

**RECLAIMING SPECTRUM FROM INCUMBENTS  
IN INEFFICIENTLY ALLOCATED BANDS:  
TRANSACTION COSTS, COMPETITION, AND FLEXIBILITY**

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# Reclaiming Spectrum from Incumbents in Inefficiently Allocated Bands: Transaction Costs, Competition, and Flexibility

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## Abstract

Unlocking spectrum from inefficient, inflexible uses assigned mostly prior to the 1990s to a more efficient, flexible-use model is a key challenge for the Federal Communications Commission. This paper focuses on transitions of spectrum use and looks at how the FCC attempted to minimize transaction and holdout costs while also facilitating competition among service providers. The FCC's recent Broadcast Incentive Auction provides a case study to examine tradeoffs between centralized mechanisms and "overlay" auctions.

The FCC experiences with overlays and more interventionist approaches leads to a set of five questions to help decide when to use simple overlays and when to add more rules to facilitate spectrum repurposing. When the FCC can facilitate repurposing through reducing hold up issues and providing alternatives for incumbents that decentralized private parties would find harder to effectuate, it may be appropriate for the FCC to step in. In other instances overlays may be better.

Keywords: Auctions, Telecommunications, Competition

## I. Introduction

Unlocking spectrum from inefficient, inflexible uses assigned mostly prior to the 1990s to a more efficient, flexible-use model is a key challenge for the Federal Communications Commission ("FCC" or "Commission") to help advance wireless services. The process, however, is not simple, in no small part because even where spectrum is used inefficiently, incumbent users and uses present obstacles to transition.

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This paper develops lessons from selected instances over the past 25 years where the FCC repurposed spectrum to more efficient use. It centers on how the FCC attempted to minimize transaction and holdout costs while also facilitating competition among service providers. We focus on licensed spectrum transitions and leaves aside considerations about the transition to or from unlicensed use, finally, we use as a prime example the FCC's 2016 Broadcast Incentive Auction.

The FCC is in charge of the non-Federal use of the electromagnetic spectrum or radio waves. Congress gave the Commission a mushy mandate for its role in spectrum policy – to manage the spectrum in “the public interest” (Brotman, 2017). Economists usually translate that to be having the spectrum used efficiently (in an economic, not necessarily technical sense).

Spectrum is an input to communication services just like radios, antennas, etc. As a result, the FCC should ensure two factors for the spectrum resource to be used efficiently: that the markets for wireless services are as competitive as possible (including consideration of economies of scale) and that its spectrum decisions account for externalities such as interference to other spectrum users.

Most spectrum rights were allocated prior to the 1990s, in a regime where spectrum use rights were not comprehensive in either geography or technology. So, for example, multiple users could be licensed to use the same spectrum covering the same area (e.g. crisscrossing microwave links or satellites broadcasting to terrestrial earth stations from different orbital slots). At the same time, Commission rules restricted some licensees to certain technologies (e.g. broadcast television or satellite signals) in each spectrum band. Converting these various spectrum rights into a coherent, comprehensive set of rights has not been straightforward or rapid, although the FCC has made progress in some bands (Rosston, 2014).

Since 1994, the FCC has generally pushed toward more comprehensive rights both geographically and technologically, especially in bands suitable for mobile use. It has moved away from site-specific licenses to more area-wide licenses. In addition, on the technology side, it has adopted more flexible use rules for both licensed and unlicensed spectrum bands so they can more easily adopt new technology (Rosston, 2003). Flexible-use licenses allow spectrum users to pursue business plans and bear the risks (positive and negative) from their investments and business decisions.<sup>1</sup> When customer tastes, technology, or other factors change, spectrum users can adapt to increase the value of their service and increase their returns subject to protection of other spectrum users' rights.

Despite initiating a move to flexible use for new spectrum licensees in the 1990s, there is still more spectrum that could be transitioned to a flexible regime. As a result of past allocations that are no longer efficient, lack of flexibility, and presence of transaction costs, the airwaves today still hold potential capacity that is not yet exploited.

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<sup>1</sup> We use the term “flexible-use license” to mean that licensees have the ability to choose technology, transmission sites, power, services, business models, and other factors within the bounds of, for example, out-of-band emissions, power limits, or geographic boundaries.

There are questions about how much the FCC should be involved in the marketplace for spectrum services and also about how much the FCC should be involved in transitions from one set of uses to another. Much has been written about rules and regulations for flexible-use licenses (*See De Vany et al, 1969 for an early example*), but much less about the nuts and bolts of a transition to flexibility. The presence of incumbent users means that transitions matter because economic and political forces can reduce the consumer benefits of a transition (Friedman, 2000).

Simply declaring all current rights to be flexible immediately would not necessarily lead to efficient or most socially optimal allocations in the short or even medium run for a variety of reasons, including interference concerns, transaction costs, and competition issues.

The FCC's recent Broadcast Incentive Auction (or 600 MHz auction, Auctions 1001 and 1002) provides a case study in implementing a novel and complex behind-the-scenes procedure. We examine the tradeoffs of this complex mechanism in comparison to a simpler and straightforward "overlay" auction.<sup>2</sup> In an overlay auction, incumbent licensees would retain their transmission and protection rights so long as they continued to fulfill their pre-existing license obligations. The "overlay" licensee would have all other rights for the spectrum (for unlicensed territory and unlicensed frequencies) and secondary rights for the use of the occupied channels. This yields the entrant (with its overlay license) and incumbents the ability to negotiate bargains that coordinate new uses in the band. For example, a new overlay licensee might pay an incumbent licensee to cease transmissions and relinquish its rights. We find that an overlay auction, while simpler initially, would have required thousands more negotiations, could have suffered from large holdout costs, and, because of the necessary larger frequency blocks, would not have been able to have the same competitive safeguards the FCC implemented.

The FCC's transition of spectrum in the 3.7 – 4.2 GHz band from satellite use to terrestrial use provides a case study of how to deal with complicated issues including compensation when multiple parties have the ability to block a transition.

The FCC experiences with overlays and more interventionist approaches leads to a set of five questions to help decide when to use simple overlays and when to add more rules to facilitate spectrum repurposing:

*How much of the band is encumbered?*

*How easy is it for the new users to "avoid" incumbents who do not want to move?*

*Is there some other way for incumbents to provide their service?*

*How valuable is the incumbent service?*

*How important are competitive considerations in that specific spectrum band?*

When the FCC can facilitate repurposing through reducing hold up issues and providing alternatives for incumbents that decentralized private parties would find harder to effectuate, it may be appropriate for the FCC to step in and set forth rules for a transition. In other instances,

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<sup>2</sup> Overlay auctions can also have different formats and features to account for incumbency. For example, the 39 GHz auction gave incumbents the ability to exchange their licenses for vouchers to be used in the auction.

such as when replacement facilities are difficult to obtain, or it is not as clear about the relative values of an incumbent service and a more flexible license, overlays may be better.

Section II provides an overview of four potential policy choices that the FCC has used when it has attempted to transition spectrum from current to a new, higher-value use. Section III provides a historical perspective on how some of the transitions have worked. Section IV provides an extensive analysis of the choices and impacts of the transition in the 600 MHz Incentive Auction. Section V highlights some of the choices in the C-band auction scheduled for late 2020. Section VII proposes lessons for future transitions based on the answers to five questions that will differ depending on the existing conditions for the bands at issue. Section VIII provides conclusions.

## II. Four policy choices

The FCC has four major policy avenues it can and has followed to (re)allocate spectrum consistently with its goal of efficient spectrum use: command and control (direct incumbents to move to some other spectrum or outright abolish existing license rights), expansion of license rights, overlay auctions, and two-sided auctions. No single solution will always be the right one because past FCC decisions, the characteristics of spectrum propagation, and how the spectrum is used may affect the transition path and therefore the most efficient mechanism. Additionally, these options are not necessarily mutually exclusive. The best response may be to combine aspects of multiple options.

1. Command and control: mandating that a user cease operation in a given band and move to another band or cease operations overall. This approach is most useful when agents do not respond to market incentives. For example, government agencies are much less sensitive to market incentives and may well not be using spectrum efficiently. Forcing government users to vacate spectrum in favor of more efficient users may therefore be the right answer but determining how to effectuate such a change may be difficult politically. Command and control outside of government spectrum transfers to public use has not generally been used by itself since spectrum auctions were introduced in the 1990s, although it remains an aspect of some auctions (see our discussion of the PCS auction and the Broadcast Incentive Auction).

Abolishing existing rights is a special case of command and control where the licensee does not get protected from change. In other countries, such changes have been part of the licensing apparatus as licenses are for a fixed term and then re-assigned or re-acted. In the U.S., licenses generally have an “expectancy of renewal” so that licensees, while not having a legal “property right,” have similar rights. One benefit of the longer life of “expectancy” rights is that licensees then have the incentive to invest in complementary assets such as networks whereas the threat of losing their licenses might cause them to reduce or cease investment near the end of the license term (Kwerel and Felker, 1985).

2. Expansion of existing rights. In some cases, the Commission has expanded rights for existing spectrum holders. For example, the initial cellular licenses awarded in the mid-1980s required implementation of Advanced Mobile Phone Service Technology, the

initial analog cellular mobile standard. Subsequently, the Commission relaxed this restriction and allowed the introduction of digital technologies (Rosston, 1994).

3. Overlay auctions: rely on market participants to negotiate solutions to free the spectrum for a new licensee to fully use the spectrum.
4. Two-sided auctions: create a centralized marketplace with the FCC serving as market-maker. In addition, the FCC can use tools like mandatory relocation to alternative spectrum that may not be available to private market participants (see discussion below of the 600 MHz auction for an example).

Both market-based approaches appear to have worked well, albeit possibly because the choice of when to use them was endogenous – the FCC likely picked what it thought would work well based on market characteristics and existing statutory and regulatory regimes for those spectrum bands and services.

### III. Overlay License Auctions: PCS, SMR, and 700 MHz

The FCC used overlay licenses in the Personal Communications Services (PCS) and Specialized Mobile Radio (SMR) bands even though it did not directly call the licenses “overlays” (FCC, 1994; FCC, 1995; FCC, 1997; FCC, 2002b). The winners of the licenses bought the right to all of the white space in the spectrum and then the right to negotiate with the incumbent licensees with the obligation to continue to protect them from harmful interference due to adjacent transmissions. The rights and obligations differed in each band and are discussed below.

#### a. PCS

The FCC auctioned PCS licenses starting in 1994 (FCC, 1994). PCS licenses were flexible and covered geographic areas rather than specific sites. The incumbent microwave licensees in these bands had three years to vacate the bands and were to be compensated for their costs to move. They could negotiate for more compensation for vacating the spectrum earlier. Incumbents could move to another microwave band, such as the 6 GHz band, with sufficient capacity to absorb the relocated licensees, they could use a fiber alternative, or they could cease transmission.

A complication was that the FCC wanted multiple PCS providers in each geographic area to ensure a competitive post-auction market structure but having more licensees meant that clearing the incumbents often benefitted multiple parties with licenses covering adjacent spectrum and/or geography. As a result, PCS licensees needed to reach agreements for sharing relocation costs when the new licensees might have had different needs and preferences. The FCC established a fund for cost sharing that ended up working well, but not perfectly, with disputes about cost, payment for premiums, and timing (Cramton et al., 1998).

#### b. SMR

SMR in the 800 MHz and 900 MHz bands was different from PCS. From 1987 through 1997, Nextel bought the vast majority of SMR site-specific licenses in the country (particularly the valuable ones). The 800 and 900 MHz SMR frequencies were interspersed with a variety of other private radio uses including public safety. Nextel and Motorola developed the iDEN technology to deploy a cellular voice and data network on these non-adjacent SMR channels. Nextel successfully petitioned the FCC to convert some of its site-specific licenses to geographic area licenses (including only the areas covered by its licensed sites). While Nextel had most of the SMR licenses, it did not control them all, nor did it have licenses for the geographic areas with no licensee.

In 1995 and 1997, the FCC held overlay auctions for both the 800 and 900 MHz SMR frequencies (FCC, 1995; FCC 1997, Hazlett, 2017). The FCC did not identify or provide alternative spectrum for the incumbent licenses. These overlay licenses gave the auction winners the rights to the unlicensed geographic areas within their license territory and the right to negotiate with incumbent SMR licensees inside the license territory as well as secondary non-interfering rights throughout the overlay geography. At the same time, the overlay licensee had the obligation to protect the incumbents from interference due to any new operation. The incumbents were provided protection for the length of their license terms (including expectancy of renewal) while the overlay winner was able to transmit on the channels around them. Given Nextel's dominant position in these frequencies, it purchased most of the overlay licenses and subsumed its own site-specific licenses and geographic waiver licenses into its new area-wide overlay licenses and negotiated with some others for their rights.

#### c. 700 MHz

In the 700 MHz band, under direction from Congress, in 2001 the FCC gave all incumbent television broadcasters between channels 52 and 69 a second digital television channel below channel 52 and mandated that they move to that spectrum (FCC, 2001). The spectrum between channels 52 and 69 was fully cleared when analog terrestrial over-the-air broadcasts ceased and the digital transition finished. The FCC was then able to auction the cleared (or to be cleared at the time of the auctions) spectrum in 2008 (FCC, 2008). Additionally, the FCC imposed strict interference protection requirements to prevent potential harmful interference to digital television service on channel 51. Some of the new licensees negotiated with those stations using channel 51 to move to different channels or change the interference rules.

## IV. Overlay + Command and Control: AWS

In 2006, the FCC held an auction for the Advanced Wireless Service AWS spectrum that had been assigned to government users (FCC, 2002b, 2006). The FCC's plan used a combination of overlay licenses and command and control to effectuate the transition from the government use to flexible private use. The government estimated a cost of about \$2 billion for the relocation of incumbent government users and required that the auction raise at least that amount of money to cover the costs. The auction raised over \$13 billion so easily cleared the cost to move

government users to other spectrum bands with a substantial amount left over for the U.S. Treasury.<sup>3</sup>

## V. Two-Sided Auction + a Little Command and Control: 600 MHz

For the recent 600 MHz transition the FCC used a state-of-the-art two-sided auction design (Leyton-Brown et al., 2017). Pre-auction, this spectrum was used by television stations to broadcast over-the-air television programming. The licenses were associated with specific six MHz channels, with many channels in any given area not being used by any station (so called “white space”). The main efficiency gains would come from re-packing television channels more closely together in frequency, removing some of the over-the-air television signals and reallocating the spectrum in larger contiguous (and paired) blocks for flexible use.

In this process, the FCC used a market mechanism to determine how much spectrum to be cleared for flexible use, which television stations would continue to broadcast, what TV station owners would be paid to cooperate (either by exiting broadcasting or volunteering to accept a less desirable channel assignment), what parties would be awarded the newly created flexible use (suitable for mobile) licenses, and what the latter would pay for those licenses. Finally, for most of the television stations that decided to stay on the air, the FCC allocated new channels (via administrative process, reimbursing the TV stations for the transition costs).

The transition to flexible use in this case, as will be discussed in part below, required significant coordination. The FCC would have faced legal and political challenges if it attempted to force any broadcaster off the air (because of the expectancy of renewal in the licenses), and its options for relocating stations to different channels were somewhat limited. For example, stations that wished to remain as over-the-air broadcasters could lose at most 0.5% of their pre-existing service territory to interference from any other station even if they gained net service territory in other directions (Leyton-Brown et al. 2017, p-7205). These constraints and the requirement not to cause interference between stations and with stations in Canada and Mexico, constrained, but did not eliminate, the FCC’s ability to move stations. The FCC decided to create a mechanism where it could facilitate the clearing of as much broadcast television spectrum as economically rational for flexible use.

However, the FCC did not know how much spectrum should be reallocated as it did not know the value placed on the spectrum by incumbents relative to the value by new service providers and the cost of transition. As a result, it needed to develop a mechanism to answer the question of how much spectrum to reallocate and how to do so most efficiently.

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<sup>3</sup> Getting more government agencies to give up spectrum in exchange for costs and then having the “market value” of the spectrum go to the Treasury would be useful but is difficult given spectrum managers’ incentives. NTIA (2019) details efforts to move spectrum from government use to the private sector.

## a. Options

The FCC had four major options to deal with the incumbent broadcasters in the bands it wanted to auction.

The first option would have been to expand property rights to all frequencies in the bands for incumbents and possibly expand geographic coverage for incumbents or create new licenses for the uncovered geography. The FCC could allow the owners of these new licenses to sell their licenses to other potentially more efficient users. One problem with this solution would have been the coordination required to aggregate enough of these licenses (and in contiguous blocks to enable more effective technology) to create a viable wireless business (and the resulting holdup problem, problems similar to what would occur in case of an overlay auction that we describe below). In addition, expanding rights in this manner would have led to a windfall gain for incumbent broadcasters that likely would have caused political backlash regardless of its size.

The second option would have been for the FCC to decree that the incumbent licensees had no rights beyond the stated term of their licenses. Since licensees have an “expectancy of renewal” and very few broadcasters have ever lost their license rights at renewal, it is likely that such a stance would have been challenged in court. In addition, it is likely that it also would have been a political non-starter.

The third option was an overlay auction like the one that Professor Thomas Hazlett advocated, whereby the television spectrum would be completely and totally covered by overlay licenses (Hazlett, 2014). Overlay licensees would have broad flexibility but would be required to “protect” remaining incumbent licensees in their bands/territories. As we described above, the FCC has used overlays with a variety of termination requirements on incumbents – for example, no termination date in the SMR overlay, to a three-year period in PCS. Using overlays would likely have guaranteed one or possibly two licensees in each geographic area in the 600 MHz band each covering a relatively wide band of spectrum.<sup>4</sup> Such wide bands would likely be necessary to provide the overlay licensee with the ability to avoid holdouts within its geographic area and also to avoid free rider issues if negotiating with an incumbent would benefit other overlay licensees.<sup>5</sup>

The fourth option, and the one the FCC chose, was to pursue a two-sided auction. Incumbents had two choices: continue broadcasting (which had a variety of sub-options) or go off the air in exchange for some payment. Key to the two-sided auction is that there is some incentive for the

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<sup>4</sup> Hazlett (2014) proposes seven licenses across the entire television band. While all seven would have been purchased, the discussion below indicates that overlays below 37 would likely have had severe incumbency issues for many years. This paragraph is looking at the potential competition in the 600 MHz licenses.

<sup>5</sup> As Hazlett notes, it is important for each overlay licensee to have relatively wide bandwidth to minimize its holdout exposure. However, such concerns mean that there will necessarily be a limited number of licensees. Hazlett provides an example of seven overlay licenses to cover the television broadcast spectrum, including two each covering half of the spectrum above channel 37, the 600 MHz spectrum. *See Hazlett, (2014) Table 4.* Importantly, he notes that the number and geographic scope possibilities are infinite, but that licensees would need substantial scale, which limits the possibilities.

sellers so that they do not try to extract all of the rents from the use of that spectrum.<sup>6</sup> In this case, the FCC was able to create competition by potentially forcing movement to another channel if a broadcaster wanted to remain on the air or demand too much money relative to other stations.

## b. Background

In 2014, the FCC announced it planned to hold a two-sided “Incentive” auction to allow incumbent television broadcasters to relinquish their rights to a 6 MHz broadcast television license in exchange for money and possibly different broadcasting rights.<sup>7</sup> The Incentive Auction commenced in 2016 and ended in 2017. The transition in the United States concluded in 2020, but the spectrum has become available earlier in many markets, including where some new licensees provided additional incentives for broadcasters to transition more rapidly than required by the FCC.

However, the story did not begin in 2014. The recognition of the value of broadcast television spectrum for mobile services was well known. In 1992, Evan Kwerel and John Williams of the FCC released a working paper discussing the value of transitioning spectrum from terrestrial over-the-air television to flexible mobile service (Kwerel and Williams, 1992).

The real push to transition spectrum from broadcasting to flexible use began in the mid-1990s with the introduction of digital television. The old analog model of broadcasting required large separations between stations. Stations broadcasting on the same channel had to be spaced far enough apart geographically to prevent “co-channel” interference. In addition, stations had to be separated in frequency to prevent “adjacent channel” interference as the analog signals and receivers were less clear in transmission and reception of signals. As a result, the “television band” spanned channels 2 – 69 for a total of 402 MHz while providing many fewer – on the order of a dozen – signals over the air for viewers to watch in each area.

Introducing digital broadcasting allowed “repacking” of television stations so they could be closer together, reducing substantially the need for “white spaces” between broadcasters. The same number of channels could be broadcast on much less spectrum, allowing the vacant spectrum to be used for other purposes.

In addition, and probably more importantly for public policy, the dramatic growth of cable television and direct broadcast satellite service meant that the value of terrestrial over-the-air television relative to flexible mobile use dropped. In 1994, 67% of households subscribed to cable and satellite (MVPDs) and 33% used terrestrial over-the-air service only. By 2004, 85% subscribed to MVPD service and only 15% relied solely on over-the-air television service

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<sup>6</sup> In fact, with sequential negotiation, multiple parties may each demand try to extract all of the rents.

<sup>7</sup> We use “Incentive” (capitalized) rather than “incentive” to refer to the specific broadcast spectrum auction as there is no such thing as an auction without incentives. We were informed, however, that getting political approval for the auction improved with the inclusion of the word “incentive.” The 2012 JOBS Act enabled the FCC to conduct this kind of auction.

(Calabrese et al, 2005, Hazlett, 2001). The reduced reliance on over-the-air television reduced the costs and objection to a transition of the spectrum to a new use.

The FCC's first step was to transition television signals from analog to digital and repack the stations after the transition. As part of the Telecommunications Act of 1996, Congress instructed the Commission to award incumbent broadcasters a "digital" television license temporarily to complement their analog licenses (Telecommunications Act of 1996). In the transition period broadcasters maintained two signals. At the conclusion of analog broadcasting, the remaining digital signals would be "repacked" and the newly freed spectrum would be auctioned. The FCC started the auction process ahead of the repacking in 2000 in part to provide a constituency that would push to have the broadcasters relinquish the analog spectrum. In 1998, TV channels 60-69 occupying the 746-806 MHz were cleared, and in 2002, channels 52-59 occupying 698-746 MHz were cleared. (FCC, 1998; FCC 2002a). This cleared 108 MHz from TV usage and allowed 84 MHz to be reallocated to flexible use in the "700 MHz" band.<sup>8</sup> In the 700 MHz band, previously used for over-the-air television, the FCC first auctioned smaller "guard bands" of four MHz and then auctioned the bulk of the paired spectrum in Auction 73 in early 2008.<sup>9</sup> Finally, in June 2009, after the inauguration of a new president and the Super Bowl, all analog stations went dark.

Reallocating more spectrum from television broadcasting to more flexible use and reducing the supply of broadcast stations in response to a decline in relative market value presented additional opportunity. In this way, low value television stations could exit the broadcast television market and be replaced by high-value flexible use providers.

In 2016-17, the FCC held its "Broadcast Incentive Auction" to reallocate spectrum from broadcasters to flexible use. The details of the auction design and the economic principles behind them are described in Milgrom and Segal (2017) and FCC (2017a). The auction consisted of several stages with different clearing targets. Within each clearing stage, the auction consisted of two parts: a reverse auction and a forward auction.

In the reverse auction, station-specific prices were offered to every participating television station, offering payments either to vacate the band or move to a different band. In every round of the reverse auction, every active television station had to decide whether it was still willing to accept one of the current clock offers or drop out of the auction (and hence remain broadcasting in the current band). At the end of each round of the reverse auction the FCC ran a packing algorithm to determine which TV stations that were still active in the auction together with stations that had exited the auction, could be repacked into the channels not allocated to wireless

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<sup>8</sup> The FCC awarded 24 MHz of the 108 MHz to Public Safety

<sup>9</sup> Not only did this auction contain a large amount of spectrum, it also had two bands with special restrictions for bidders. First, the Commission mandated that C block winners have an open access network if the bidding reached a certain revenue threshold (which Google bid to ensure it did). In addition, the D block required that there be a minimum bid for the right to negotiate with public service entities to use the band. Bidding did not meet this level so public safety entities maintained control of the spectrum (in addition to the 24 MHz assigned directly for Public Safety use) and later negotiated a deal with AT&T to operate a system that met their requirements and allows AT&T access the band for commercial activities as well.

service.<sup>10</sup> Those that still could be repacked saw their prices decline. Those that could not were “frozen” – they could no longer elect to remain on the air, but also did not see their offers go down.

The reverse auction ended once all remaining TV stations were frozen or the prices dropped to zero (in some areas, there were enough empty channels that all stations could be repacked, so that the offered prices dropped to zero).

The next part of the auction was a forward auction, during which wireless service providers competed to buy re-packaged spectrum from the FCC. The geographical license areas were no longer connected to the areas served by the TV stations but were based on Partial Economic Areas (PEAs). Moreover, the 6 MHz channels used by the TV stations were repacked to paired 5x5 MHz uplink and downlink licenses. Clock prices started low in every PEA and interested buyers expressed how many licenses they wanted to buy at those prices. Across rounds, prices increased in PEAs with total demand exceeding total supply. Bidders were allowed to switch their demand across PEAs subject to an activity rule and the “no excess supply” rule – demand reductions were processed only if that processing did not result in less demand than supply in a given PEA.

As the forward auction progressed from one round to another, the FCC tracked the difference between the total “ask” from the reverse auction and the total “offer” from the forward auction. When the sum offered in the forward auction exceeded the revenue requirement from the reverse auction plus a fixed sum to cover clearing cost (i.e. costs to move stations that remained on air) bidding satisfied the “Final Stage Rule.”<sup>11</sup>

The forward auction stage ended when there was no excess demand in any PEA. If at that point the auction did not clear, the auction progressed to the next stage, with a smaller clearing target and a repetition of the reverse-forward-auction sequence.

Once the forward auction cleared the target revenue, the winners from the reverse auction (and their payouts) were decided. Competition and price increases continued in every PEA with excess demand. At the conclusion of the clearing forward auction stage, the winning bidders knew their winning quantity (how many licenses they won in every PEA), but not specific frequency allocations. Those were determined afterwards via an assignment auction, which was a one-shot package auction in every PEA (although bidding took place in multiple PEAs at once to speed up the process). In the assignment auction every bidder was assured a contiguous allocation of licenses, but via bidding for different such blocks could express preferences over specific ranges.

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<sup>10</sup> The repacking algorithm is a complicated optimization program that ensures stations that wanted remain on air could continue to do so without loss of audience coverage or interference to or from other broadcast stations.

<sup>11</sup> To declare clearance, the FCC also required that the average price in the top-40 PEAs reached \$1.25 per MHz-POP when 70 MHz was available (FCC, 2017a).

The auction design, mechanics, and calculations behind the scenes were quite complicated, but the interface and decisions for participants were intended to be straightforward and familiar to participants in previous auctions.

The reverse auction started with high prices that went down in areas with excess supply to promote simple and efficient bidding by the sellers. If every TV station in the country were held by a different owner and all stations had well-formed valuations, a simple strategy of offering to sell (go off-air) at prices higher than a station's value would be optimal.

However, in reality the reverse auction was more complicated. Most importantly, some owners were allowed to control (either directly or indirectly) multiple stations in the same or related-via-interference areas. Ownership of multiple stations led to incentives to reduce supply strategically. For example, if the FCC needed 5 stations to go off air in some market, a seller with 2 stations in that market and valuations of 100 and 120 respectively, would no longer find it always optimal to offer to go off air with both stations up to price 120. By dropping out with the second station at a price higher than 120, the owner could obtain a higher price for the first station.

These "supply reduction" incentives led to some buyers acquiring multiple overlapping stations.<sup>12</sup> Doraszelski, Seim, Sinkinson, and Wang (2019) explained and documented this concern (the working paper version was circulated before the auction).

Another potential strategic problem could have appeared if a station thought it could drop out of the auction with the hope to sell its spectrum directly to the wireless providers after the auction for a higher price. The FCC reduced this incentive in several ways. It declared that the auction would be the only chance for stations to sell. It also made post-auction channel assignments for stations that elected to remain on air unpredictable during the auction and also ensured there were enough stations going off the air so that demand for an additional station to go off air would be low.

There is also the complication that television stations were not presented with a single option. Instead, they were given one price for going off the air, one price for moving from UHF to high-VHF and a third price to move to a low-VHF channel.

### c. Outcomes

The auction started with the reverse auction to free 126 MHz (13 TV channels) with the opening FCC-set) price at \$341 billion. With the declining clock prices in the reverse auction, the first stage ended with the broadcasters asking for \$86.4 billion to vacate the necessary channels for 126 MHz to clear. However, bidders in the forward auction were only willing to pay \$23.5 billion for the 100 MHz of spectrum that would be made available for flexible use in the forward auction, so the market did not clear. The difference between the 126 MHz cleared in reverse auction and the 100 MHz in the forward auction is for separation of the uplink and downlink

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<sup>12</sup> The FCC has rules about common ownership and control that these buyers needed to satisfy so they could not buy all of the stations in an area.

parts of the new licenses and guard bands. These spaces could be used for low power, non-interfering transmissions.

Table 1 below shows the stages of the auction and the amounts that could have been cleared in each stage, the money demanded to clear that spectrum and the willingness to pay for the cleared spectrum. In addition, it shows the number of incumbent television stations that would either need to be moved or paid to cease broadcasting. Table 1 also reveals the substantial prices that broadcasters demanded for their spectrum rights for the amounts above vacating 84 MHz. The per MHz value of the increment from 84 MHz to 108 MHz was valued by broadcasters at roughly 10 times the average value of the first 84 MHz, and the highest 12 MHz, from 114 MHz to 126 MHz at double that or 20 times the 84 MHz value.

**Table 1**

Stage	Reverse Auction Clearing Target	Highest Remaining UHF Channel	# of stations above that channel	\$B demanded	Forward Auction Available	\$B offered
1	126 MHz	29	931	\$86.4	100 MHz	\$23.5
2	114 MHz	31	831	\$54.5	90 MHz	\$21.5
3	108 MHz	32	789	\$40.3	80 MHz	\$19.6
4	84 MHz	36	585	\$10.1	70 MHz	\$19.6

The first three stages did not “clear” meaning that buyers were not willing to pay enough to compensate sellers to vacate that amount of spectrum. With lower clearing targets, prices per MHz came down and the amount of spectrum to be cleared also decreased meaning that the amount for willingness to accept had to decrease. It decreased substantially. On the other side, as the auction progressed through stages towards smaller clearing targets, price per MHz for the flexible-use spectrum increased, but the quantity decreased as well, so in advance it was not clear if the total willingness to pay would go up or down. Ultimately, the total willingness to pay decreased about 17% when the spectrum available decreased by 30% (from 100 MHz to 70 MHz).

In the end, the Broadcast Incentive Auction caused 70 MHz of spectrum to move from broadcast television channels 38 – 51 to flexible use across the country. To transition this spectrum, all 585 stations across the country that had licenses to use a channel from 38 – 52 had to move to below channel 37 or shut down.<sup>13</sup> Of the 585 stations, 70 will receive \$4.7 billion in compensation, including 59 that will be paid \$4.4 billion for going off the air and 11 that will receive \$340 million for moving to other television bands. (See Table 2).

<sup>13</sup> Sources: FCC pre-auction TV station data: [https://data.fcc.gov/download/incentive-auctions/Constraint\\_Files/](https://data.fcc.gov/download/incentive-auctions/Constraint_Files/) (Nov 2015 parameters.csv file) which shows 589 non-duplicated stations in the channel range in the US. See also, Technical Parameters for Post-Auction Table of Allotments, [https://data.fcc.gov/download/incentive-auctions/Transition\\_Files/](https://data.fcc.gov/download/incentive-auctions/Transition_Files/). Note that stations that elected to go “off air” gave up their 6 MHz license but kept the option to negotiate to share a channel with another station that kept its 6 MHz license. In this paper we refer to those stations as “shutting down” or “going off air” because we focus on the re-using of the spectrum.

In addition to the 59 “above 37” channels going off the air, another 86 stations were paid to cease broadcasting (as shown below in Table 2), \$360 million to four “High VHF” and \$4.1 billion to 82 “Low VHF” stations. For stations agreeing to move bands, \$1.2 billion went to the 30 stations that were willing to move bands – in addition to the \$340 million for the “above 37” channels, one “High VHF” station received \$9.8 million and 18 UHF stations received \$858 million for moving channels.

**Table 2**

**Compensation for stations moving or ceasing broadcasting in Stage 4**

<b>Pre-Auction Band</b>	<b>Stations</b>	<b>Compensation</b>
<b>UHF &gt; 37</b>	<b>70</b>	<b>4,752,329,315</b>
Go off-air	59	4,412,621,763
Move to High-VHF	7	186,113,627
Move to Low-VHF	4	153,593,925
<b>High VHF</b>	<b>5</b>	<b>371,113,458</b>
Go off-air	4	361,259,676
Move to Low-VHF	1	9,853,782
<b>UHF &lt; 37</b>	<b>100</b>	<b>4,931,234,049</b>
Go off-air	82	4,072,961,324
Move to High-VHF	6	205,455,901
Move to Low-VHF	12	652,816,824
<b>Grand Total</b>	<b>175</b>	<b>10,054,676,822</b>

The ability for the FCC to have 86 stations that were previously below channel 37 compete to go off the air with the stations above channel 37 was one of the key features of the auction: a station above channel 37 that demanded a high price could be relocated involuntarily to a UHF channel below channel 37 and the auction would clear at a lower price. The FCC’s ability to mandate relocation to a lower UHF channel created competition for stations above channel 37 – if they demanded a high price to vacate, they could be relocated without extra compensation (i.e. with only relocation costs covered). In some areas there were enough vacant channels below channel 37 that no stations needed to go off air so no payment above relocation costs went to stations above channel 37 in those areas.<sup>14</sup> In other areas, there was competition between stations above and below channel 37 to go off the air to create enough space for the new licensees.

Involuntary relocations became a major part of the auction – most of the stations (70 of the 585) that vacated the spectrum above channel 37 did not receive compensation above their relocation costs. Without the FCC’s power to mandate relocations, the costs would likely have been higher to transition the spectrum due to reduced competition and holdout issues.

<sup>14</sup> See Table A in the appendix for a description of the channels moving and going off-air.

While the FCC (or more accurately the new licensees) will be paying \$10.1 billion to clear the 84 MHz above channel 37, only 175 of the directly affected 1,032 (987 moving + 145 off-air) stations will receive compensation above their costs directly from the auction proceeds. Slightly fewer than half of all television stations will be directly affected (and compensated at least for their costs) by the transition.

#### d. Competition

In addition to clearing a significant amount of spectrum, the FCC wants to promote competition for services that use spectrum as an important input. The FCC's recent two-sided spectrum auction provides evidence about how auction design and competition policy can work together in the context of efficient resource reallocation. Auctions tend to award licenses to those who have the highest expected producer surplus. As a result, auction allocation may underweight the benefits of competition in increasing consumer surplus (Hazlett and Munoz, 2009).<sup>15</sup>

The FCC has long been concerned with promoting competition within auctions and even more with promoting competition in the market for spectrum services. The FCC has deviated from a simple auction to encourage entry and competition in the past through eligibility restrictions and set asides. The recent two-sided auction process diverged from past "set asides" by waiting to trigger a "reserve" until it ensured sufficient revenue to clear the spectrum.<sup>16</sup> The success of such a mechanism showed that dynamic reserves can be a part of the auction process. Such triggers can be implemented within an auction process for other social goals such as open access conditions or investment commitments.<sup>17</sup>

The FCC felt the 600 MHz band was important for competition because of the particular characteristics of low-band spectrum. Transmissions in the 600 MHz band have the ability to travel long distances and also to provide more robust in-building coverage than higher "mid-band" spectrum. Prior to the auction, Verizon and AT&T held the majority of sub 1 GHz available for mobile wireless service.<sup>18</sup>

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<sup>15</sup> Cramton et al. (2011) discuss the importance of competition and how those concerns can be incorporated into auction design.

<sup>16</sup> We proposed that if the FCC wanted to implement rules to encourage acquisition of spectrum by firms without low-band spectrum, it could implement a "Dynamic Market Rule" that started the auction with restrictions and relaxed them if the clearing target was not met.

<sup>17</sup> For example, with 3 bidders and 4 licenses, the regulator may decide that it would be efficient for all bidders to win at least one license. However, setting aside one license for each from the start can result in a windfall for the bidders or in inefficient allocation in case one of the bidders does not really want to deploy service. In such a case, the auctioneer can set a contingent set-aside: the auction starts without any constraints, but if the price reaches a certain price level (assuring that bidders are serious in their plans to deploy), every bidder still active in the auction gets one license and bidding continues for the rest.

<sup>18</sup> Fierce Wireless, "Special Report—25 charts on spectrum ownership in the United States," [Mike Dano](https://www.fiercewireless.com/wireless/25-charts-spectrum-ownership-united-states), Jul 12, 2018. Available at <https://www.fiercewireless.com/wireless/25-charts-spectrum-ownership-united-states> (Checked 9/10/20)

#### e. Transaction costs

The auction also showed how a centralized marketplace can help avoid holdout, free rider, and transaction cost problems. One alternative to the two-sided auction was a one-sided auction of overlay licenses for wide bands of spectrum and wide geographic areas. The FCC was worried about holdout problems with such an approach. By taking away the ability to hold out for better deals, the FCC facilitated negotiation and created additional competition amongst television licensees. The convening power of the FCC and its centralized market also created a mechanism to facilitate negotiation. To clear the 84 MHz of spectrum would have required hundreds of deals and thousands of negotiations about potential transactions. In addition, the auction alleviated free rider problems that likely would have arisen in an overlay that had multiple licensees. With multiple geographies and adjacent bands, clearing a television station would not only benefit the direct overlay licensee, but might have spilled over to benefit other overlay winners who might be direct competitors.

Table 1 above shows that even to free up an additional 10 MHz would have meant clearing an additional 204 stations above the 589 that will vacate the 84 MHz, or 35% more stations (and four times as much money). However, as the auction showed, the stations that need to be cleared are not the only relevant stations. Minimizing the cost of clearing requires determining the willingness to leave of all possible stations and picking the lowest cost combination (including transaction cost of determining valuations) of those stations. By implementing a process that generally caused stations to reveal something close to their willingness to accept, the FCC process likely came close to that set of negotiations.<sup>19</sup>

As a result, the license winners in an overlay auction likely would have had to pay at least as much if not much more to free up the spectrum. In addition, they would have had to engage in an extremely large number of contingent negotiations to try to effectuate the moves.

To assess the cost of such alternative negotiations, we looked at the amount that each of the 376 participating stations above Ch 37 was willing to accept or not in the auction.<sup>20</sup> As discussed above, of the 585 stations above Ch 37, 376 stations participated in the auction and auction data reveal what price offers they were willing to accept to vacate the band. First, 70 stations were “winners” in the auction and were paid \$4.75 billion to either move to a lower band or go off air for (Table 2). The other 306 stations collectively demanded at least \$30.8 billion to vacate the spectrum. That is, each of them rejected offers to vacate the spectrum and \$30.8 billion is the sum of the lowest rejected offers.

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<sup>19</sup> As noted above, some bidders in the reverse auction had incentives to act strategically to raise the price, an argument made before the auction by Doraszelski, Seim, Sinkinson, and Wang (2019) “Ownership Concentration and Strategic Supply Reduction.”

<sup>20</sup> 376 of the 585 stations above Ch 37 participated in the reverse auction. 1,031 stations out of the 2,200 total stations in the US participated.

Adding the auction payments from the 70 auction winners leads to a cost of \$35.6 billion.<sup>21</sup> We think that this number could be a lower bound on what private negotiators owning the overlay licenses would have to pay, because the structure of the auction led to more competition for relocation than would occur with overlay licensees. In addition, the \$35.6 billion total does not factor in the costs of negotiating with and paying the 209 stations that did not participate in the auction but were relocated by the FCC. Had there been an overlay license, the licensee would not have been able to effectuate such relocations without additional compensation.<sup>22</sup>

Table 3 replicates Table 2 for each stage of the auction to show the number of stations above 37 that were willing to go off the air and the price they would demand in the auction. The “Grand Total” numbers represent a lower bound of what it likely would have cost an overlay licensee to free up the spectrum in each stage as those above 37 that were willing to go off the air represent a small fraction of the total costs that would be incurred, as for example, it does not include the \$30.8 billion necessary for even the Stage 4 total of 70 MHz.

**Table 3**  
**Compensation for stations moving or ceasing broadcasting**

	<b>Stage 1</b>		<b>Stage 2</b>		<b>Stage 3</b>		<b>Stage 4</b>	
	<b># St</b>	<b>Compensation</b>						
<b>High VHF</b>	<b>29</b>	<b>\$ 2,443,591,699</b>	<b>19</b>	<b>\$1,431,629,138</b>	<b>16</b>	<b>\$1,191,740,089</b>	<b>5</b>	<b>\$371,113,458</b>
Go off-air	21	1,679,108,260	12	754,372,979	11	742,640,826	4	361,259,676
Move to Low-VHF	8	764,483,439	7	677,256,159	5	449,099,263	1	9,853,782
<b>UHF &lt; 37</b>	<b>287</b>	<b>46,587,379,243</b>	<b>212</b>	<b>28,445,830,324</b>	<b>184</b>	<b>20,669,918,578</b>	<b>100</b>	<b>4,931,234,049</b>
Go off-air	245	44,300,954,140	183	26,703,275,932	161	19,313,791,505	82	4,072,961,324
Move to High-VHF	16	763,011,271	9	464,027,040	8	381,021,715	6	205,455,901
Move to Low-VHF	26	1,523,413,832	20	1,278,527,352	15	975,105,358	12	652,816,824
<b>UHF &gt; 37</b>	<b>202</b>	<b>37,391,587,762</b>	<b>149</b>	<b>24,708,573,374</b>	<b>126</b>	<b>18,451,505,758</b>	<b>70</b>	<b>4,752,329,315</b>
Go off-air	162	35,820,681,187	125	23,619,871,621	110	17,699,240,445	59	4,412,621,763
Move to High-VHF	20	788,029,039	10	368,595,582	7	307,816,989	7	186,113,627
Move to Low-VHF	20	782,877,536	14	720,106,171	9	444,448,324	4	153,593,925
<b>Grand Total</b>	<b>518</b>	<b>\$86,422,558,704</b>	<b>380</b>	<b>\$54,586,032,836</b>	<b>326</b>	<b>\$40,313,164,425</b>	<b>175</b>	<b>\$10,054,676,822</b>

## VI. Command and Control + Auction: C-Band

<sup>21</sup> Another way to set a lower bound would be look at the lowest price of the three possible options (moving to high or low VHF or shutting down) of the stations participating in the auction. Using this method leads to \$18.2 billion to clear the 376 channels above channel 37 that participated in the auction.

<sup>22</sup> It is possible that in some areas with available channels below channel 37 that an overlay licensee could have paid a licensee less to move to the open channel, but such situations were likely rare given the encumbrances.

The 500 MHz of spectrum from 3.7 GHz to 4.2 GHz, the “C-Band,” has historically been used to provide video and audio signals from satellites to large earth station dishes. The FCC awarded multiple satellite licenses to different entities for what is known as “full-band, full-arc” service. In other words, each satellite licensee had the right to use the full band from any satellite location as long as it did not interfere with the signals of other satellite licensees. In 2017, the FCC began a proceeding to transition some or all of the C-Band spectrum to (presumably) more highly valued use by terrestrial wireless service providers (FCC, 2017b).

Intelsat and Intel (2017) submitted comments where they proposed to sell 100 MHz of the C-band to terrestrial service providers and use part of the proceeds to transition current service to the remaining 400 MHz (including spectrum for a “guard band”) and retain the rest of the money as an incentive for performing this process. They submitted this proposal as a market-based approach that would require the FCC to expand their rights from satellite service only to include more valuable terrestrial rights. In addition, they would need to ensure that all satellite licensees agreed to participate (i.e., clear the same 100 MHz of spectrum) since all licensees had the right to broadcast across the full range of the spectrum. Finally, the FCC would have to limit licensing of new satellite entities.

Throughout the proceeding, the main issues were how much of the 500 MHz should be transitioned to more valuable uses, who should decide how much to transition, how the transition should proceed, and what parties should profit from proceeds above the cost of making the satellite service more efficient to free up the spectrum. Ultimately, the FCC decided that it rather than the satellite operators should run an auction for the new terrestrial licenses, that it would auction 280 MHz (and allow for a 20 MHz guard band) leaving 200 MHz for the satellite operators. The newly flexible spectrum would be made available in tranches.<sup>23</sup> The FCC made accelerated payments from the new terrestrial licensees to the existing satellite licensees contingent on the incumbents vacating the spectrum in line with the deadlines.

The FCC set up multiple 20 MHz licenses (five for the first tranche of 100 MHz in 46 areas and 5 for that spectrum in the remaining areas, and nine for the remaining 180 MHz). The 14 licenses in each geographic area are available to all potential buyers. It is theoretically possible that one or two licensees could buy all 14 and foreclose others from accessing this spectrum. However with the amount of spectrum available in this band and in other bands, it is unlikely that one or two licensees would buy all of the licenses in an area unless the prices were relatively low and thus the damage from any attempted foreclosure would be low as well.

In essence, the FCC used mostly command and control to force existing licensees to give up 60% of their spectrum (after existing licensees proposed they could sell a small part (20%) of the spectrum and keep the money for themselves). The FCC will give some of the proceeds from the auction to existing licensees, injecting some incentive for them to transition the spectrum in a reasonable timeframe.

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<sup>23</sup> 100 MHz is to be available in the top 46 PEAs by October 2021 and to the remaining markets by October 2023, along with the other 180 MHz (FCC, 2020) nationwide.

While this mechanism will lead to 280 MHz of spectrum moving to higher-value use, it appears to leave 200 MHz in satellite transmission where it might be less highly valued (and also a 20 MHz guard band that might not be necessary). The FCC could have combined more market forces in a couple of ways to increase the possibility that if the spectrum were more valuable in other uses, it could have been transitioned. First, it could have tried to sell the entire 500 MHz and let satellite users compete with terrestrial earth station operators who might have been willing to forego satellite service in favor of money and the opportunity to receive service via fiber. A second mechanism would be to allow the satellite operators an option to sell the remaining 200 MHz that is currently designated for satellite use. Such a sale could be nationwide or focused on dense urban areas where the spectrum is likely to be more valuable in alternative uses and the cost of connecting earth stations to fiber is lower. Finally, the FCC could have offered increased incentive payments (e.g., a larger fraction of the auction proceeds) in case the satellite operators offered to sell the whole 500 MHz of spectrum (again, especially in some highest-value areas).

## VII. Lessons for the future

There is still a large amount of spectrum that is not licensed for flexible use so the FCC will be faced with situations where it should facilitate the reallocation of license rights to more efficient use. In those situations, it is likely to be pressured by different interest groups to use different mechanisms to allow spectrum to be used more efficiently. As a result, the Commission should consider in advance the conditions for when it should use each of the four mechanisms discussed above to transition to more flexible licensed use: command and control, relaxing existing license constraints, two-sided auctions, and overlays.

The key economic questions for transition are the transaction costs and associated holdout problems that could forestall efficient repurposing, and the post-auction market structure for service provision.

The key transaction costs concern co-channel and adjacent channel interference protection and existing implicit property rights. How many incumbents are required to stop or move operations to “clear” a band of spectrum to make it useful? And how much will the clearance of incumbents benefit other potential license holders (and potential competitors)?

The more incumbents that need to be cleared, the more complicated negotiations will be, especially if each incumbent has some degree of blocking power. As a result, facilitating the ability to avoid having to negotiate with any specific licensee can reduce transaction costs substantially. As Hazlett (2014) notes, broader spectrum rights for new licensees mean that a single incumbent licensee may be able to remain in the band and not disproportionately affect spectrum value in the band.

Even if it is possible to avoid specific incumbents, reallocation may take a large number of contingent contracts to clear the spectrum. With small numbers, such contracts may be able to be effectuated – while many shopping malls require negotiations with a number of pre-existing

landowners, we see a large number of shopping malls (and expansions of existing malls) so it is possible to have multiple negotiations work.<sup>24</sup>

Another consideration is the impact of clearing on other licensees. Hazlett (2014) makes the important point that larger overlay licenses can ameliorate the free rider effect from clearing. However, the larger licenses mean that there is a lower chance of multiple licensees and competitive service provision.

To examine the tradeoffs that the FCC should consider, we have put together a set of five initial questions that will help think about the tradeoff between overlay licenses and centralized two-sided auctions if the FCC is not going to implement mandatory vacating of the spectrum (which could be used with either of these two mechanisms).

*Question 1: How much of the band is encumbered?*

The degree of encumbrance is key. Is there a lot of spectrum unencumbered? Is it easy to work around the incumbents? Is it encumbered by multiple entities or by one? The greater the encumbrances and number of incumbents, the greater the argument that some way of increasing the alternatives (through mandatory FCC relocation to equivalent service) would facilitate the transition. For example, in both 600 MHz and the C-Band, much of the spectrum was encumbered by multiple parties.

*Question 2: How easy is it for the new users to “avoid” incumbents who do not want to move?*

If it is easy to avoid incumbents, they will not be able to “hold up” the transition. If incumbents are not required to move for the new licensee to realize the benefits of flexibility, then overlay licenses will be particularly useful. In the SMR overlay auctions, the new licensees could operate around the incumbent users which made it easier in turn to pay them to cease transmission without paying a hold-out value.

*Question 3: Is there some other way for incumbents to provide their service?*

The ability of incumbents to replace their existing service (with other spectrum or non-spectrum alternatives) should make it easier for them to be held harmless. It may not affect their willingness not to hold out if remaining can be strategic for them, but it will reduce the cost to them of vacating spectrum bands. In the PCS auctions, incumbents were able to transition their service either to fiber or to alternative spectrum. Some incumbents bargained for increased payments to move early and their willingness to vacate the spectrum increased because they could get equivalent or better service using alternatives and have the costs paid for by the new licensees.

*Question 4: How valuable is the incumbent service?*

The answer to this question is somewhat related to question 3, but slightly different. Question 3 relates to the opportunity cost of the use of the spectrum for the incumbent service whereas this relates to the entire value of the incumbent service if there is no alternative. Some services have relatively little value using spectrum. For example, some analog television over-the-air

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<sup>24</sup> That said, such negotiations are not always fully successful: there are examples where holdouts need to be built around or are able to extract large premiums for their property.

broadcasts were used to exercise “must carry” rights on local MVPD service rather than to reach viewers over the air.<sup>25</sup>

*Question 5: How important are competitive considerations in that specific spectrum band?*

Overlays tend to work best when there are large licenses so that licensees can internalize the benefits of relocating incumbents. However, if the large licenses would reduce competition for the service post-auction, overlays may not be as good as centralized incentive auctions with multiple licensees in the band. In the 600 MHz auction, Hazlett (2014) proposed overlay licenses that were relatively large in terms of spectrum and geographic areas. As a result, the auction winners could have been able to clear spectrum and realize most of the benefits of paying a station to shut down. However, such large licenses could then lead to less competition in the services provided by flexible use licensees.

We think that answering the questions above provides information about where the FCC should use overlays and other times where it should be more actively involved. Overlays will be useful when there are less competition concerns based on specific bands, when the government is unlikely to be a large help in resolving hold out problems or providing alternative facilities, and when there is a lower need for centralized marketplace.

An example where overlays may be useful is in the remaining television bands. It is unlikely that the Commission will be able to provide alternative facilities for a large number of stations to relocate, say from channels 27-36, to free up that spectrum. In addition, that spectrum is unlikely to be the key to competition for wireless services. And it is unlikely to be important in the near future. So, overlay licensees may buy the rights to negotiate with incumbents and proceed slowly to free up the band depending on opportunity. Even with such flexibility, new licensees would need to consider whether the newly flexible spectrum should be used on a paired basis, the size of the channels, and many other factors.

Overlays may also be useful for the remaining 200 MHz allocated to satellites in the C-Band. An overlay would help determine if that spectrum is worth more in terrestrial service, especially before the satellite operators spend billions of dollars to reoptimize their satellite service.

## VIII. Conclusions

The FCC has used a variety of different mechanisms to move spectrum to more flexible and highly valued uses over the past thirty years. The two main market-based mechanisms are overlays and two-sided auctions.

Overlays licenses have an important role when it is possible to leave more of the transition to private negotiations. But market conditions matter and can make overlays less optimal than a more interventionist or more centralized approach. Pre-existing rules can make it more difficult

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<sup>25</sup> Recognizing that TV broadcast licenses created two benefits for TV stations: reaching viewers over the air and “must carry” rights, the FCC facilitated the 600 MHz auction by granting “must carry” rights to all stations that offered to abandon their spectrum usage rights if they continued to broadcast on a “shared” channel.

to negotiate with incumbents: they may have some power to hold-up in negotiations by demanding a large share of the possible increased value of the spectrum from their overlay licensee, and there may be a large number of incumbents with varying rights making the negotiations too complex and costly.

The second main concern for overlay licenses arises from the possible effect on *ex post* market performance. To have viable overlays may require large licenses in terms of frequency (and possibly geography). However, large licenses may preclude the use of the spectrum by competitors. If the spectrum is sufficiently unique in its characteristics for providing a service, the Commission may be concerned about the ability of new entrants (or existing competitors who do not win the overlay license) to provide similar services.

Two-sided auctions are complex and do not eliminate all transaction costs. The Incentive Auction required many more stations to move involuntarily than are moving voluntarily in exchange for the incentive payments. Even the involuntary relocations will cost money, about 18% of the money that is being paid to broadcasters from the auction proceeds.<sup>26</sup> However, the power to force stations to move involuntarily (but to keep their transmission area) allowed the FCC to enhance competition and prevent holdouts.

Moving forward, the Commission should ensure that there is sufficient spectrum in flexible use so that providers can satisfy the growing demands for wireless services.<sup>27</sup> The Commission's goal should be to transition as much commercial spectrum as possible through market mechanisms. It should also work with NTIA to develop mechanisms to transfer low-value government-controlled spectrum to flexible use where that spectrum is worth more when used commercially.

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<sup>26</sup> The auction raised \$19.8 billion. \$10.1 billion was paid directly to the broadcasters participating in the auction leaving \$9.7 billion. The FCC paid out \$1.75 billion for costs for other channel relocations, or 18% of the remaining money.

<sup>27</sup> As noted in the Introduction, we are not opining about the split of spectrum between licensed and unlicensed use.

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## Appendix

Table below shows that there were 987 stations, including 463 that were below channel 37 prior to the auction, that moved channels (but lost less than 1% of their potential audiences) to free up the spectrum. Of those, 513 had been above channel 37 and will move to UHF channels below 37 with no compensation above their costs while 11 that agreed to move to VHF channels will get paid a premium to do so. In addition, 444 stations with channels below 37 will move with no compensation above their costs while 19 will be paid for moving. Of the 987 stations moving channels, 957 (97%) will be doing so “involuntarily.”

**Table A**  
**Moving channels**

	<b>Above 37</b>	<b>Below 37</b>	<b>Total</b>
<b>Move</b>	<b>524</b>	<b>463</b>	<b>987</b>
High VHF	7	73	80
Low VHF	4	13	17
UHF	513	377	890
<b>No Move</b>		<b>1063</b>	<b>1063</b>
High VHF		370	370
Low VHF		45	45
UHF		648	648
<b>Grand Total</b>	<b>524</b>	<b>1524</b>	<b>2050</b>