said, even in the absence of a precise empirical estimate, there is a significant risk that the interference-related disadvantages of the proposed band plan would be substantial. At a minimum, that concern, along with industry uncertainty about the cost and efficacy of any mitigation measures, would depress forward-auction participation and threaten outright auction

[14] In addition, under certain circumstances, these interference concerns could keep carriers from smoothly handing off LTE customers from one cell site or network to the next if, in the process, the customers need to be transferred from the 600 MHz band to the 700 MHz, PCS, or EBS/BRS bands. Reed/Tripathi Analysis at 20.

failure. AT&T thus urges the Commission to modify the NPRM's proposed band plan in the general respects discussed in Section I.C below.

2. *Implementation Issues Due to the Size of the Duplex Gap*

Quite apart from these interference concerns, the NPRM's proposed band plan would present a substantial independent disadvantage: the extreme width of its duplex gap would necessitate the use of larger antennas and pose major engineering challenges.

Under the NPRM's proposal, paired downlink spectrum would be placed no higher than channel 36 and, depending on how many stations are cleared, would go as low as channel 30. (See Fig. 2 above.) Because, under basic laws of physics, the size of an optimally designed antenna is inversely proportional to the frequency used, the placement of downlink spectrum at such low frequencies would require larger device and base-station antennas than would the use of downlink blocks higher in the 600 MHz band. Reed/Tripathi Analysis at 22-23. Indeed, keeping performance constant, an antenna optimized for 570 MHz transmissions would need to be 22 percent longer than an antenna optimized for 614 MHz. *Id.* at 23.

Second, under the NPRM's proposal, the duplex gap between the uplink and downlink blocks would be about 70 megahertz. *See* Reed/Tripathi Analysis at 7. Any carrier using paired 600 MHz spectrum under the NPRM's proposal would thus need to deploy base-station antennas that are sized to cover at least the entire expanse of spectrum encompassing the duplex gap and the downlink and uplink blocks.[15] That, too,

[15] In fact, the antennas may need to cover an even greater expanse of spectrum—under the NPRM's proposal, covering everything from Channel 51 down to Channel 30—because equipment parts often tend to be standardized and may thus need to work with devices used by multiple carriers that have disparate spectrum holdings throughout the 600 MHz band.

would increase the needed size of base-station antennas because antenna size generally increases in proportion to the expanse of spectrum it must cover. Reed/Tripathi Analysis at 7, 23-24.

The need for these larger antennas would present at least three undesirable consequences. First, all else held equal, a need for larger antennas would require equipment manufacturers either to create bulkier devices or free up device space by compromising on the performance of other device components (such as batteries). *See id.* at 24. Second, the need for larger *base-station* antennas would pose costly engineering challenges as well. For example, it may not be feasible to place these larger antennas on existing (or prospective) towers and other structures due to weight, size, or other limitations. *Id*. Carriers would thus have to make do with suboptimally-sized antennas in order to fill gaps in their networks, sustaining performance degradation in the process, or they would incur the costs and delays of finding new cell-site structures capable of accommodating larger antennas. Third, larger antennas would make it more difficult to deploy MIMO, a technology that increases capacity by using multi-antenna arrays on handsets and base stations. *See id*. Because it is more difficult to deploy such arrays the larger the constituent antennas become, this is yet another respect in which the use of unnecessarily low downlink frequencies would impair the value of 600 MHz spectrum.

C. The Commission Should Modify Its Proposed Band Plan To Address These Interference and Implementation Issues.

The Commission should build on the NPRM's proposal but make some modifications designed to alleviate the interference and implementation issues identified above. In this section, we discuss some key features of such an alternative band plan and illustrate what that plan might look like. As AT&T continues to analyze the issues and confer with other industry participants, its proposal may well evolve. That said, although any band plan will involve tradeoffs, the alternative discussed below would strike a better balance among the core objectives discussed in Section I.A than would the NPRM's proposal. In particular, it would minimize interference and implementation issues, increase the value of the available spectrum, trigger greater forward-auction participation, and increase the odds that the closing conditions will be met for ambitious channel-clearing targets.

In broad strokes, AT&T's notional alternative is captured in the following diagram, which shows a band plan for each market depending on how many TV channels are cleared in each (for example, the first row shows markets where 5-7 channels are cleared, the second shows markets where 8-11 are cleared, etc.):

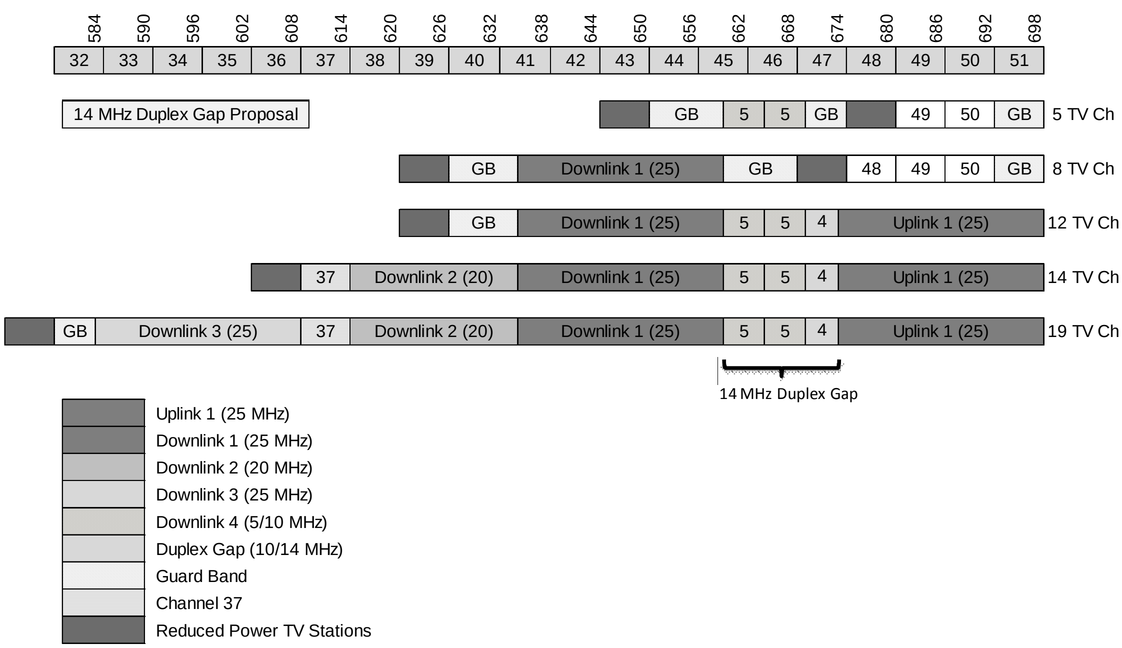

Fig. 4: Example of an alternative band plan proposal

AT&T offers this alternative not as a formal proposal, but merely as an illustration of one way to implement the general advantages discussed below.

Advantage 1: reducing the duplex gap and interference risks associated with placement of television channels in that gap.

Rather than place downlink spectrum only below Channel 37, as proposed in the NPRM, AT&T's alternative would greatly shrink the duplex gap and place the downlink spectrum just below that gap. In markets that meet robust channel-clearing targets (fourteen to eighteen channels), this approach would allow the Commission to create two groupings of downlink spectrum above Channel 37: one 25-megahertz grouping of paired downlink blocks and one 20-megahertz grouping of supplemental downlink blocks.[16] AT&T's alternative approach would thereby avoid the spectral disadvantages that, as discussed, the NPRM proposal would create by using an excessively wide duplex gap combined with lower-frequency 600 MHz downlink spectrum. In particular, it would (1) avoid the intermodulation and adjacent-channel interference concerns arising from the placement of television stations in the duplex gap and (2) permit the use of smaller (and potentially fewer) antennas.[17]

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[16] In markets where nineteen or more channels are cleared, the Commission could allocate a second supplemental-downlink grouping below Channel 37, which the diagram above identifies as Downlink 3. In one variation on this plan, it might be possible to convert that grouping into uplink spectrum instead and pair it with the downlink grouping just above Channel 37 (Downlink 2). AT&T is continuing to evaluate whether that alternative would be technically feasible.

[17] In markets where eleven or fewer stations are cleared, AT&T's proposal would create only supplemental downlink spectrum, to be used in conjunction with operations outside the 600 MHz band. Alternatively, the plan could be modified to create a very small amount of paired spectrum, with a few uplink blocks placed at the top end of the 600 MHz spectrum, much as the FCC's proposed plan does. But that approach would present a tradeoff that the Commission would have to weigh carefully: Although it

The size of an ideal duplex gap would likely range from ten to fourteen megahertz, depending on a number of factors that AT&T continues to analyze in conjunction with other industry participants. Reed/Tripathi Analysis at 27. The duplex gap shown in Figure 4 above is fourteen megahertz wide and, significantly, contains two five-megahertz supplemental downlink blocks. If inclusion of such blocks in the duplex gap is technically feasible, that approach would maximize the spectrum that the Commission could auction off for licensed mobile broadband uses, thereby increasing the likelihood of meeting the auction-clearing conditions for ambitious spectrum-clearing targets. Inclusion of these supplemental downlink blocks would require a fourteen-megahertz duplex gap, because it would be necessary to interpose a four-megahertz guard band between these blocks and the newly allocated uplink spectrum. By contrast, a smaller duplex gap of ten to twelve megahertz could potentially be sufficient if the duplex gap were not used for supplemental downlink.

Advantage 2: reducing harmonics-related interference risks.

Unlike the NPRM's proposal, AT&T's proposed alternative would not create the harmonic interference concerns presented by the NPRM's proposed band plan. Reed/Tripathi Analysis 26. As explained above, those concerns are an unacceptable by-product of the NPRM's proposal for potential uplink use of spectrum overlapping Channels 42-46. AT&T's alternative would avoid that outcome by not creating uplink spectrum below Channel 47.

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would provide a modicum of paired spectrum in such markets, it would leave television stations in the duplex gap and thus increase the risk that intermodulation interference would impair the use of the downlink spectrum.

Advantage 3: reducing co-channel interference between adjacent markets.

As discussed above, the NPRM's proposed band plan poses an undue risk that television stations operating in one market will create co-channel interference with base stations using cleared uplink spectrum in geographically proximate markets. That risk arises from the NPRM's choice of an unusually high degree of market-by-market variation in blocks of cleared uplink spectrum; indeed, for each additional station cleared in a market, the NPRM's proposal would always vary the amount of uplink spectrum. Our alternative proposal would diminish this risk of co-channel interference by reducing the degree of such variation and thus the risk that blocks used in one market for mobile broadband would be used in nearby markets for potentially interfering TV transmissions.

To be sure, our alternative presents a trade-off: in order to reduce the risk of these four forms of interference (intermodulation, adjacent-channel, harmonics-related, and co-channel), it would create somewhat less uplink spectrum in some markets and therefore somewhat less paired spectrum. By contrast, precisely because the NPRM's proposal makes the problematic technological choices that it does, it would allow the creation of incremental five-megahertz uplink blocks (and thus paired spectrum) on a market-by-market basis as additional channels are cleared (starting with markets with seven cleared channels). But whatever benefit that might bring would come at the greater risk of pervasive, value-degrading interference.

Moreover, although the NPRM's proposal would permit more paired spectrum than AT&T's illustrative alternative in some markets, it would *not* generally free up more mobile broadband spectrum overall, as shown in the following chart:[18]

# of Stations Cleared	Mobile Spectrum—AT&T	Mobile Spectrum—FCC
12	60 MHz	55 MHz
13	60 MHz	60 MHz
14	80 MHz	70 MHz
15	80 MHz	75 MHz
16	80 MHz	80 MHz
17	80 MHz	80 MHz
18	80 MHz	80 MHz
19	105 MHz	80 MHz

Fig. 5: Comparison of overall spectrum cleared for mobile broadband

To be sure, in markets with fewer than twelve cleared stations, the NPRM's proposal would allocate slightly more spectrum to mobile broadband than our alternative would, primarily by adding a new cleared uplink block with every cleared channel. Again, however, the NPRM can achieve that outcome only at the price of maintaining TV stations in the duplex gap and posing severe interference risks. Those risks would more than cancel out the benefits of the slightly greater cleared spectrum in markets with fewer than twelve cleared channels.

Finally, one indirect benefit of the NPRM's proposal is that, in *all* channel-clearing scenarios, it would repack the television stations currently operating in Channel 51, which has caused widespread interference with the Lower 700 MHz A Block. Although the NPRM's proposal would accomplish that outcome by automatically designating Channel 51 spectrum for an uplink block, *any* sound band plan—including

[18] This chart assumes that the duplex gap would be used for supplemental downlink spectrum, as described above.

AT&T's—would provide for repacking of Channel 51 TV stations whether Channel 51 is designated for mobile broadband uses or not.

As the Commission is aware, Channel 51 is immediately adjacent to the lower 700 MHz A Block spectrum allocated for mobile wireless broadband services. Recognizing the harmful interference that can be caused by adjacent broadcast and wireless operations, the Commission adopted a 60-mile exclusion zone for A Block build-out.[19] Recently, a number of A Block licensees have requested extensions of their build-out deadlines on the ground that they cannot provide adequate (or any) service because of these exclusion zones and interference from Channel 51. For example, Cincinnati Bell Wireless has claimed that the exclusion zone surrounding each Channel 51 station "effectively prevents" its deployment of wireless service in *100%* of its A Block territory.[20] Cox has noted "significant concerns" due to the interference caused by the operations of Channel 51 broadcasts,[21] and Cavalier Wireless has provided a detailed discussion of the harm from the exclusion zones and broadcast operation on Channel

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19 *See* 47 C.F.R. § 27.60(b)(ii)(D) ("[C]ontrol, fixed, and mobile stations may affect different TV/DTV stations…. Control, fixed, and mobile stations shall keep a minimum distance of 96.5 kilometers (60 miles) from all adjacent channel TV/DTV stations. Since mobiles and portables are able to move and communicate with each other, licensees must determine the areas where the mobiles can and cannot roam in order to protect the TV/DTV stations.").

20 Cincinnati Bell Wireless, LLC Request for Waiver or Extension, WT Docket No. 12-332, at 4-5 (filed Nov. 13, 2012) (The rules "impose[] a 60 mile exclusion zone surrounding each Channel 51 station.... [T]his exclusion zone effectively prevents deployment in the absence of cooperation from or agreement with the Channel 51 licensee…. This means, from a geographic perspective, that ***100 percent*** of CBW's licensed territory – the entire 3,558 square miles – is unusable for the wireless broadband that CBW plans to provide.") (emphasis in original).

21 *See* Request of Cox Communications, Inc. for Extension of the Lower 700 MHz A Block Build-Out Deadline, WT Docket No. 12-332, at 7 (filed Oct. 12, 2012).

51.[22] In short, the presence of broadcast operations on Channel 51 prevents the full deployment of wireless broadband operations in the adjacent A Block spectrum. Thus, any 600 MHz band plan should clear Channel 51 of broadcast operations, as both the NPRM's and AT&T's proposals would do.

Advantage 4: reducing the risk of interference by selective repacking.

One additional aspect of AT&T's alternative warrants discussion even though it could and should be implemented in connection with virtually any band-plan proposal. As shown in Figure 4, our proposal addresses two categories of repacked TV stations: high-power and reduced power—*i.e.*, 50 kW or less. As previously discussed, a six-megahertz guard band is insufficient to keep high-power TV stations from interfering with downlink operations. Again, the solution to this concern is not to leave mobile broadband spectrum on the table by enlarging guard bands, but, if possible, to design the repacking process so as to place a reduced-power TV station on the other side of the guard band adjacent to downlink spectrum. *See* Section I.A, *supra*. Similarly, to reduce the residual risk of co-channel interference between neighboring markets, the Commission could place reduced-power TV stations in the spectrum blocks that are variably cleared in some markets but not others.

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[22] Cavalier Wireless, LLC Request for Limited Extension of Initial Construction Requirements, WT Docket No. 12-332, at 7-13 (filed Nov. 13, 2012) (detailed discussion of Channel 51 interference issues). *See also* Comments of King Street Wireless, L.P., *Petitions for an Extension of Time to Meet the First Interim Construction Benchmark for Lower 700 MHz Licensees*, WT Docket No. 12-332, at 2 (filed Dec. 13, 2012) ("King Street agrees that Channel 51 complications generally present an independent basis for the relief requested").

D. The Commission Should Preserve Channel 37 for Its Existing Uses

As the NPRM explains, Channel 37 (608-614 MHz) is currently used for receive-only radio astronomy observations and wireless medical telemetry systems (WMTS). NPRM ¶ 199. The Commission seeks comment on, among other things, whether these services should be relocated in order to make Channel 37 available for use by mobile broadband providers. *Id.* AT&T's current understanding is that it would likely be cost-prohibitive to relocate wireless medical telemetry devices from Channel 37 and that, therefore, the channel will likely remain unavailable for assignment to mobile broadband providers. These devices are used in hospitals and other health care facilities to transmit patient data (such as pulse) to a nearby receiver. It would be challenging to relocate this large installed base of wireless medical telemetry devices that currently use Channel 37.

Because Channel 37 is currently adjacent to full-power television operations, the services using that channel will certainly face no greater risk of harmful interference than they already face today when Channels 36 and 38 are reallocated to mobile broadband uses.[23] Under the Commission's rules, television operators are not required to protect WMTS from adjacent band interference.[24] When such interference exists, users of wireless medical telemetry devices can move to the other bands designated for WMTS,[25] or "can design equipment to provide sufficient protection from adjacent channel

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23 *See* NPRM ¶ 155 ("Because the proposed in-band and out-of-band emissions of the 600 MHz downlink band are significantly lower than those of the television stations, we do not propose a guard band between the 600 MHz downlink band and Channel 37.").

24 *See* Report and Order, *Amendment of Parts 2 and 95 of the Commission*'s *Rules to Create a Wireless Medical Telemetry Service,* 15 FCC Rcd 11206, 11213 ¶ 19 (2000) ("*WMTS Order*").

25 NPRM ¶ 209 (explaining that wireless medical telemetry services operate on a protected basis in three different bands, including Channel 37).

interference as is current practice."[26] Those same options will remain available once adjacent channels are converted to mobile broadband use, and there is no policy basis for granting medical telemetry operators new protections that would further restrict adjacent mobile operations. That said, the Commission should continue to study the issue to confirm there are no significant interference issues that would undermine the value of mobile spectrum located next to Channel 37.[27]

II. THE COMMISSION SHOULD ENABLE FORWARD-AUCTION PARTICIPANTS TO CAST BIDS THAT EXPRESS THE GREATEST VALUE THAT CAN BE EXTRACTED FROM THE SPECTRUM RIGHTS BEING AUCTIONED

A. The Commission Should Fine-Tune Its Proposal for "Generic Bidding" to Account for Disparities in Value Among Spectrum Blocks

This proceeding presents one of the most complex challenges in auction theory that any regulatory authority has ever been asked to address, and the Commission has prudently begun by searching for ways to promote simplicity in the auction process. For the forward auction, the NPRM proposes two basic features that are well-designed to minimize complexity. First, it proposes the use of an *ascending clock* auction, in which the Commission (rather than any bidder) designates the price level for each round of bidding, and bidders simply indicate how much spectrum they wish to buy at various price levels as that level is raised. As Professors Che, Haile, and Kearns explain, this format is both simpler than the traditional SMR ("simultaneous multiple-round") format

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[26] *WMTS Order*, 15 FCC Rcd at 11213 ¶ 19.

[27] If the Commission preserves Channel 37 for its current uses, the Commission would need to evaluate whether a guard band would be needed if, as both the NPRM and AT&T band plans propose, the Commission allocates a mobile wireless downlink block in the immediately adjacent spectrum.

and less susceptible to bidder manipulation, and the Commission should adopt it for the forward auction.[28]

Second, the NPRM proposes to define "'generic' categories of licenses, such as paired or unpaired licenses, in a geographic area." NPRM ¶ 56. Under this approach, the forward auction will treat all frequency blocks within each defined category as fungible and will require bidders to make generic bids for them. Unlike in past auctions, where participants bid on individual frequency blocks, each participant here will bid to win *some* block (or blocks) within a defined category of interchangeable blocks, and the assignment of *particular* blocks to particular bidders will occur in a separate phase. For example, if there are four blocks of 5x5 paired spectrum for sale in a given market, auction participants would not bid individually on each block; each participant would bid only for some number of blocks within the group, and winners would find out only later which actual blocks they will be licensed to use. As Professors Che, Haile, and Kearns explain, this approach presents key advantages over block-by-block bidding: it will greatly simplify the auction process, and it will also ensure denser (and thus more efficient) competition for the spectrum assets at issue. *See* CHK Analysis at 5-6.

That said, it is essential to define the categories of generic licenses to ensure that each category contains only genuinely interchangeable spectrum assets of comparable value. If bidders face uncertainty about the value of the spectrum they will ultimately receive after they "win" an auction, they will discount their bids to reflect that uncertainty, thereby increasing the risk that forward-auction revenues will be insufficient

[28] Yeon-Koo Che, Phil Haile, and Michael Kearns, *Design of the FCC Incentive Auctions*, at 5-7, 22-23 (Jan. 25, 2013) ("CHK Analysis") (attached as Exh. B).

to meet the closing conditions for a given spectrum target. By analogy, if an auctioneer sought to elicit efficiently high bids for distinct generic categories of “economy compact cars” and “luxury full-size sedans,” he would exclude Yugos from the latter category because the exposure risk of “winning” a Yugo would inefficiently depress all bids for luxury sedans.

Theoretically, the Commission could try to rectify the exposure problem caused by poorly defined “generic” categories by placing greater emphasis on a subsequent “assignment” phase in which participants submit supplemental bids for rights to specific spectrum blocks within those categories. *See* NPRM ¶ 64. Under that approach, however, bidders could be expected in the first bidding phase to set their bids on the basis of the least valuable license in each improperly defined “generic” category. The Commission would thus often have to wait until after the supplemental (non-generic) bidding phase before making any determination about whether the statutory closing conditions have been met. As a practical matter, therefore, defining “generic” bidding categories to include objects of incommensurate value would substantially prolong the auction process and potentially deter broadcasters from participating. Indeed, the extra time that would be needed under that scenario to complete both the generic and assignment phases would seem to defeat the goal of speeding up the process via generic bidding. This is not to say that supplemental assignment-round bidding is *inappropriate*; it may indeed be an efficient and appropriate means of assigning actual licenses, as discussed below. But to avoid delay, the Commission should structure the overall auction to avoid reliance on such supplemental bidding in order to satisfy the closing conditions. To that end, it should ensure that the generic-bidding round is the main event and that any assignment-round bidding is as inconsequential as possible to individual bidders.

The question is thus how best to optimize the main "generic bidding" round in order to balance two goals: (1) controlling bidding complexity by keeping the number of generic categories to a minimum and (2) reducing the exposure problem by ensuring comparability of spectrum assets within each category. As an initial matter, the Commission can do much to satisfy these goals by choosing an appropriate band plan. If, as AT&T proposes, the Commission designs the band plan to minimize the interference concerns discussed above, it will reduce valuation disparities among the spectrum blocks it is auctioning off and thereby increase the utility of generic bidding. For example, the Commission should keep high-power television stations out of the duplex gap to avoid creating intermodulation interference that, depending on geographic location, would create disproportionate interference within certain spectrum blocks. Similarly, as also discussed above, the Commission should avoid creating uplink blocks that would create third-order harmonic interference in the PCS bands used by a number of carriers.

No matter what band plan the Commission adopts, however, substantial variations in value will warrant the division of spectrum blocks into several discrete "object classes," which will be the subjects of separate generic auctions. Although these object classes will vary depending on the details of the particular band plan the Commission ultimately adopts, we can make several general observations that will likely hold true irrespective of any given band plan's details.

Separate object classes for paired and unpaired spectrum. First, as the NPRM appears to propose (*see* ¶ 56), the Commission should define 5x5 megahertz pairs of uplink and downlink spectrum as a separate object class. In general, paired spectrum commands substantially higher prices than unpaired, and no auction participant would bid the full value of paired spectrum blocks if it believes that it may end up with an equivalent amount of unpaired downlink spectrum.

Multiple object classes for supplemental downlink spectrum. As discussed in Section I.C, AT&T's alternative band plan proposal would create a uniform set of paired spectrum blocks for every market that contains paired spectrum, and the blocks within that set would be more or less interchangeable. The same would not be true, however, of unpaired supplemental downlink spectrum, under AT&T's proposal or the NPRM's. Instead, under either approach, the number of supplemental downlink blocks would vary widely by market depending on how much spectrum the Commission succeeds in reallocating in each market. As discussed below, the Commission should create a separate object class of supplemental downlink spectrum for each grouping of such spectrum that the Commission is able to free up in any given market.[29] And if the Commission adopts any band plan with multiple groupings of *paired* spectrum blocks that vary significantly either by market or by band, it should also define separate objects for each such grouping, for essentially the same reasons given here with respect to unpaired spectrum.

Some blocks of supplemental downlink spectrum will be more valuable than others depending on, among other considerations, whether a block lies at the lower or

[29] We are using the term "grouping" here to denote a defined set of contiguous blocks of spectrum, which will be cleared in some markets but not others depending on the number of channels cleared in each market. For example, under the alternative band-plan proposal shown in Figure 4 above, "Downlink 2" and "Downlink 3" are separate groupings of supplemental downlink spectrum.

upper end of the 600 MHz band and the number of markets nationwide in which that block has been cleared. Those valuation differences strongly support holding separate auctions for separate groupings of supplemental downlink spectrum. Suppose, for example, the Commission designates paired uplink and downlink spectrum on the upper end of the band and additional groupings of unpaired downlink spectrum in markets where successively greater numbers of TV stations are cleared. In particular, suppose that in markets 1, 2, and 3, the Commission clears enough spectrum to auction off several 5 MHz blocks of supplemental downlink spectrum substantially above Channel 37 ("Supplemental Downlink Grouping 1"). And suppose that in markets 4, 5, and 6, the Commission clears yet more spectrum—enough to auction off not only *that* supplemental downlink spectrum, but also several additional 5 MHz blocks of such spectrum below Channel 37 as well ("Supplemental Downlink Grouping 2").

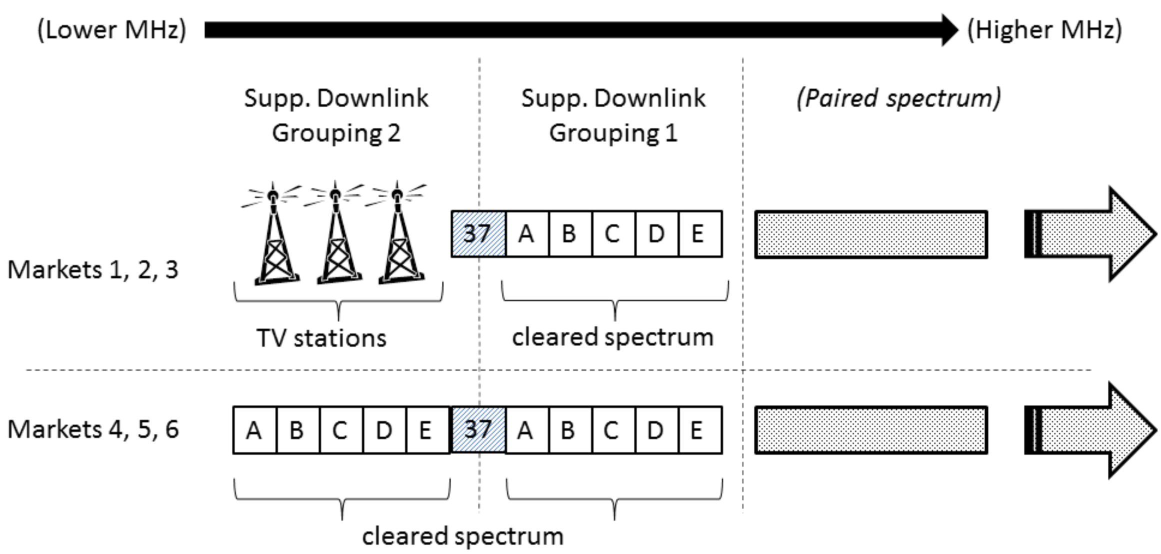

Fig. 6: market-by-market variation in supplemental downlink groupings

All else held equal, bidders will tend to value the generic blocks in Supplemental Downlink Grouping 1 more than the generic blocks in Supplemental Downlink Grouping

2. To begin with, as discussed in Section I, lower-frequency blocks may require the use of larger antennas, and larger antennas require bulkier handsets, pose weight and wind-shear challenges for cell sites, and complicate efforts to enhance capacity through MIMO technologies.

Just as important, a bidder will value given blocks of spectrum more highly if they are cleared in a greater number of markets (here, those in Grouping 1) than other blocks of such spectrum used for the same function (here, those in Grouping 2). First, auction participants seeking a regional or nationwide spectrum footprint will be able to place a block in Grouping 1 to greater use than a block in Grouping 2 while using handsets with a nationally uniform set of filters. Second, handsets with filters designed to work with Grouping 1 will be subject to less co-channel interference from TV stations in geographically proximate markets than handsets with filters designed to work with Grouping 2. For example, if a carrier deploys handsets with filters designed to use Grouping 2 spectrum in Markets 4, 5, and 6, those handsets may be subject to co-channel interference if one or more of those markets are geographically close to Markets 1, 2, or 3, where the same spectrum is used for television broadcasts.

For these reasons, the Commission should define, as a separate object class, the blocks within each grouping of supplemental downlink spectrum. Again, within each grouping, the blocks will be viewed as roughly interchangeable, and auction participants will thus bid generically for blocks within that grouping. For example, if the Commission clears Channels 33 to 36 to free up five blocks of supplemental downlink spectrum, any participant that wishes to purchase one of those five blocks will have to bid generically for it, in competition with every other participant that wishes to purchase any of those five blocks. But that auction will be held separately from any auction for blocks of supplemental downlink in cleared Channels 38 to 41; participants will bid separately for those in a distinct auction. This approach strikes an appropriate balance between, on the one hand, the beneficial simplicity of generic bidding and, on the other hand, the need to reduce exposure risks to bidders who would otherwise discount their bids to reflect uncertainty about whether, if they "win," they will actually receive what they paid to obtain.

The band-plan implications of a generic bidding format. The considerations just discussed underscore an additional shortcoming of the NPRM's proposed band plan: that band plan would contain excessive market-by-market variation in uplink spectrum and would thus frustrate efforts to design an efficient generic auction with a manageable number of generic object classes.

Again, where possible, the Commission should avoid placing two blocks in the same generic bidding category if each is cleared in a different number of markets because most bidders will attribute far greater value to blocks cleared in all markets than in only a few. That observation applies to paired uplink/downlink spectrum as well as to supplemental downlink spectrum. Suppose, for example, that a given bidding category contains four paired blocks, A through D, and that the A Block is cleared in all markets within a populous geographic region and the D Block is cleared in only one. The uplink operations of a winning bidder that is assigned the D Block in that market would be vulnerable to co-channel interference from TV stations that would continue to operate in the D Block in neighboring cities (see Fig. 3 above). In contrast, if the same carrier were assigned the A Block in that market instead, it would be subject to no such uplink interference, and its spectrum holdings would therefore be more valuable. If both the A and D Blocks were grouped within the same generic bidding category, auction participants would discount their bids across the board to reflect the risk of being assigned the interference-prone D Block.

The NPRM's proposed band plan would present exactly this exposure problem because, by design, it would create radical market-by-market disparities in the amount of cleared uplink spectrum. For example, as shown in Figure 9 of the NPRM (at ¶ 142), the D Block would presumably appear in the same generic bidding category as the A Block even though the A Block would be cleared in many more markets and would have much greater value. In contrast, AT&T's band plan proposal would avoid that exposure problem because the blocks within any given grouping would all be cleared—or not cleared—within any given market.

Border interference concerns. The need for separate bidding arises whenever the objects to be auctioned are not truly interchangeable. For the reasons discussed, paired spectrum is not interchangeable with unpaired spectrum, and one market-variable supplemental downlink grouping is not interchangeable with another; that is why AT&T recommends a distinct auction for each of these object classes. Depending on the facts, a similar issue may arise with respect to interference for particular spectrum blocks along the Canadian and Mexican borders, although the industry currently lacks the information it needs to propose a considered solution to that problem.

This border-interference concern is well-known. In key metropolitan areas along the borders, such as Detroit, San Diego, and El Paso, some blocks will face greater interference than others from Canadian and Mexican TV stations, which the Commission obviously cannot reassign to new frequencies. Although confined to border areas, such interference tends to depress the value of affected blocks *throughout the U.S.*, at least for carriers with a national footprint, because each such carrier will wish to sell the same handsets to its customers no matter where they live or travel.

That said, there is probably no spectrum block within the 600 MHz band that will be free of such interference in every major U.S. market. AT&T's preliminary research suggests that interference from Canadian and Mexican television stations may be somewhat evenly distributed across the spectrum the Commission is likely to reallocate in this proceeding, and in some key border markets, most of the available spectrum blocks may be impaired. But AT&T and other private entities lack the full information needed to assess that issue because the exact locations, frequencies, and power levels of Canadian and Mexican television stations are not easily accessible. To address these concerns, the Commission should seek further information on those topics by issuing a separate notice specific to border-area interference and soliciting the input of Canadian and Mexican regulatory authorities.

This block-by-block checkerboard of border interference concerns, however, points to another benefit of holding separate auctions for different object classes of supplemental downlink spectrum. In particular border markets, certain blocks set aside for supplemental downlink may be subject to more severe interference problems than others. Dividing supplemental downlink blocks into two or more object classes will give bidders greater control over the quality of the spectrum they will obtain in those markets. Specifically, it will allow them to avoid the bid-suppressing exposure risk that they will end up with supplemental downlink spectrum that is largely useless because the block assigned to them (or a nearby block included in the same passband filter) is subject to interference from cross-border television stations. Suppose, for example, a bidder wishes to obtain supplemental downlink spectrum in a metropolitan area that is subject to interference from a Canadian TV station operating in Channel 40. Under AT&T's proposed band plan, the bidder could achieve that objective by bidding only in the auction for spectrum in cleared Channels 33 through 36 and by avoiding the separate auction for spectrum in cleared Channels 38 through 41.

Moreover, creating two or more object classes of supplemental downlink spectrum will allow bidders with regional or nationwide footprints (current or planned) to diversify their spectrum assets so that their customers' handsets can make use of at least one supplemental downlink block in the 600 MHz band even in markets subject to cross-border interference. For example, if a bidder wishes to establish a national footprint with 600 MHz spectrum, it could bid separately for spectrum in each of the separate object-class auctions noted above. If successful in each auction, it could then install separate passband filters in its handsets: say, one that accepts signals between Channels 33 and 36, and one that accepts signals between Channels 38 through 41. When a customer travels to a market where the first passband filter would admit unacceptable interference from a cross-border TV station, the handset could rely on the other passband filter for supplemental downlink capacity. And the reverse would be true when the customer travels to another market where the *second* passband filter would admit unacceptable interference but the first would not.

Of course, no matter how the Commission defines these object classes, the industry-wide standards-setting process will and should continue playing its longstanding role: establishing standards for passband filters, which may or may not accommodate all of the spectrum within a given object class. For example, within an object class defined by the spectrum range between Channels 33 and 36, the process could hypothetically create standards for three passband filters: one that accommodates all signals within that range; a second that passes signals only the lower end of that range; and a third that passes signals only for the higher end. That flexibility may be essential for a carrier that, within a particular market, would otherwise face interference that does not originate from the specific spectrum block the carrier has won and that the carrier could thus exclude by the use of a narrow passband filter.

The NPRM does not propose to supplant this standard-setting process with regulatory mandates for the use of particular filters, and for good reason: that step would be unprecedented and would substantially reduce the projected value of all this spectrum for many bidders. In short, the Commission should *not* micro-manage the process of extracting the most value from 600 MHz spectrum after the auction is over, but it *should* enhance the market's ability to accomplish that objective by structuring this auction in a way that maximizes both (1) bidders' certainty about the value of the assets they are seeking to acquire and (2) their subsequent flexibility to derive the greatest value from assets they do acquire.

B. The Commission Should Facilitate Efficient Package Bidding

Quite apart from any given spectrum block's value in the abstract, the value to a carrier of any particular block of 600 MHz spectrum will vary depending on that carrier's *other* spectrum assets in the 600 MHz band because of the various complementarities discussed below. To increase forward-auction participation and thus the odds of meeting the closing conditions for any given target level of spectrum clearing, the Commission should take the steps needed to allow bidders to express the value of those complementarities. We begin with the issue of geographic package bidding.

Many carriers will wish to invest in 600 MHz technology in a particular geographic area only if they can be assured of having 600 MHz spectrum holdings throughout a larger set of geographic areas, such as their regional or national service footprints. An inability to place all-or-nothing bids for geographic packages would present a classic exposure problem, in which auction participants suppress their bids lest they "win" geographic areas that have limited value to them unless their spectrum holdings in those areas can be combined with similar spectrum holdings in other geographic areas. Both the Commission and the academic literature have confirmed that this exposure risk can reduce spectrum valuations and suppress bidding.[30] That exposure risk would be a concern in any auction, but it presents a particular danger in this one, with its stringent statutory closing conditions. Simply put, if the Commission precludes

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[30] *See* CHK Analysis at 7-8, 23-26; *see generally* Second Report and Order, *Service Rules for the 698-746, 747-762 and 777-792 MHz Bands et al.*, 22 FCC Rcd 15289, 15396-97 ¶¶ 287, 290 (2007) ("[A] bidder whose business plan is premised on realizing economies of scale may need to win a large number of licenses in order to justify the bid that it would make if it could win all of them. The risk of winning less than all the licenses needed to support the amount of the aggregate bid is sometimes known as the 'exposure problem.' . . . [W]e conclude that package bidding with respect to licenses in the Upper 700 MHz Band C Block would serve the public interest by reducing the exposure problem that might otherwise inhibit bidders."); Sang Won Kim *et al.*, *Measuring the Performance of Large-Scale Combinatorial Auctions: A Structural Estimation Approach*, at 1 (June 11, 2012), http://www.columbia.edu/~gyw2105/GYW/GabrielWeintraub_files/PAPER% 20MS120502-post.pdf. ("The main advantage of package bidding is that it allows bidders to express cost synergies in their bids. In contrast, if bidders were allowed only to submit bids for each unit separately they would face the risk of winning some units but not others. This phenomenon, known as the *exposure problem*, makes the bidders less aggressive[.]").

forward-auction participants from expressing the full value of geographic complementarities in their bids, it will substantially increase the risk that the auction will fail.

A concrete example helps illustrate the nature of this exposure problem and the need for a package-bidding solution. Suppose that an auction contains no package-bidding mechanism, but that, because of scale economies, Bidder X can profitably build out a 600 MHz footprint in *some* Northeastern metropolitan areas only if it can deploy 600 MHz technology in *most or all* major Northeastern metropolitan areas. Bidder X may find it unprofitable to invest in 600 MHz handsets and base-station equipment that can be used in Buffalo and Boston but not in New York and Philadelphia. And it will therefore wish to avoid paying substantial sums for 600 MHz licenses in Buffalo and Boston if it does not win licenses in New York and Philadelphia. Depending on how the auction is structured, however, Bidder X may get stuck "winning" such unwanted licenses if it bids separately in all four cities at once. For example, the Buffalo and Boston forward auctions might conclude early and leave Bidder X as a high bidder, while the bidding proceeds to such high levels in New York and Philadelphia that Bidder X can no longer afford to remain in those auctions. Faced with that prospect, Bidder X would have a strong incentive to exit the auction process inefficiently early in order to avoid the risk of paying for spectrum that later turns out to be much less valuable than it would have been as part of a multi-area package.

To minimize this exposure problem and thus encourage forward-auction bidders to express the value of such scale economies, the Commission should follow through on its proposal to permit those bidders to place package bids. Specifically, it should permit "a single, all-or-nothing bid amount that would apply to a group of licenses, such as . . . the same block in multiple geographic areas." NPRM ¶ 62. As the Commission adds, "[p]ackage bidding options generally complicate an auction, although such complexity can be limited if certain restrictions apply to the ways bidders can group licenses." *Id.* One of the Commission's key challenges will be to balance the need to manage complexity against the equally important need to maximize the value of the spectrum being auctioned.

The attached white paper by Professors Che, Haile, and Kearns proposes a detailed package-bidding mechanism for meeting that challenge within the general auction structure the Commission has proposed. *See* CHK Analysis at 14-15, 34-54. Among its other benefits, this proposal—

- will allow bidders to express the substantial value they attribute to geographic packages and horizontal and vertical contiguity;
- will nonetheless avoid introducing significant complexity to the bidding process;
- will not require setting aside spectrum for packages;
- will not require equalized clearing of spectrum on a regional or national basis; and
- will create no advantage for package bidders vis-à-vis bidders for individual EAs.

The first step in designing an efficient package-bidding mechanism is to define the set of allowable packages and how they relate to the elemental geographic building block, which AT&T agrees should be the EA ("Economic Area"). As Professors Che, Haile, and Kearns explain, the Commission should reduce computational complexity by specifying allowable package bids such that each pre-defined package is fully nested within the next-larger pre-defined package in a clear hierarchy. *See* CHK Analysis at 35, 37-39. Such a nested hierarchy is readily available in the established categories of EAs, MEAs ("Major Economic Areas"), and REAs ("Regional Economic Areas"). *See generally* NPRM ¶¶ 145-48. Each EA is fully included in an MEA, and each MEA is fully included in an REA (of which there are six in the continental United States):

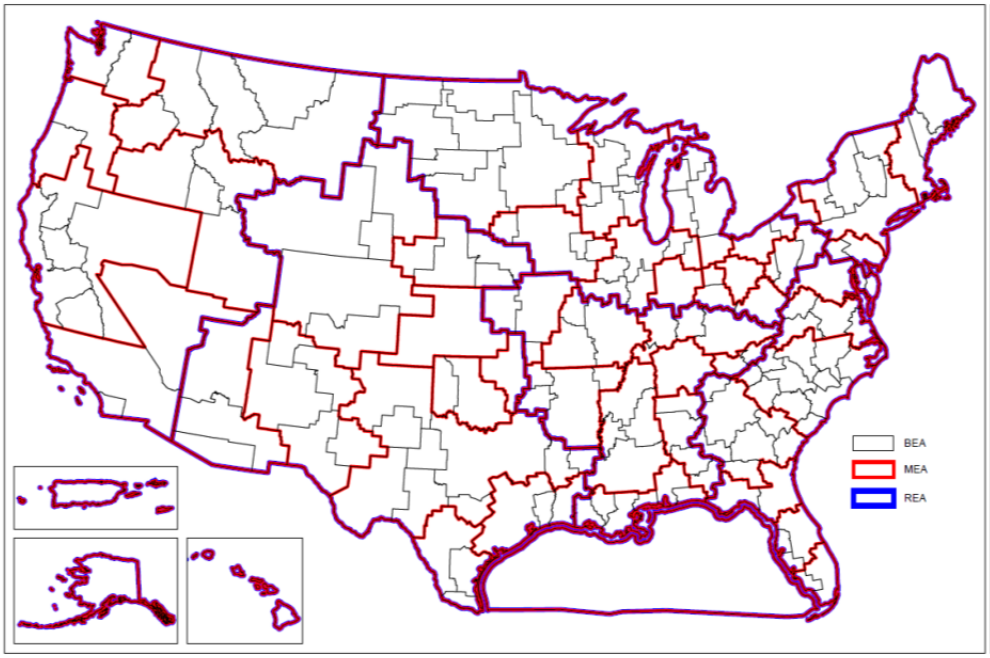

Fig. 7: EAs, MEAs, and REAs

Under the Che/Haile/Kearns proposal, bidders could bid on an EA, on a package consisting of all EAs within an MEA, on a package consisting of all EAs (and thus MEAs) within an REA, or on a package consisting of all EAs (and thus MEAs and REAs) within the United States. But a participant could *not* place a package bid for some subset of multiple EAs within an MEA, for some subset of multiple MEAs within an REA, or for various EAs scattered across the country. *See* CHK Analysis at 36-39 & n.14. For example, a participant could not make its bid for the Los Angeles EA contingent on winning its bid for the New York City EA. This nested hierarchy of permissible packages will help solve the exposure problem for bidders while avoiding the severe computational complexity the Commission would face in picking winners if it simply allowed bidders to define their own, partially overlapping packages.[31]

Under another key feature of the Che/Haile/Kearns proposal, an individual EA and a larger geographic package are presented as separate objects for sale, even when the latter encompasses the former. Thus, if an auction participant bids for spectrum in an EA both on an EA-specific basis and as part of a package containing that EA, any spectrum that it wins in the EA-specific auction is separate from and in addition to any spectrum it wins as part of the package bid. For example, if a bidder successfully bids for a five-megahertz block of spectrum in the Boston EA auction and for a five-megahertz block in the separate auction for the upper-New England MEA (which includes the Boston EA), the bidder will obtain both a five-megahertz block for the entire MEA and an additional five-megahertz block for the Boston EA, for a total of ten megahertz in that EA. Similarly, a package bid for an REA is a separate object from a package bid for a nested MEA, and a package bid for the U.S. is a separate object from a package bid from a nested REA.

The Che/Haile/Kearns proposal further addresses the need to coordinate the ascending-clock bidding for individual EAs with the distinct ascending-clock bidding for various types of packages in order to maximize the total value expressed in the aggregate forward-auction bidding—and thus to meet the closing conditions for the greatest possible spectrum targets. CHK Analysis at 40-54. As a general rule, a package bidder

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[31] *See generally* Public Notice, *Comment Sought on Competitive Bidding Procedures for Auction 901 and Certain Program Requirements*, 27 FCC Rcd 530, 539 ¶ 32 (2012) (proposing to limit the number of package bids based on census blocks because selecting winning bidders "can be difficult . . . with large numbers of partially overlapping package bids").

would win the specified amount of spectrum in all EAs within its geographic package if the total price it offers for the spectrum in that package exceeds the sum of the bids that would otherwise prevail in the absence of that bidder's package bid. To take a highly simplified example, if there is only one five-megahertz block available in each of the EAs within an MEA, a package bidder offering $1 million for that block throughout the MEA could prevail only if (1) no one else offers that much for the same MEA-wide block and (2) the sum of the bids for the individual EAs within that block falls short of $1 million.

The Che/Haile/Kearns proposal fleshes out this mechanism in greater detail in a variety of more complex scenarios, such as those where different amounts of spectrum are available in the various EAs within a package. *See id*. The common denominator is that the proposal neither favors nor disfavors package bidders as compared to bidders for individual EAs. Instead, it picks winners solely on the basis of which combination of bids expresses—and can be presumed to produce—the greatest economic value for consumers. In particular, by enabling bidders to express the substantial complementarities they can achieve through geographic packages, the Che/Haile/Kearns proposal would promote economic efficiency and help maximize the odds of satisfying the closing conditions for a given spectrum-clearing target. It would also satisfy the substance of the Commission's statutory mandate to "consider assigning licenses that cover geographic areas of a variety of different sizes." Spectrum Act § 6403(c)(3).

Finally, the Commission asks whether it should facilitate package bidding not only for licenses across geographic areas, but also for "a group of licenses, such as more than one block in a [single] geographic area." NPRM ¶ 62. In fact, no specific rules are needed for that purpose because the structure of an ascending clock auction already accommodates multi-block package bidding. For example, if a bidder wishes to place an all-or-nothing bid for two blocks of spectrum in a given EA, it need only express its wish to buy two such blocks in response to any price offer below its reserve value for those two blocks—and then exit the auction for both blocks in unison if the price level rises above that value. It will never be stuck "winning" one block but not the other.[32]

C. The Commission Should Enable Bidders to Express the Additional Complementarities Derived from Horizontal and Vertical Spectrum Contiguity

To this point, we have addressed the complementarities that providers can derive from winning rights (1) to *some* 600 MHz spectrum in all EAs within a larger geographic category (whether or not the frequencies it wins are the same from place to place) and (2) to two or more blocks *somewhere* in the same object class of 600 MHz spectrum within a given EA (whether those blocks are adjacent or not). Beyond those threshold complementarities, however, providers can also derive substantial additional value from rights (1) to *the same* frequency blocks from one EA to the next and (2) to *adjacent* frequency blocks within any given EA. The Commission should establish clear assignment rules that increase the likelihood that successful package bidders will realize

[32] That and related features of any clock auction produce a separate challenge, however: scenarios in which isolated blocks of spectrum remain unsold once the ascending clock stops for a given EA. In those scenarios, the Commission should hold out the prospect of supplementary bidding to fill the gaps, perhaps by means of a sealed-bid approach. *See* CHK Analysis at 54-57. To avoid creating perverse incentives to underbid in the main bidding round, the Commission should restrict such supplementary bidding to blocks that no bidder has "won" at the conclusion of the clock auction, and it should also announce beforehand that it will exercise discretion whether to conduct such supplementary bidding in the first place. *See id.* Of course, this supplementary round would still involve generic bidding: bidders would still be seeking rights to *some* spectrum block (or blocks) within a generic category but would not yet know *which* precise block (or blocks) they will ultimately be assigned.

these two additional types of complementarities—and that they will therefore express the value of those complementarities in the main bidding round.

We begin by briefly explaining the technological reasons such contiguity is important. Suppose that Carriers X and Y both operate in adjacent Markets 1 and 2, that Carrier X has A Block spectrum in Market 1 and C Block spectrum in Market 2, and that Carrier Y has just the reverse: C Block spectrum in Market 1 and A Block spectrum in Market 2. Each carrier must limit the field strength of its signals at the boundary to prevent interference with the other carrier's network, whether as a matter of FCC rules or as a result of a negotiated agreement. *See* Reed/Tripathi Analysis at 35-37.[33] The result is often the creation of a "dead zone" at the boundary, where reduced signal levels severely degrade capacity and throughput and cause frequent dropped calls. *Id.* at 35 (discussing dead zone running through the middle of Oklahoma City). The Commission will thus increase the value of spectrum for consumers and bidders alike to the extent its assignment rules yield as much horizontal contiguity as possible. The fewer the boundaries a carrier faces with different co-channel licensees on the other side, the more

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[33] Such agreements can be difficult to negotiate, in part because one party often has less of an incentive than the other to strike a deal. *See* Reed/Tripathi Analysis at 36. Even when the parties can strike an agreement, the result is still a substantially less efficient use of spectrum than the networks could achieve if each held the same spectrum on either side of the boundary. *See id.* Negotiations also would not necessarily lead the carriers in our hypothetical to swap spectrum holdings in order to create greater contiguity. To begin with, in deciding which spectrum swaps to make, each carrier cannot consider one boundary and co-channel neighbor in isolation; throughout its network, it will have many other boundaries and neighbors to take into account as well. Moreover, because co-channel neighbors are often competitors, negotiations could break down whenever one carrier would benefit more from a proposed swap than the other and thus perhaps at the expense of the other.

efficiently the carrier and its customers can exploit its spectrum resources and the fewer coordination negotiations that carrier must try to reach with its co-channel neighbors.

As this discussion suggests, horizontal contiguity is most important for immediately neighboring geographic areas. For example, to avoid co-channel licensee complications, a given carrier would place a high value on uniform spectrum blocks in the heavily traveled corridor between Washington and Boston. It may be less important for a given carrier to have uniform spectrum holdings in non-neighboring areas, such as Los Angeles and New York, unless that non-uniformity would create an otherwise avoidable need for additional passband filters. In general, therefore, the Commission should place a higher premium on ensuring REA-wide contiguity than on nationwide contiguity if the two objectives are in conflict. It should also give priority for these purposes to winning package bidders over auction participants that bid only on individual EAs and happen to win several adjacent ones. A participant that bids only on a non-package basis is signaling that it would not derive the same complementarities from winning multiple neighboring areas as a package bidder would, and it can be fairly presumed to attach less value to horizontal spectrum contiguity as well.

Second, in any given geographic area, even if Blocks A, B, and C are equivalent in all other respects, a bidder seeking multiple blocks within the same band will generally attach value to holding those blocks in the form of *vertically contiguous* spectrum: *i.e.*, neighboring blocks A and B (or B and C) rather than A and C. Although a carrier can use A and C in combination, it will lose spectral efficiencies in the process; all else held equal, the combination of A and C will provide less capacity than the combination of A and B. *See* Reed/Tripathi Analysis at 34-35. An efficient auction design would thus avoid those costs altogether by arranging for winners of multiple blocks to receive vertically contiguous spectrum.

In short, both horizontal (EA-by-EA) and vertical (block-by-block) contiguities present substantial efficiencies. If bidders have a strong expectation of obtaining those efficiencies with a winning package bid, they will express those efficiencies in the form of higher package bids, increasing the odds that the forward auction will meet the auction-closing conditions for a given target level of spectrum.[34] Indeed, the Auctionomics framework already appears to facilitate the assignment of vertically contiguous spectrum within any given EA. *See* CHK Analysis at 26; *see also* NPRM at ¶ 64. But the Commission should also establish, from the outset of the auction, clear rules that maximize a package bidder's expectation of horizontal contiguity as well.[35] In particular, it should show how its assignment process will give priority to carriers that have successfully bid for a larger geographic package of spectrum across multiple EAs because those carriers are the ones that intend to exploit the efficiencies inherent in contiguity. The Che/Haile/Kearns proposal would address this challenge by defining geographic package bids as bids for horizontally contiguous spectrum, and winning

[34] *See generally* NPRM ¶ 63 ("If bidders are allowed to specify packages or other contingencies, the assignment procedures would take those conditions into account in determining a set of best bids that are consistent with our forward auction objective of maximizing the aggregate amount of the bids that we accept for the available licenses.").

[35] *See* NPRM ¶ 64 ("We anticipate that if generic blocks are made available in the forward auction, the assignment procedures would assign contiguous blocks to bidders that bid for multiple blocks in the same geographic area and could take into account the need to coordinate frequencies across adjacent areas.").

package bidders would thus generally obtain such horizontal contiguity. *See* CHK Analysis at 37 & n.12.[36]

Finally, the Commission seeks comment on whether it should create "an additional auction phase to assign specific frequencies for generic licenses, which could be based on accepting additional bids." NPRM ¶ 64; *see also* Auctionomics Proposal at 17-18. Of course, if the Commission first conducts bidding for generic spectrum blocks, it will have to create some mechanism for assigning specific frequencies to the winners of those generic blocks. That will be true even after the Commission makes provision for horizontal and vertical contiguity for package bidders. For example, suppose that there are five spectrum blocks within an object class (A, B, C, D, and E); that Package Bidders X, Y, and Z each win one block apiece within that object class for a given MEA; and that non-package bidders win the remaining blocks within individual EAs. Under the Che/Haile/Kearns proposal, Bidders X, Y, and Z will each be entitled to horizontally contiguous spectrum throughout the MEA by virtue of winning MEA-wide package bids. Yet the Commission must still decide *which particular* block each such bidder will obtain throughout the MEA. It may well be efficient to require X, Y, and Z to bid against one another for any jointly preferred block within this object class.

[36] In the event that the Commission does not provide for package bidding, Professors Che, Haile, and Kearns alternatively propose to improve upon the random-priority regime in the Auctionomics proposal by allowing bidders to rank-order alternative *combinations* of frequency blocks *across different EAs* rather than restricting bidders to rank-ordering alternative frequency blocks in each EA separately. *See* CHK Analysis at 57-62. As they explain, however, either of those approaches would be inferior to package bidding. *Id.* at 57.

That said, if the Commission has defined the object class optimally, so that the class contains only interchangeable blocks of roughly equivalent value, the bidding in this supplemental round should be very low because each bidder will be almost indifferent to which block it obtains. The assignment-phase bidding could be high only if the blocks have substantially different values and bidders have thus artificially reduced their bids in the generic-round bidding to account for the exposure risk of "winning" lower-value blocks. As discussed, that outcome would be highly problematic because the Commission—and auction participants—need to know at the conclusion of the main (generic bidding) round, not much later in any assignment round, whether the closing conditions have been met for a given channel-clearing target.

III. THE COMMISSION SHOULD CONDUCT A SINGLE-PASS REVERSE AUCTION BEFORE ANY FORWARD-AUCTION BIDDING RATHER THAN AN ALTERNATING REVERSE/FORWARD AUCTION FORMAT

A. The Commission Should Avoid the Repeated Delays Endemic to a Repeatedly Alternating Forward/Reverse Framework

The NPRM seeks comment on two design options for the reverse auction: "sealed bid" and "multiple-round descending clock." Under the "sealed bid" approach, "bidders would specify, during a single bidding round, the payment they would be willing to accept in exchange for relinquishing various spectrum usage rights." NPRM ¶ 38. In contrast, under a "multiple round" descending clock auction, "bidders would indicate their willingness to accept iteratively lower payments in exchange for relinquishing rights." *Id.* ¶ 39. The Auctionomics proposal adopts the latter approach and would further limit the reverse auction to determining only how much broadcaster compensation is needed to meet a single spectrum-clearing target at a time. *See* Auctionomics Proposal at 3. In other words, the reverse auction would "ask[] only for the information it needs: no winning bidder [would] reveal[] any information about how low it would have been willing to go." *Id*.

The problem with that aspect of the Auctionomics proposal is that, by statutory design, this auction cannot close, and no spectrum can be reallocated, unless forward-auction revenues exceed (1) the amount the Commission must pay to winning reverse-auction participants plus (2) estimated repacking costs and certain administrative expenses. As the Commission recognizes, that statutory requirement will likely require it to make repeated adjustments to its channel-clearing targets in order to match supply (spectrum freed up by broadcasters at particular prices) with demand (bidders seeking to buy spectrum rights at particular prices). And the Auctionomics approach would thus require the Commission to reconvene broadcasters repeatedly for additional rounds of reverse-auction bidding (each combined with new repacking computations) whenever the forward-auction results fall short of a given statutory revenue benchmark, and those new rounds would in turn interrupt the forward-auction bidding.[37] The likely result would be repeated and prolonged delays, and that prospect would depress auction participation and increase the risk of auction failure.

In their attached white paper, Professors Che, Haile, and Kearns propose a "single-pass" descending clock auction that builds on the Auctionomics approach but

[37] *See* NPRM ¶ 67 ("If the closing conditions are met, the incentive auction process would end. If not, we continue running the forward auction to see if the closing conditions can be met. If the closing conditions cannot be met, another auction stage would be run, this time using a smaller provisional quantity of cleared spectrum and correspondingly smaller number of licenses available in the forward auction. If closing conditions were met at the end of this stage, the process would end. If not, additional stages would be run with the quantity of spectrum sought to be cleared further reduced, until the auction results met them.").

modifies it to avoid these endemic delay problems. Under the single-pass approach, as under the Auctionomics framework, the Commission would begin by announcing a very high bid level designed to reveal what the aggregate revenue requirement would be for the greatest realistically achievable spectrum-clearing target in a given market, taking repacking considerations into account. But the bidding would not stop whenever the descending clock has ticked down to the price level needed to eliminate excess supply for (*i.e.*, just meet) that target. Instead, the clock would continue ticking down to identify the revenue requirements for successively less ambitious channel-clearing targets, each time in conjunction with a repacking analysis. The reverse auction would stop only when the bidding reveals the price needed to clear the smallest number of channels necessary to support a viable mobile wireless band plan—say, seven or eight. In each round, the Commission would also elicit intra-round bidding to identify any intermediate point at which broadcasters would agree to cede just enough spectrum rights to satisfy the channel-clearing target.[38]

The results of this single-pass reverse auction would thus confidentially reveal to the Commission the entire relevant supply curve—*i.e.*, the prices at which broadcasters disclose that they would agree to cede spectrum rights for the range of feasible channel-clearing targets—*before* any forward-auction activity reveals the demand for the spectrum at issue. It would thus enable the Commission, once it begins the forward

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[38] In intra-round bidding, a participant in a descending clock auction submits a sealed bid indicating the specific price between two announced price levels at which it would reduce the supply it offered at the first price level. Suppose, for example, that Station X offers to go off the air at an announced price level of $110, and the Commission announces a new price of $100. If Station X would exit the auction at that price but stay in the bidding at $103, it may disclose that fact to the Commission.

auction, to adjust the spectrum-clearing target as necessary to ensure satisfaction of the statutory auction-closing conditions *without* any need to reconvene the broadcasters and interrupt the forward-auction bidding. Specifically, if the forward-auction bidding falls short of the closing conditions for a given spectrum target, the Commission could immediately resume that bidding for the next-lower target without stopping to call the broadcasters back because it will already know, from the single-pass reverse auction, what the revenue requirements are for that lower target. The single-pass approach would thereby avoid the repeated, unpredictable, and potentially lengthy delays endemic to the Auctionomics approach.[39] It would also avoid a potential bid-distorting dynamic in the reverse auction by ensuring that all binding bids of winning broadcasters will be made in the same bidding session, on the basis of the same basic market information, rather than many weeks apart and on the basis of changed market information, as could happen under the Auctionomics proposal. *See* CHK Analysis at 72-73.

The NPRM suggests that the Auctionomics proposal's narrow focus on identifying the revenue requirements for only one channel-clearing target at a time may be a virtue, in that broadcasters might prefer to avoid "determin[ing] an exact bid at the beginning of an auction." NPRM ¶ 40. But under *any* reverse-auction format, broadcasters would have to expect that, within a constrained time period, they might well need to make multiple offers to cede their spectrum rights at successively lower price

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[39] As discussed in Section IV below, a single-pass approach would also (and for similar reasons) give the Commission the supply-side information it will need to maximize the odds of closing any revenue gap for a given clearing target by determining how much lower the existing reverse-auction winners would go in their compensation demands after *excess* supply is eliminated for that target but before *sufficient* supply is eliminated.

levels, either because excess supply remains or because the auction-closing conditions have not yet been met. That expectation would lead most broadcasters to make at least rough station-value determinations at the outset of bidding, no matter what the auction format is. In short, the single-pass approach would not appear to place any major new burden on broadcasters that they would not already face under any other approach to the reverse auction, including the Auctionomics proposal.

Of course, under the single-pass format proposed here, broadcasters will likely give the Commission a greater amount of confidential information in the aggregate than would be necessary under the Auctionomics proposal (depending again on how many rounds of bidding they would ultimately need to participate in under the Auctionomics proposal before excess supply is eliminated and the auction-closing conditions are satisfied). As an initial matter, that should be a concern to them only if they have some reasonable basis to fear that their confidential information will be leaked to third parties. The Commission can effectively address that concern by adopting strong protections against the disclosure of confidential data, as it has successfully done in many other contexts. In any event, a broadcaster *that ultimately keeps its license* would generally reveal no additional confidential information under the single-pass approach than under the Auctionomics approach. In general, the only broadcasters that will confidentially reveal to the Commission "unnecessary" price information—how low they would have gone beyond the compensation level needed to meet the prevailing channel-clearing target—are broadcasters that will win the reverse auction and will cede their licenses. *Those* broadcasters should have only attenuated confidentiality concerns.

B. Depending on the Tractability and Comparative Efficiency of Different Repacking Algorithms, the Commission Should Consider Modifying the Single-Pass Framework to Include a Proxy-Bidding Component

Like the Auctionomics proposal, the basic single-pass approach just discussed would entail a *sequential* repacking analysis in conjunction with each round of the reverse auction. Each round of bidding for a given channel-clearing target would produce basic decisions about which stations are subject to repacking and which will be "frozen" (excused from further bidding because they cannot be feasibly repacked), and those decisions would then have preclusive consequences for subsequent repacking analysis under progressively less ambitious channel-clearing targets.[40] For example, if Station X is slated for repacking at one spectrum-clearing target, it will also be slated for repacking at all subsequent targets (albeit potentially in a different channel location). The difference between the two proposals is that the single-pass framework would complete this sequential repacking analysis for all spectrum-clearing targets before any forward-auction bidding begins.

Under *either* proposal, however, this sequential approach to repacking is appropriate only if two conditions hold. First, the Commission must determine that it will be computationally feasible to conduct the repacking analysis in real time, while broadcasters wait to bid on new price levels from the descending clock. It is not yet clear that it will be. As Professors Che, Haile, and Kearns explain, the sequential "feasibility checking" procedure outlined in the Auctionomics proposal "takes the form of a 'graph coloring problem,' which is known to be computationally hard in the worst case," and

[40] *See* NPRM ¶ 46 (discussing "sequential algorithm approach"); *see also* Auctionomics Proposal at 10-11; CHK Analysis at 10-12, 80-83.

“[w]ithout knowing the fine details of repacking constraints, it is impossible to determine whether the feasibility checking required by the [Auctionomics] proposal is itself computationally feasible.” CHK Analysis at 76.

Second, the Commission must also determine that its sequential repacking algorithm will not produce radically less efficient repacking outcomes than would result from a feasible *non*-sequential repacking analysis—*i.e.*, an analysis that could identify an optimal (or close-to-optimal) repacking solution for any given channel-clearing target, *without* taking as given any repacking choices made in prior rounds. This second condition is as important as the first. The more efficiently the Commission can repack stations, the more stations it will be able to repack, the less it will need to compensate the remaining stations for ceding spectrum rights—and thus the more likely it will be that the Commission can meet the statutory closing conditions for a given channel-clearing target.[41] The Commission should therefore place a high premium on any mechanism that is needed to optimize the efficiency of the repacking process because that mechanism will be critical to freeing up the most new spectrum for mobile broadband uses. And it is not yet clear that a computationally feasible sequential algorithm is available that could avoid substantial losses in repacking efficiency as compared to a non-sequential approach. *See* CHK Analysis at 75-76, 83-86.

If either of these conditions *fails* to hold—*i.e.*, if the Commission determines either that an efficient repacking analysis is infeasible to compute in real time or that any

[41] Of course, the Commission must factor “the estimated costs” of repacking into the equation for determining whether the closing conditions are met, *see* Spectrum Act § 6403(c)(2)(B)(iii), but the cost of repacking a given station is likely to be far lower than the cost of paying that station to cede spectrum rights.

feasible sequential approach would produce unacceptably suboptimal repacking outcomes—the Commission should consider modifying the single-pass framework to include proxy bidding. Under that approach, broadcasters would confidentially tell the Commission their reserve prices (the lowest prices at which they would cede given spectrum rights), and a computer algorithm would then bid for them. That algorithm would select winners on the basis of their comparative bids and would assign them compensation on the basis of what, in a descending clock auction (with infinitesimal decrements), the price level *would* be at the point where excess supply is eliminated—a level that might well substantially exceed the winners' reserve prices.[42] This approach would avoid the need for the Commission to engage in the repacking analysis in between each round, would therefore allow the Commission to complete the single-pass reverse auction quickly, and might well yield more optimal repacking solutions than a sequential algorithm would permit.

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[42] The pricing rule under this approach would produce exactly the same results as a conventional descending-clock auction where broadcasters reveal their reserve prices only where when the clock ticks down to them. Consider the example of a conventional reverse auction where, at the original price of $110, the Commission needs to induce only one broadcaster to exit the auction in order to eliminate excess supply (*i.e.*, too many stations vying for compensation to vacate channels needed for a given channel-clearing target). Suppose that Stations X and Y both exit at the next announced price level ($100); that Station X submits an intraround bid stating that $103 is the lowest price it would have accepted to go off the air; and that Station Y submits its own intraround bid stating that $107 is the lowest price *it* would have accepted. Under this scenario, Station X wins the auction and will be compensated at the level of Station Y's intra-round bid ($107), which is also the point at which Station X would have won if the descending clock auction had proceeded in infinitesimal decrements rather than $10 decrements. This result is equivalent to a single-pass proxy auction with threshold pricing, which "would pay a winning bidder the highest amount it could have bid and still have had its bid accepted." NPRM ¶ 51.

IV. THE COMMISSION SHOULD CLOSE ANY REVENUE GAP FOR A GIVEN CLEARING TARGET BY CONTINUING BOTH THE FORWARD AND THE REVERSE AUCTIONS ONCE EXCESS SUPPLY AND EXCESS DEMAND ARE ELIMINATED

The NPRM anticipates that, for any given channel-clearing target, bidding in the reverse auction will stop when excess supply is eliminated, and bidding in the forward auction will stop when excess demand is eliminated. The NPRM then provides that, "[i]f the closing conditions are met, the incentive auction process would end. If not, we continue running *the forward auction* to see if the closing conditions can be met." ¶ 67 (emphasis added). In fact, the Commission should look to additional bidding in *both* the forward auction *and* the reverse auction in these circumstances to maximize the odds of meeting the closing conditions for a given channel-clearing target rather than settling for some lesser target. This point is subtle but important and warrants some brief background on the mechanics of clock auctions.[43]

For any channel-clearing target, a descending clock auction stops when just enough broadcasters say "no" to a particular price level (and thus drop out of the auction) that there is no longer excess supply to meet that target. Critically, however, that price level may substantially exceed the reserve valuations of the still-participating broadcasters to cede the necessary spectrum rights. To take a simplified example, suppose that the Commission sets a spectrum-clearing target of eleven stations in a given market; fourteen stations offer to go off the air at $150 apiece; and successive $5

[43] The advantage discussed in this section is similar to but distinct from the advantage discussed in the previous section. The issue here addresses efficient mechanisms for trying to *maintain* an ambitious channel-clearing target even after initial bidding reveals a gap between the revenue requirement and the forward-auction bidding. The prior section addressed efficient mechanisms for promptly moving from one channel-clearing target to the next once it is determined that the revenue condition for the first target *cannot* be met.

reductions in the price level bring the number of still-participating stations down to the desired eleven at a price of $100 apiece.[44] Again, under the Auctionomics proposal, the reverse auction must stop there because it is designed to "ask[] only for the information it needs: no winning bidder reveals any information about how low it would have been willing to go." Auctionomics Proposal at 3.

That approach, however, would reduce the odds of meeting the auction-closing conditions for any given spectrum-clearing target because, in effect, the reverse auction would stop too soon. And that outcome would harm not only consumers (by consigning them to less mobile broadband spectrum), but also broadcasters and forward-auction bidders (by depriving them of economically beneficial opportunities). *See* CHK Analysis at 96-97. In our hypothetical, suppose that the revenue generated in the forward auction falls just short of what is needed to meet the closing conditions for clearing the channels for the eleven "winning" stations at $100 apiece. It is entirely possible that those same eleven stations still would have agreed to go off the air at $95 or even $90. If so, the Commission could meet the statutory closing conditions for clearing eleven channels simply by accepting those lower compensation offers, and consumers would benefit from the reallocation of those eleven channels to mobile broadband uses. Under the Auctionomics proposal, however, the Commission would not know that the eleven stations would have vacated their channels at $95 or $90 because it never would have

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[44] This example is simplified in the sense that any determination of whether the statutory closing conditions have been met is inherently national in scope. *See* Spectrum Act § 6403(c)(2). The relevant revenue requirement is thus set by reverse-auction participants nationwide, not in any particular market. In future submissions, AT&T will address how the national character of this closing requirement may affect the optimal strategy for assigning different spectrum-clearing targets to different local markets, depending on the initial outcomes of the reverse and forward auctions.

asked them. Thus, unless it could extract enough extra revenue from the forward auction to close the entire gap, it would have to move immediately to a less ambitious channel-clearing target.

The Auctionomics proposal recognizes that a similar dynamic could arise on the forward-auction side, but it offers a fix: additional bidding. Auctionomics Proposal at 16-17. Suppose, for example, that the Commission solicits bids in a forward auction for a clearing target of eleven channels, and excess demand for that amount of spectrum disappears once the ascending clock auction reaches price level X, which is just below the amount needed to meet the statutory revenue requirement. In contrast to its approach for the reverse auction, the Auctionomics proposal does not call for the Commission in those circumstances to re-run the forward and reverse auctions at a reduced channel-clearing target. Instead, it calls for additional bidding at higher price levels in the forward auction to see if the auction-closing conditions can still be met *for the same channel-clearing target*. *Id.*; *accord* NPRM ¶ 67. And those conditions might indeed be met, and more spectrum would be freed up, if the remaining forward-auction bidders all value the spectrum at a price somewhat higher than X.

That mechanism is entirely appropriate, but it should be supplemented by a parallel mechanism on the reverse-auction side. If, for a given channel-clearing target, a gap remains between revenue requirements and revenue results after the reverse auction has eliminated excess supply and the forward auction has eliminated excess demand, the Commission should try to close the gap through additional bidding *on both sides* (while taking various steps to help prevent overshooting). *See* CHK Analysis at 97-102. In particular, the Commission should test whether there are incrementally lower prices at which the same broadcasters would agree to cede the same spectrum rights. In contrast, if the Commission tried to close the gap *only* through additional forward-auction bidding, it would substantially reduce the odds of success in meeting the statutory closing conditions for that spectrum-clearing target, and it would therefore increase the risk of settling for less cleared spectrum than is achievable.

These considerations underscore yet another reason for conducting a single-pass reverse auction. By revealing the entire relevant supply curve, the single-pass approach, unlike the Auctionomics approach, would give the Commission in advance the information it may need to close the gap between revenue requirements and revenue results without compromising on the amount of spectrum it frees up.[45]

V. THE COMMISSION SHOULD MINIMIZE CONSTRAINTS ON EFFICIENT REPACKING

The repacking analysis is as critical to the success of this proceeding as it is formidably complex. Because repacking is "part of the process for determining which broadcaster bids will be accepted" (NPRM ¶ 43), it will determine how much spectrum is available in the forward auction.[46] Done flexibly and well, repacking will free up more capacity for mobile broadband while protecting the interests of households that still rely

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45 To be sure, the Commission could obtain that information by slightly modifying the Auctionomics proposal to require, for each channel-clearing target, additional reverse-auction bidding at successively lower price levels until the number of channels cleared would fall *below* that target. In other words, whereas the Auctionomics approach would stop the reverse-auction bidding whenever *excess* supply is eliminated, this slight modification would continue that bidding down to the price level at which supply is no longer *sufficient*. As under the single-pass approach, the Commission would then know, for example, that the next-lower price decrement (or some point in between) presents the lowest possible revenue requirement for any given clearing target. Although preferable to the unmodified Auctionomics approach, however, this modified version would still be inferior to a single-pass approach for the reasons identified in the previous section.

46 *See also* NPRM ¶ 5 ("[T]he amount of spectrum available in the forward auction will depend on reverse auction bids and repacking[.]").

on over-the-air signals for television viewing. Done poorly, repacking would free up less spectrum, impose greater demands on the reverse auction to induce more broadcasters to go off the air altogether, and impose commensurately greater demands on the *forward* auction to produce the extra revenues needed to compensate those extra market-vacating broadcasters. In short, inefficient repacking could dramatically increase the risk of auction failure. That risk presents a compelling reason for the Commission to avoid placing any undue constraints on the repacking process.

Although AT&T will address repacking issues in greater detail in future submissions, it wishes to stress the following points up front. *First*, the Commission should avoid undue geographic constraints on its repacking discretion and should thus assess repacking options from a nationwide rather than local perspective. One key challenge will be to account for the interdependence of television frequency assignments in neighboring metropolitan areas. Television stations are currently licensed with very large "co-channel separations." This means, for example, that a channel licensed to a broadcaster in New York City cannot be licensed to another broadcaster in Bridgeport, Connecticut, and vice versa. As a result, a broadcaster that "goes dark" in Bridgeport may free up spectrum not only there but also in New York. As the attached Che/Haile/Kearns white paper explains, the Commission should use a repacking algorithm that takes these "daisy-chain" effects into account and assesses efficient repacking solutions across very wide geographic regions. That holistic approach will be particularly critical in the Northeast, where such effects are most prevalent and complex, but it may well be important elsewhere as well.

Of course, the potentially national scope of this repacking analysis will instill a potentially national dimension into the reverse auction itself. On one level, broadcasters seeking compensation for ceding spectrum rights will obviously be competing against broadcasters in the same market with similar signal contours. But on a separate level, *groups* of broadcasters will also effectively be competing against other groups of broadcasters region-wide and potentially nationwide. Within the limits of algorithmic feasibility, the Commission's optimization analysis will require taking long-distance daisy-chain relationships into full account. *See* CHK Analysis at 67-68, 77-78.

Second, the Commission should also avoid reading into the operative legislation any unnecessary *legal* constraints on efficient repacking. The Spectrum Act directs that, "[f]or purposes of making available spectrum to carry out the forward auction," the Commission may "make such reassignments of television stations that the Commission considers appropriate." Spectrum Act § 6403(b)(1), (b)(1)(B)(i). This broad authority to repack stations as the Commission "considers appropriate" is limited by a single directive: the Commission must "make all *reasonable efforts* to preserve, as of the date of the enactment of this Act, the coverage area and population served of each broadcast television licensee, as determined using the methodology described in OET Bulletin 69 of the Office of Engineering and Technology of the Commission." *Id.* § 6403(b)(2) (emphasis added).

As the Commission recognizes, the "reasonable efforts" standard gives it great flexibility to perform repacking in light of the overarching goals of the Spectrum Act. In the Commission's words, "[w]hile the statute does not define the term 'all reasonable efforts,' that phrase is not uncommon: its meaning depends on the circumstances involved, and comports with the common meaning of the word 'reasonable,'" which includes "[f]it and appropriate to the end in view."[47] When Congress instructs an agency to take "reasonable" steps to accomplish any goal, it grants the agency considerable discretion to apply that term to suit the circumstances, and courts will grant the agency "substantial deference" when it does so.[48] Here, the overwhelming objective of the Spectrum Act is to reallocate more spectrum for mobile broadband purposes, and Chairman Genachowski has underscored that the Commission's first goal should be to "maximize[e] the amount of spectrum freed up."[49] Against that backdrop, it is hardly *unreasonable* for the Commission to repack spectrum as efficiently as possible to free up the most spectrum for mobile broadband.

Third, the Commission should try to structure the repacking process to distinguish between TV stations that currently transmit above 50 kW (up to the maximum of 1 MW) and those that operate at 50 kW or below. As discussed in Section II, the latter stations pose far fewer interference challenges to mobile broadband operations than higher-power stations do. In the repacking process, therefore, the Commission should assign those stations to channels that are adjacent to guard bands protecting mobile broadband downlink spectrum. Choosing such reduced-power stations for those locations will enable the Commission to limit the size of those guard bands to six megahertz (in

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47 NPRM ¶ 105 (citing, *inter alia*, Black's Law Dictionary 1265 (6th ed. 1990)) (footnotes omitted).

48 *Capital Network Sys., Inc. v. FCC*, 28 F.3d 201, 204 (D.C. Cir. 1994). Indeed, the Supreme Court has said that the same phrase used in the Spectrum Act—"reasonable efforts"—is a directive that, when no further statutory guidance is found, will "obviously vary with the circumstances," and confers significant flexibility on the administrative decisionmaker. *See Suter v. Artist M.*, 503 U.S. 347, 360 (1992).

49 *See* NPRM (statement of Chairman Genachowski).

contrast to the much wider guard bands that would be needed for higher-power stations) and, in turn, will allow the Commission to maximize the amount of spectrum that it can reallocate to mobile broadband uses.[50]

Fourth, the Commission should provide as much advance information as possible about how it will structure the repacking process to maximize the value of the spectrum reallocated to mobile broadband uses. Only then can it ensure that forward-auction participants will express that increased value in their bids. The Commission should thus establish clear repacking algorithms up front and make them fully available to the public. Greater insight into the repacking process will also help broadcasters make fully informed choices about participation in the reverse auction. For example, the more information a broadcaster has about the location of repacked channels, the better able it will be to make an educated decision about whether to cede spectrum altogether or, alternatively, to enter into a channel-sharing arrangement with another station.

Finally, the Commission should establish a clear and expeditious timetable for the repacking process once the auction is complete. There is generally no need for a lengthy delay before broadcasters who remain on air must switch channels. The Commission has noted that, "of the more than 100 licensees whose requests to substitute channels were granted towards the end of the digital transition, most completed construction within 12 months of receiving a construction permit." NPRM ¶ 322. Establishing a much

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[50] To the extent possible, the Commission should also consider minimizing co-channel interference by assigning additional reduced-power stations to the frequency blocks that are cleared in some markets but not others. For example, if Channel 42 is reallocated to mobile broadband uses in City X but not nearby City Y, the cleared mobile broadband spectrum in City X will face far less interference if the co-channel television licensee in City Y is broadcasting at 50 kW rather than 1 MW.

lengthier transition would also depress forward-auction participation: bidders would substantially discount their bids to reflect the risk of lengthy delays in their ability to make actual use of 600 MHz spectrum.

VI. TO REDUCE THE RISK OF AUCTION FAILURE, THE COMMISSION SHOULD NOT CONSTRAIN THE PARTICIPATION OF PARTICULAR CARRIERS IN THE FORWARD AUCTION

As AT&T has explained elsewhere, the Commission should reject proposals to impose *ex ante* limits on the spectrum that particular carriers can obtain through this auction.[51] In brief, if a winning bidder's acquisition of new spectrum would bring its total holdings in a market to a level that is determined to threaten competition, that licensee should be free to choose which spectrum it will divest to remedy the anticompetitive harm. *See* NPRM ¶ 384. Such flexibility will allow a licensee to achieve efficiencies by rationalizing its spectrum holdings, and it will create no risk to competition. In contrast, if the Commission adopted rules that would limit the participation of well-capitalized market actors in this auction, it would sabotage forward-auction competition and undermine prospects for obtaining the bid levels needed to meet the statutory closing conditions for any given channel-clearing target.

Such competition-suppressing rules would thus thwart the Commission's central statutory mission. This is a once-per-decade opportunity to create immense consumer value by repurposing spectrum for bandwidth-constrained mobile broadband services, and the more spectrum the Commission can unleash for that purpose, the greater the consumer benefit will be in the form of increased capacity and lower prices per unit of

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[51] *See* Comments of AT&T Inc., *Policies Regarding Mobile Spectrum Holdings*, WT Docket No. 12-269, at 11-12, 59 (Nov. 28, 2012); *see also id.*, Attach. A at ¶¶ 67-69 (Declaration of Mark Israel and Michael Katz).

capacity. It is difficult to imagine a policy more inimical to that objective, and more likely to trigger outright auction failure, than unnecessary regulatory constraints on forward-auction participation.

The NPRM acknowledges that, "under current spectrum aggregation policies, the Commission would apply its spectrum screen and undertake its competitive analysis only after the auction." *Id.* But it suggests that this practice is somehow in tension with the need "to have certainty for bidders in this auction." *Id.* This concern is difficult to understand. Certainty is "of particular importance" (*id.*) here insofar as it will reduce bid-suppressing exposure risks and thereby increase revenue-generating participation, which in turn will increase the spectrum that can be reallocated to mobile broadband. Against that backdrop, it makes little sense to invoke "certainty" as a rationale for taking steps that are guaranteed by definition to *reduce* revenue-generating participation and threaten to *slash* the amount of spectrum that can be unleashed for the benefit of mobile broadband consumers. Instead, any "certainty" rationale for *ex ante* restrictions on auction participation would have to rest on a false premise: that if the Commission decides after the auction that a winner now has "too much" spectrum, the Commission would have no alternative but to withhold 600 MHz licenses from that winner. Again, however, the Commission could avoid any such uncertainty by allowing the winner to divest *other* spectrum holdings to bring its overall holdings below any cap. That approach would accommodate certainty concerns while allowing for more efficient spectrum allocation and increasing the odds of auction success.

CONCLUSION

The Commission should take the steps outlined in these comments to derive the greatest value from the 600 MHz band and ensure that as much of it as possible is reallocated to mobile broadband uses.

Respectfully submitted,

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