2014

The Middle Class Tax Relief And Job Creation Act Of 2012 And Its Impact On Television Broadcasting And Future Broadband Wireless Communications

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THE MIDDLE CLASS TAX RELIEF AND JOB CREATION ACT OF 2012

AND THE FUTURE OF UHF TELEVISION AND WIRELESS COMMUNICATIONS

A Thesis
Presented in partial fulfillment of requirements
for the degree of Master of Arts
in the School of Journalism
The University of Mississippi

by

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December 2014

ABSTRACT

The upcoming Incentive Auction for the 600 MHz band will cause the relocation of hundreds of UHF television stations while potentially freeing up as much as 120 MHz of valuable electromagnetic spectrum for utilization by wireless communications providers. This "new" wireless spectrum will allow wireless providers to increase their wireless broadband capabilities and feed the ever-growing demand by consumers for more wireless broadband capacity.

This thesis addresses the mechanics of the proposed auction platforms, the impact the auction will have on existing television broadcasters, and explores some of the possible future opportunities the repurposing of the 600 MHz band presents to wireless communications providers and consumers.

LIST OF ABBREVIATIONS

AGL	Above Ground Level
CMA	Cellular Market Areas
CP	Construction Permit
DMA	Designated Market Area
DTS	Distributed Transmission Services
EA	Economic Areas
ERI	Electronic Research, Inc.
FCBA	Federal Communications Bar Association
FM	Frequency Modulation
FCC	Federal Communications Commission
GHz	Gigahertz
HAAT	Height Above Average Terrain
IOT	Inductive Output Tube
kW	Kilowatt
LPTV	Low Power Television
MHz	Megahertz
MW	Megawatt
NAB	National Association of Broadcasters
OET	Office of Engineering and Technology
PER	Partial Economic Areas

RF	Radio Frequency
SS	Solid State
TASO	Television Allocations Study Organization
UHF	Ultra High Frequency
VHF	Very High Frequency

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CHAPTER 1

STATEMENT OF THE PROBLEM

On February 22, 2012 the U.S. Congress passed the *Middle Class Tax Relief and Job Creation Act of* 2012 (Public Law 112-96). Title VI of the *Middle Class Tax Relief and Job Creation Act of* 2012 empowers the FCC to conduct incentive auctions.

> Title VI of the Middle Class Tax Relief and Job Creation Act of 2012, commonly know as the Spectrum Act, addresses public safety communications and electromagnetic spectrum auctions. Section 6402, codified at 47 U.S.C. § 309(j)(8)(G), authorizes the Commission to conduct incentive auctions in which licensees may voluntarily relinquish their spectrum usage rights in order to permit the assignment by auction of new initial licenses subject to flexible use service rules, in exchange for a portion of the resulting auction proceeds.[1]

The FCC has decided to repurpose the 600 MHz band through the use of incentive auctions. What impact will repurposing the 600 MHz band, currently UHF television channels 35 through 51, have on television broadcasting, wireless broadband communications, and the consumers of both services?

The problem facing the FCC, and addressed in this thesis, is how to repurpose the 600 MHz band through an incentive auction platform, the possible band plans for use of the spectrum once relinquished by UHF television stations, and the repacking of the UHF television stations previously in the 600 MHz band that decided not to participate in the incentive auction.

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[1] Federal Communications Commission, *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, 2012, FCC 12-118, § 2(C).

The purpose of this thesis is to address the mechanics of the proposed auction, the impact on television broadcasting – in particular the repacking of UHF television stations – and the future opportunities the repurposing of the 600 MHz band presents to wireless broadband providers and consumers. This paper will provide a layman's guide to the most dynamic spectrum change and challenge since the development of cellular communications and digital television.

CHAPTER 2

LITERATURE REVIEW

The literature related to the Federal Communications Commission's upcoming incentive auction to repurpose the 600 MHz band from UHF television to wireless broadband is centered around the *Middle Class Tax Relief and Job Creation Act of 2012*, as passed by the U.S. Congress, Pub. L. No. 112-96, §§ 6402, 6403, 125 Stat. 156 (2012), known as the *Spectrum Act*; the Federal Communications Commission, *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, 2012, FCC 12-118; and the Federal Communications Commission, *Report and Order Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, 2014, FCC 14-50.

Additional literature includes public comments made by various industry groups (in particular broadcasters), wireless communication providers, wireless microphone manufacturers, cable television and satellite television system providers, and industry groups such as the National Association of Broadcasters, the Cellular Telecommunications & Internet Association, The Association of Independent Television Stations, and the Expanding Opportunities For Broadcasters Coalition.

Numerous communications trade publications have addressed the issues, with each one taking on the position of the different trade group or coalition they represent.

To date there are 1,516 public comment and exparte filings related to the incentive auction. These filings are available to view and download through the FCC's Electronic Comment Filing System (ECFS) at http//apps.fcc.gov/ecfs.

The governing documents direct the FCC to: (1) hold an incentive auction for the 600 MHz portion of the UHF band, (2) relocate television stations that choose not to participate in the auction to another portion of the UHF band below the 600 MHz portion of the UHF band, and in some rare cases, to relocate a television station from the UHF band to the VHF band, (3) auction off the spectrum relinquished by the participating and relocated television stations to participating wireless communications providers, (4) take the proceeds of the wireless auction and pay the participating broadcasters for their relinquished television channels, (5) take $1.75 billion of the incentive auction proceeds to cover the cost of relocating the non-participating stations displaced by the auction, and (6) turn the balance of the auction proceeds over to the U.S. Treasury – all before the end of 2019.

CHAPTER 3

METHODOLOGY

The methodology employed in the development of this thesis differs from that usually found in a typical research oriented thesis because this thesis is not research oriented.

Since March 2012 the author has been an active participant in the pre-planning discussions with industry groups, as well as a consultant to the Federal Communications Commissions' (FCC) Media Bureau, regarding both the costs and timelines associated with the repacking process envisioned in the proposed incentive auction for the 600 MHz band. In 2013 the author co-authored Widelity, Inc.'s *Response to the Federal Communications Commission for the Broadcaster Transition Study Solicitation – FCC13R0003*, 2013.

The author has extensively reviewed the available literature as well as relied upon notes made during numerous meetings with the FCC's Media Bureau regarding possible repacking scenarios and transition planning.

To June 16, 2014, the author represented Widelity, Inc. at the Federal Communications Bar Associations' seminar "Broadcast Spectrum Incentive and Forward Auctions".

CHAPTER 4

THE PROJECT

The Incentive Auction

> Title VI of the Middle Class Tax Relief and Job Creation Act of 2012, commonly known as the Spectrum Act, addresses public safety communications and electromagnetic spectrum auctions. Section 6402, codified at 47 U.S.C. § 309(j)(8)(G), authorizes the Commission to conduct incentive auctions in which licensees may voluntarily relinquish their spectrum usage rights in order to permit the assignment by auction of new initial licenses subject to flexible use service rules, in exchange for a portion of the resulting auction process.[1]

> FCC 14-50 Report and Order Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions, will make "more spectrum available for mobile broadband use" and "will benefit consumers by easing congestion on the Nation's airwaves, expediting the development of new, more robust wireless services and applications, and spurring job creation and economic growth."[2]

The Spectrum Act of 2012 provides for two auction platforms: (1) the reverse auction, in which broadcasters who choose to relinquish some or all of their spectrum rights will participate in and share in auction proceeds, and (2) the forward auction, in which broadband wireless providers will participate in anticipation of acquiring duplex 5 MHz uplink/downlink licenses.

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[1] Federal Communications Commission, *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, 2012, FCC 12-118, § 2(C).

[2] Federal Communications Commission, *Report and Order Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, 2014, FCC 14-50, § 1.

The reverse auction determines the amount a broadcast licensee is willing to accept for voluntarily relinquishing some or all of their spectrum usage rights.

> Pursuant to that provision, broadcast television licensees may bid in the reverse auction to indicate the amount of compensation that they would accept to relinquish different spectrum usage rights, including the following (A) "all usage rights with respect to a particular television channel without receiving in return any usage rights with respect to another television channel"; (B) "all usage rights with respect to a [UHF] television channel in return for receiving usage rights with respect to a [VHF] television channel"; or (C) "usage rights in order to share a television channel with another licensee."[1]

Reverse Auction

Under the proposed reverse auction, the broadcast licensee of a UHF station has three options. First, they may choose to relinquish all spectrum usage rights. Upon successful completion of the reverse auction the licensee turns their station off the air and relinquishes all spectrum usage rights to the FCC for the pre-auction channel the station is occupying. In return for relinquishing all of their spectrum rights, the former licensee will receive a portion of the auction proceeds based upon the licensee's bid in the reverse auction. Second, the licensee may chose to relinquish all of the spectrum rights of their current pre-auction UHF channel in return for being relocated to an available VHF channel and a portion of the auction proceeds based upon the licensee's bid in the reverse auction. Third, the licensee may chose to relinquish all usage rights of their currently pre-auction UHF television channel in order to share a television channel with another station in the same television market, and again, for a portion of the auction proceeds based upon the licensee's bid in the reverse auction.

[1] *Middle Class Tax Relief and Job Creation Act of 2012,* Pub. L. No. 112-96, Spectrum Act § 6403(a)(2).

The methodology the FCC has adopted for the reverse auction is a descending clock format.

> "In the bidding round, stations will be offered prices for one or more bid options and will indicate their choices at these prices. The prices offered to each station for options will be adjusted downward as the rounds progress in a way that accounts for the availability of television channels in different bands in the repacking process.[2]

The descending clock format "is a multiple round, or dynamic, procedure in which bidders would indicate their willingness to accept iteratively lower payments in exchange for relinquishing rights . . . auction prices would start high and decline over time."[3] Under this scenario, the broadcast licensee would indicate their willingness to continue to participate in the auction at each declining level until they reached a tipping point at which time they would not be willing to accept the bid price for the relinquishment of their spectrum usage rights. This auction model is very complicated and will require the FCC to develop a software system capable of running this type of auction. While complicated, this auction model is anticipated to maximize the amount of spectrum acquired in the reverse auction for the lowest possible price.

Bidders, broadcasters voluntarily participating in the reverse auction, will indicate price levels that they would accept for the bid options, or drop out of the auction and remain on their existing pre-auction licensed facility, subject to relocation in the repacking process at the end of the reverse auction.

Prior to the commencement of the reverse auction, the FCC, through public notices, will provide guidance to participating broadcasters about the way the FCC will establish initial bid pricing for stations participating in the auction. The FCC also hopes the number of broadcasters

[2] FCC 14-50, § 2(30).
[3] FCC 12-118, § 3(A)(1).

willing to voluntarily participate in the auction will increase after the release of the public notices that provide guidance on bid pricing.

The FCC will set initial spectrum clearing targets for each television market prior to the commencement of the reverse auction for a given television market. This initial spectrum clearing target will be based upon the number of broadcasters in a given market that are voluntarily choosing to participate in the reverse auction and the anticipated number of stations in the market that are not participating in the reverse auction and will require repacking at the conclusion of the reverse auction.

As an example of the reverse auction bid option A, "Broadcaster X" determines that they are interested in relinquishing all of their spectrum usage rights and are interested in participating in the FCC's reverse auction. To that end Broadcaster X must first determine if he is eligible to participate. The reverse auction is limited to full power television stations and Class A television stations operating on both commercially allocated channels and noncommercial educational (NCE) reserved channels. As a full power commercial UHF station licensee, Broadcaster X is qualified, and determines the "value" of the spectrum usage rights he is willing to relinquish to be $30 million following the guidance provided by the FCC in their yet to be published public notices.

The broadcaster enters the reverse auction pool with other stations in the television market that have decided to participate. Some of the stations that are also participating in the auction are willing to relinquish their spectrum rights at different levels, or values, than Broadcaster X.

The stations that choose to participate in the reverse auction notify the FCC of their decision to participate. The FCC determines the target amount of spectrum it would like to clear in the market, based upon the number of participating stations, and announces the opening bid price for the bid options. At this point the participating stations either accept the opening bid price or reject the opening bid price. Each station that rejects the opening bid price leaves the reverse auction and will be repacked if necessary. The stations that accept the opening bid price are then provided with a lower, or descending, bid price for the three bid options. For each round the participating stations either accept the bid price for one or more of the bid options or reject the bid prices at, which point they leave the reverse auction. The auction continues until the FCC has either cleared the desired spectrum amount or there are no participating stations.

If the bid is accepted in the reverse auction, Broadcaster X will go off the air within 90 days of the conclusion of both the reverse and forward auctions and relinquish all of his spectrum usage rights to the FCC. The relinquished spectrum rights will then be included in the forward auction. If the auction price submitted by the FCC is not accepted, then Broadcaster X will not relinquish any of the spectrum rights and will continue to broadcast on his currently assigned frequency, and will be subject to the involuntary repacking that will occur at the conclusion of the reverse and forward auctions.

While on the surface this may seem to be a relatively straightforward process, in reality it is quite complicated. For each station bid that is not accepted, that station will remain on the air. Thus, there is a high likelihood that the station will have to be repacked into the remaining television broadcast spectrum, even if the station is not operating in the targeted range of channels 31 to 51. Stations operating below channel 31 may have to be relocated ("repacked") to free up spectrum for stations in the upper UHF band that will also require relocation.

Upon further examination, Broadcaster X has decided to participate in the reverse auction, but has chosen to relinquish the spectrum rights for the UHF channel Broadcaster X is currently the licensee of, and is willing to accept an allocation of spectrum rights to a VHF channel (bid option B). Broadcaster X has determined the appropriate level of compensation for this "migration" from the UHF band to the VHF band to be $25 million. As with the previously discussed bid option A, Broadcaster X participates in the bidding. If the FCC's "bid" is accepted, then Broadcaster X will receive auction proceeds and be assigned a new channel in the VHF band, assuming there is space in the VHF band in the broadcaster's market. Broadcaster X will be fully responsible for all costs associated with the move to the newly assigned frequency in the VHF band.

Broadcaster Y, a non-commercial educational UHF station licensee also located in the same market with Broadcaster X, has decided to participate in the reverse auction and has chosen to participate under bid option C, relinquishing their spectrum usage rights so they can share Broadcaster Z's channel. Under this arrangement, Broadcaster Y has worked out an agreement with Broadcaster Z to share Broadcaster Z's spectrum usage rights. Broadcaster Y has accepted a bid of $20 million to relinquish the broadcast usage rights and to share Broadcaster Z's channel. Broadcaster Y will be fully responsible for the expenses associated with the shared channel arrangement with Broadcaster Z. All compensation arrangements between broadcasters Y and Z are between those parties, the FCC will only compensate Broadcaster Y from the auction proceeds based upon the accepted bid.

In the reverse auction, each participating station is offering the same goods for sale, that is, 6 MHz of spectrum for a particular geographic area. The difference is the size of the geographic area covered by each station, based upon each station's licensed coverage contour, and the population within the geographic area covered by each station, again based upon its licensed coverage contour, and its channel in the UHF band. This is illustrated in **TABLE 1** on the following page. **TABLE 1** compares stations on two separate television channels, 28 and 51 respectively, with four stations on each channel from four different sized markets.

How will a broadcaster know how much their television station is worth in the reverse auction? One way to consider the value of a television station is to look at the price per population covered, or "price per pop". This metric simplifies part of the analysis for the FCC by allowing the FCC to consider the maximum population available for the lowest bid price offered in the reverse auction. For example, if two stations in a television market are each bidding in the reverse auction, the station that provides the largest audience coverage for the lowest "price per pop" would be the logical bid for the FCC to accept. So, while station "X" has placed a higher bid in the auction than station "Y", if station "Y" provides greater market coverage and thus a lower "price per pop", it would win the bid.

By choosing Broadcaster Y's bid, the FCC clears spectrum in the market as well as allowing a station to continue to broadcast in the market by sharing spectrum usage rights with Broadcaster Z.

TABLE 1

Population Comparison for Television Stations on Channels 28 and 51

Market	DMA Rank	Call Letters	Channel	Television Households	Contour Population	Area w/in Contour in sq. km	Pops w/in sq. km
New York	1	WNBC	28	7,461,030	20,141,597	26,575	758
Memphis	50	WREG	28	672,390	1,623,756	29,707	55
Rochester	78	WUHF	28	402,300	1,138,548	13,024	87
Anchorage	146	KTVA	28	158,120	355,801	8,846	40
San Francisco-Oakland-San Jose, CA	6	KDTV-DT	51	2,518,900	8,004,907	32,264	248
Memphis	50	WPXX	51	672,390	1,588,915	29,070	55
Augusta, GA-Aiken, SC	112	WFXG	51	264,130	687,327	17,196	40
Bend, OR	193	KOHD	51	64,160	200,925	13,303	15

Sources:
2014 Complete Television, Radio & Cable Industry Directory, Grey House Publishing
Chesapeake RF Consultants, LLC, Joseph M. Davis, P.E.
Nielsen 2013-2014 DMA Ranks, The Nielsen Company
Television Households - Television Bureau of Advertising

This logic holds true not only for stations in the same market but also for different market sizes. A full power station on channel 28 in New York is generally going to have a lower "price per pop" than a station in Memphis on the same channel, due to the difference in the population covered by each station in their respective markets (see the population within square kilometer in table above).

Spectrum usage rights are also more valuable in congested wireless markets than in more rural markets where spectrum is generally less constrained, such as – Bend, Oregon. The FCC will take this value differential into consideration when looking at the bid acceptance process for the reverse auction.

Other factors to be considered in the bid acceptance process for the reverse auction may include the difficulty of repacking a particular station "because they would block more potential channel assignments to other stations"[4], population served by the bidding stations

[4] FCC 12-118, § 3(A)(2).

(demographics), the density of the population served by the bidding stations (population per square kilometer of coverage), and the availability of VHF spectrum in a given market for relocation to the VHF band. These factors may be used to weigh the bids provided by the broadcasters in the reverse auction.

The New York City television market is the number one Nielsen designated market area (DMA 1) with 7.46 million television households. It consists of 7 VHF stations (full and low power) and 22 UHF stations (full and low power). Of the 29 stations serving the New York City DMA, 22 are full power stations with 18 of the full power stations occupying channels in the UHF band and 9 of the full power stations located within the 600 MHz band. Both the Fox and CBS owned and operated (O&O) stations in New York are located in the 600 MHz band as well as the flagship stations for Univision, Telemundo, and Azteca America.

The need for additional wireless spectrum in markets like New York City will place a great demand on the FCC to clear spectrum for wireless usage via both the reverse auction and in the repacking of the remaining stations. **TABLE 2** on the next page illustrates the New York City television market.

A possible advantage in the New York City market is the opportunity to co-locate many of the stations together using broadband antennas and sites such as One World Trade Center, Empire State Building, or Four Time Square. Co-locating stations at one site, especially with broadband antennas, eliminates co-channel interference, thus making it possible to "stack" channels on top of each other. As an example, it would be possible, utilizing a broadband antenna, to have channels 20-26 all co-located at one site.

TABLE 2
New York City Television Stations

Call Letters	Digital Channel	Full Power	Low Power	Network Affiliation	600 MHz Band
WKOB-LD	2		✓	Daystar	
WBQM-LD	3		✓	CNN Latino	
WNYZ-LP	6*		✓	Audio	
WABC	7	✓		ABC	
WNJB	8	✓		PBS	
WPIX	11	✓		CW	
WNET	13	✓		PBS	
WEBR-LD	17		✓	GCN	
WMBC	18	✓		IND	
WLIW	21	✓		PBS	
WFTY	23	✓		Uni Mas	
WNYE	24	✓		IND	
WASA-LD	25		✓	Estrella	
WTBY	27	✓		TBN	
WNBC	28	✓		NBC	
WFME	29	✓		REL	
WPXN	30	✓		ION	
WFUT-DT	30	✓		Uni Mas	
WPXO-LP	34*		✓	Mundo Fox	
WNJU	36	✓		Telemundo	✓
WWOR	38	✓		My TV	✓
WNYN-LD	39		✓	Azteca America	✓
WXTV	41	✓		Univision	✓
WSAH	42	✓		Shopping	✓
WCBS	43	✓		CBS	✓
WNYW	44	✓		Fox	✓
WLNY	47	✓		IND	✓
WRNN	48	✓		News	✓
WNJN	51	✓		PBS	✓

Sources:
FCC TV Query at www.fcc.gov
StationIndex.com
An * indicates a station still broadcasting with an analog signal.

To be a participant in the reverse auction, a station must provide the following information:

- The applicant's name and contact information;
- The license(s) (including station and channel information, full power or Class A status, and NCE status) and the associated spectrum usage rights that may be offered in the reverse auction;
- Any additional information required to assess the spectrum usage rights available for the reverse auction;
- The identity of the individuals authorized to bid on the applicant's behalf;
- The applicant's ownership information as set forth in section 1.2112(a) of the FCC rules (47 C.F.R. § 1.2112 and 47 C.F.R. § 1.2105(a)(2)(ii)(B));
- For a channel sharing applicant, the channel the parties intend to share and any necessary information regarding the channel sharing agreement;
- An exhibit identifying any bidding agreements, bidding consortia, or other such arrangements to which the applicant is a party, if permitted;
- Any current delinquencies on any non-tax debt owed to any federal agency, but only if we (FCC) determine in this proceeding that such information is necessary in order to assess the licensee's eligibility to participate in the reverse auction . . . that would allow the Commission to offset incentive payments by the amount of the licensee's outstanding delinquencies;
- Any additional information that the Commission may require.[5]

Furthermore, applicants would be required to certify on the pre-auction application that:

- The applicant meets the statutory and regulatory requirements for participants in the reverse auction, including any requirements with respect to the applicant's licenses for the spectrum usage rights offered in the reverse auction;
- If the applicant is a Class A television station, that it is, and will remain during the pendency of its application(s), in compliance with the ongoing statutory eligibility requirements to remain a Class A station;
- For a channel sharing applicant, that the channel sharing agreement is consistent with all Commission rules and policies, and that the applicant accepts any risk that the

[5] FCC 12-118, § 9(A)(2).

implementation of the channel sharing agreement may not be feasible for any reason, including any conflict with requirements for operation on the shared channel;

- For a channel sharing applicant, that its shared channel facilities will continue to provide minimum coverage to its principal community of license as set forth in the Commission's rules;

- The applicant agrees that the bids it submits in the reverse auction are irrevocable, and binding offers of the licensee;

- The applicant agrees that it has the sole responsibility for investigating and evaluating all technical and marketplace factors that may have a bearing on the bids it submits in the reverse auction; and

- The individual submitting the application and providing the certification is authorized to do so on behalf of the applicant.[6]

Based upon my own conversations with members of the Media Bureau, I believe the Commission will ask for additional information pertinent to the re-packing process. The anticipated additional questions will be addressed in Chapter 4's discussion of the re-packing process.

Forward Auction

The forward auction "will identify the prices that potential users of repurposed spectrum would pay for new licenses to use the spectrum."[7] In past spectrum auctions "a fixed quantity of spectrum is licensed based on a band plan defined in the service rules. The licenses in the forward auction will depend upon how much spectrum the reverse auction clears in specific geographic areas."[8] In this situation the FCC will not know how much spectrum it will have available for auction until the reverse auction has run its course. The Spectrum Act gives the FCC the authority to run the two auctions simultaneously. It would be very difficult to clear

[6] FCC 12-118, § 9(A)(2).
[7] FCC 12-118, § 3(B).
[8] FCC 12-118, § 3(B).

broadcast spectrum and auction off that same spectrum at the same time. Therefore, the FCC has decided to run the reverse auction and then the forward auction.

Spectrum Band Plans

The spectrum band plans provided in the FCC's *Report and Order Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions* (FCC 14-50) are designed to maximize the repurposing of spectrum in the 600 MHz band for broadband wireless utilization. The plans range from two sets of paired blocks (36 MHz scenario) to twelve sets of paired blocks (144 MHz scenario). Since the amount of spectrum available in any given television market will vary with the amount of spectrum that can be cleared through the reverse auction and the repacking of the remaining television stations, the FCC has adopted a "market variability" approach – flexible allocation of spectrum blocks based on geographic areas and market needs rather than a lowest common denominator for all markets.

> The 600 MHz Band Plan we adopt consists of paired uplink and downlink bands offered in 5 + 5 MHz blocks. The uplink band will begin at channel 51 (698 MHz), followed by a duplex gap, and then the downlink band. We will license the 600 MHz Band on a geographic area license basis, using Partial Economic Areas (PEAs). Further, we will accommodate market variation: specifically, we will use the 600 MHz Band Plan in all areas where sufficient spectrum is available; and in constrained markets where less spectrum is available, we may offer fewer blocks, or impaired blocks, than we generally in the 600 MHz Band Plan. Finally, we establish technically reasonable guard bands to prevent harmful interference and to ensure that the spectrum blocks are as interchangeable as possible.[9]

There are a number of firsts in the FCC's 600 MHz Band Plan. These include the use of paired 5 MHz blocks for uplink and downlink, the use of Partial Economic Areas (PEAs) as the

[9] Federal Communications Commission, *Report and Order Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive* Auctions, 2014, FCC 14-50, § 3 (A)(2)(45).

licensed geographic blocks, and the market variability aspects of the 600 MHz Band Plan. There is no way of knowing the amount of spectrum that can be repurposed in each market until after the reverse and forward auctions and the repacking of the remaining television stations. Prior spectrum auctions have been very structured in the allocation of spectrum to be auctioned and most wireless spectrum auctions have relied on either Cellular Market Areas (CMAs) or larger market areas as the designated license blocks. The inclusion of 5 + 5 MHz blocks will facilitate the 600 MHz band supporting Frequency Division Duplex (FDD) operations, an operating technology that is especially well suited to the signal propagation characteristics found in the 600 MHz band.[10]

In developing the 600 MHz Band Plan, the FCC has focused on five goals as the guiding tenets of the Band Plan. These five goals include: (1) utility, (2) certainty, (3) interchangeability, (4) quantity, and (5) interoperability.[11] The 600 MHz Band Plan achieves these goals by making spectrum blocks interchangeable from a technical and functional aspect. The use of paired 5 MHz blocks provides the forward auction participants with a known entity, thus maximizing both the utility and the certainty of the spectrum blocks in the auction. The Plan also incorporates an uplink/downlink scheme that is reliably used internationally, and should facilitate international border operations with minimal cross border coordination.

The FCC adopted PEAs (Partial Economic Areas) because PEAs are smaller than Economic Areas (EAs), yet fit within EAs, and can easily be aggregated into larger areas such as Major Economic Areas (MEAs) and Regional Economic Areas (REAs).[12] PEAs, like CMAs, divide urban and rural areas into separate service areas, thus allowing rural carriers to focus on

[10] FCC 14-50, § 3(A)(2)(b)(64).
[11] FCC 14-50, § 3(A)(1)(41).
[12] FCC 14-50, § 3(A)(2)(44).

their desired markets without having to acquire urban blocks.[13] The FCC also adopted PEAs to encourage entry into the auction by applicants that want to provide wireless broadband services on a local level. For major service providers, the PEAs can be aggregated into large block creating regional coverage areas.[14]

Uplink and Downlink Blocks

Television channels are allocated as 6 MHz blocks with each block assigned to a channel. The UHF (Ultra High Frequency) band consists of 228 MHz of spectrum divided into 38 six megahertz channels (14 – 52). The incentive auction is the FCC's chosen methodology to clear broadcasters from the 600 MHz band and to repurpose the freed up spectrum for wireless broadband and other services. 5 MHz blocks are the spectrum block allocations for broadband wireless service in the repurposing of the 600 MHz band through the incentive auction.

The Band Plan calls for pairs of 5 MHz spectrum block, one block allocated for uplink transmission and one block allocated for downlink transmission. With all the band plans considered by the FCC, the uplink portion of the paired spectrum blocks has always been assigned to the upper most portion of the 600 MHz band and descending. These are known as channel 51 down plans. The Commission considered a number of variations for the downlink portion of the 5 + 5 MHz pairs, but settled on a plan that will provide for a nationwide standard for uplink transmissions and allows for variability in the downlink assignments.

In each instance, the amount of spectrum available in a given market is directly dependent on the amount of spectrum cleared through the reverse auction and the repacking

[13] FCC 14-50, § 3(A)(2)(18).
[14] FCC 14-50, § 3(A)(2)(c)(69).

process. The cleared spectrum will then be auctioned off in the forward auction. The number of 5 MHz paired blocks will be determined by the absorption rate (supply and demand) for that particular market. The low demand for spectrum in a market will allow the FCC more flexibility in allocating uplink/downlink blocks for current and future expansion in the market.

As would be expected, the markets that need the most wireless broadband spectrum are the large urban markets that have the greatest number of television stations. The Commission is hopeful that some of the smaller broadcasters in those markets will voluntarily choose to participate in the reverse auction; the more television stations that participate in the reverse auction, the more broadcast spectrum that can be repurposed for wireless use. The smaller the number of participating stations in the reverse auction, the greater the number of stations that will require repacking, and thus a decrease in the amount of spectrum in the market to be repurposed.

It is anticipated that the Commission's opening bid pricing will be greater in the more congested television markets as an incentive to increase the number of stations voluntarily participating in the reverse auction. The Commission's opening bid pricing, not yet made public, will most likely be less robust in the medium and small television markets. These markets have fewer stations and initially a smaller need for wireless broadband spectrum, but may be significantly impacted by repacking changes needed in adjacent major television markets. The opening bid pricing may increase in these medium and small markets that are adjacent to major markets in order to facilitate repacking in the major markets.

Of course the main difficulty facing the Commission is the relationships between adjacent television markets. A change in one market has a domino effect into all of the adjacent markets. For example, the New York City television market, while bounded on one side by the

Atlantic Ocean, is surrounded on three sides by five television markets – Philadelphia, Wilkes Barre-Scranton, Hartford-New Haven, Binghamton, and Albany-Schenectady-Troy. Any repacking change made to a television station in the New York City market must be coordinated with these five immediately adjacent markets, these five markets have adjacent markets in which the changes must also be coordinated. The complexity of these changes and the FCC's new software, *TV Study*, are discussed in more detail in Chapter 4.

Band Plan Examples

While the FCC has developed eleven Band Plans, I will address only four of these plans, and provide examples of the four plans that focus on the portions of the Band Plans that are unique to that particular plan. The examples chosen for illustration are representative of two possible scenarios (1) for television markets with minimal spectrum clearance and (2) for television markets with a high level of spectrum clearance. In all instances the uplink portion starts at channel 51 and descends down from there. This provides a nationwide configuration that provides the wireless operators with a portion of the Band Plan that is consistent from market to market. The downlink portion is separated from the uplink portion by a duplex guard band 11 MHz wide. This guard band provides sufficient separation from the uplink and downlink signals to eliminate the potential for interference using an FDD modulation platform. Additional guard bands are required to protect the remaining broadcast operations from interference from the wireless broadband operations and vice versa. These guard bands are typically three to seven megahertz wide with some as wide as 11 MHz. The guard bands may be used for non-licensed operations as well as for wireless microphone use.

In all Band Plans, channel 37 is not utilized for either broadcast operations or wireless broadband operations. Channel 37 is currently set aside for medical telemetry use and in the proposed band plans will continue to be used for medical telemetry and will also be made available for some non-licensed use.

60 MHz Scenario

The 60 MHz Band Plan scenario consists of four pairs of 5 MHz blocks, four uplink and four downlink blocks. The 60 MHz Band Plan preserves 26 UHF channels for broadcast operations (excluding channel 37) and repurpose four pairs of 5 MHz blocks (40 MHz) for wireless broadband operations. There are two guard bands – one 9 MHz guard band separating channel 41 from the downlink blocks A-D and the 11 MHz duplex guard band separating the uplink blocks A-D from the downlink blocks.

21	22	23	23	24	25	26	27	28	29	30	31	33	34	35	36	37	38	39	40	41	9 MHz	A	B	C	D	11 MHz	A	B	C	D	700 MHz

Downlink Blocks
Uplink Blocks
Guard Bands

As illustrated above, each downlink block (A) has a matching uplink block (A). It is this paired block configuration that will facilitate the wireless broadband providers in implementing the Frequency Division Duplex (FDD) operations that most providers requested of the FCC. In the 60 MHz Scenario the FCC will repurpose four sets of paired uplink/downlink blocks.

78 MHz Scenario

The 78 MHz Band Plan scenario consists of six pairs of 5 MHz blocks. The 78 MHz Band Plan preserves 23 UHF channels for broadcast operations (excluding channel 37) and repurpose six pairs of 5 MHz blocks (60 MHz) for wireless broadband operations. There are two guard bands – one 7 MHz guard band separating channel 38 from the downlink blocks A-F and the 11 MHz duplex guard band separating the uplink blocks A-F from the downlink blocks.

21	22	23	23	24	25	26	27	28	29	30	31	33	34	35	36	37	38	7 MHz	A	B	C	D	E	F	11 MHz	A	B	C	D	E	F	700 MHz

Downlink Blocks
Uplink Blocks
Guard Bands

108 MHz Scenario

The 108 MHz Band Plan consists of eight pairs of 5 MHz blocks. The 108 MHz Band Plan preserves 18 UHF channels for broadcast operations (excluding channel 37) and repurpose eight pairs of 5 MHz blocks (80 MHz) for wireless broadband operations. In this scenario there are four guard bands – an 11 MHz guard band after channel 32 and downlink block A, a 3 MHz guard band after downlink block B and channel 37, a 3 MHz guard band between channel 37 and downlink block C, and an 11 MHz duplex guard band between downlink block H and uplink block A. As illustrated in this Band Plan scenario, as the FCC repurposes more spectrum because of the continued use of channel 37 for non-broadcast and non-wireless operations; the inclusion of additional guard bands is required and creates a scenario with more interruptions in the continuity of the downlink portion of the Band Plan.

21	22	23	23	24	25	26	27	28	29	30	31	32	11 MHz	A	B	3	37	3	C	D	E	F	G	H	11 MHz	A	B	C	D	E	F	G	H	700 MHz

Downlink Blocks
Uplink Blocks
Guard Bands

126 MHz Scenario

The 126 MHz Band Plan consists of 10 pairs of 5 MHz uplink/downlink blocks. The 126 MHz Band Plan preserves 15 UHF channels for broadcast operations (excluding channel 37) and repurpose ten pairs of 5 MHz blocks (100 MHz) for wireless broadband operations. As in the 108 MHz Band Plan this scenario also utilizes four guard bands – a 9 MHz guard band after channel 29 and before downlink block A, a 3 MHz guard band after downlink block F and before channel 37, a 3 MHz guard band between channel 37 and downlink block G, and an 11 MHz duplex guard band between downlink block J and uplink block A. This band plan provides 50 MHz of downlink spectrum and 50 MHz of uplink spectrum.

21	22	23	23	24	25	26	27	28	29	9 MHz	A	B	C	D	E	F	3	37	3	G	H	I	J	11 MHz	A	B	C	D	E	F	G	H	I	J	700 MHz

Downlink Blocks
Uplink Blocks
Guard Bands

These are just four examples of the eleven Band Plans developed by the FCC for the reallocation of the 600 MHz spectrum from UHF broadcast operations to wireless broadband operations. Illustrations of all eleven Band Plans are provided in the Appendix.

Repacking the Spectrum

At the conclusion of the Incentive Auction, the television stations that chose not to participate in the Reverse Auction, or the stations that chose to participate but were not successful in the Reverse Auction, will have to be repacked, or relocated, in the non-repurposed portion of the UHF band remaining in their television market. As with the earlier discussions of the Incentive Auction, the FCC has no way of knowing how much of the UHF spectrum will remain for television broadcast use until the end of both the Reverse and Forward auctions.

During the reverse auction bidding process the Commission will undertake a "repacking feasibility check"[15] to ensure that each station that remains on the air after the incentive auction is reassigned to a channel that meets the regulatory requirements. That is, the FCC will 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-69".[16] Final channel assignment and optimization will be finalized after the "final stage rule" is satisfied and bidding has stopped.

In order to conduct the "repacking feasibility check" each station will have an "interference-paired" file and a "domain" file, combined these files are known as the "constraint files"[17]. "The interference-paired file will include a list of all the other television stations that could *not* be assigned to operate on the same channel or on an adjacent channel with each particular station."[18] "The domain file will include a list of all the channels to which the station

[15] Federal Communications Commission, *Report and Order Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, 2014, FCC 14-50, § 3(B)(1).
[16] *Middle Class Tax Relief and Job Creation Act of 2012*, Pub. L. No. 112-96, §§ 6403, (b)(1)(B), (b)(2), 125 Stat. 156 (2012) (Spectrum Act).
[17] FCC 14-50, § III(B)(1)(114).
[18] FCC 14-50, § III(B)(1)(114).

could be assigned considering "fixed constraints", that is, incumbents in the bands other than domestic television stations that are entitled to interference protection at fixed geographic locations and on specific channels."[19] The FCC cannot successfully end an auction segment without meeting the "final stage rule" that requires the non-participating television stations have a channel assignment and that the proceeds of the forward auction provide sufficient funds to cover the costs of the repacking for that particular television market and the associated administrative costs.[20]

As should be apparent to the reader, the number of moving parts in the Incentive Auction changes with every variable and every possible iteration during both the reverse and forward auctions. The "clearing target"[21], estimated prior to the commencement of each reverse auction, is the Commission's estimation of the amount of spectrum to be cleared in a given market based upon the number of broadcast stations that are willing to relinquish their spectrum usage rights at the announced opening prices by the FCC. The "clearing target" dictates the number of stations in a given market that will require repacking. Each time a station drops out of the reverse auction the repacking feasibility checker will be run to ascertain channel availability for the station that dropped out of the auction. Each station that drops out of the auction has the potential to change the "clearing target's" viability for a given market.

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[19] FCC 14-50, § III(B)(1)(114).
[20] FCC 14-50, § III(B)(1)(118).
[21] FCC 14-50, § III(B)(1)(116).

The Spectrum Act requires the FCC to 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-69"[22] when repacking a non-voluntary television station to replicate the station's coverage area and population served. The determination of the station's coverage area and population served are to be determined as of February 22, 2012, the date the Spectrum Act was enacted, by the methodologies in OET Bulletin No. 69, titled "Longley-Rice Methodology for Evaluating TV Coverage and Interference."[23] OET-69 provides guidance for the implementation of Longley-Rice coverage and interference studies. The FCC maintains a computer program that utilizes the methodologies for the Longley-Rice studies. The computer program incorporates population data, geographic terrain data, and data about a station's transmission facility including antenna height above average terrain, effective radiated power, and antenna pattern constraints, if any. The output of the FCC's Longley-Rice computer program is a prediction of the subject station's coverage area and population served.[24] As with any computer program, the output is always subject to the validity of the input data. The FCC's original Longley-Rice computer program was developed before the implementation of digital television and was used to study both the analog NTSC television signals and the digital ATSC signals to predict digital coverage replication for the transition to digital television. The databases utilized by the original Longley-Rice model have not been updated and in several cases are no longer supported by the

[22] Spectrum Act, §§ 6403(b)(1)(B), (b)(2), 2012.
[23] FCC 14-50, § III.B.2.b(127).
[24] FCC 14-50, § III.B.2.b(127).

government agencies that developed the data in the first place. As an example, the population database used by the original Longley-Rice program is 2000 census data.

The FCC has developed a new computer program, *TV Study*, for performing the coverage area and population served estimates. The new program relies on updated inputs, in particular: (1) population data from the 2010 census, (2) terrain data with a finer level of accuracy, (3) corrected known inaccurate data in the FCC's databases, (4) more effectively addressed antenna constraints, in particular, antenna beam tilt, (5) more precise calculation of engineering data previously addressable in the Longley-Rice model, and (6) the establishment of a uniform calculation grid.[25] *TV Study* is capable of dealing with the volume of data processing required to support the reverse auction and the need to repeatedly run the "repacking feasibility checker". The older Longley-Rice model cannot, in a timely manner, deal with the volume of study parameters to support the reverse auction. Another flaw in the original Longley-Rice model is its inability to produce uniform calculation grids. A uniform nationwide calculation grid is essential for the analysis of coverage area and population served for the repacking process.[26] The updated data and upgraded software provide a more accurate prediction of a station's coverage area and population served.

Anytime there is a proposed change in the "yard stick", there will be groups that object to the use of the new "yard stick", pointing out several complaints: (1) there was nothing wrong with the old one, it has been used for decades and has served broadcasters well, (2) use of the new yard stick will produce results that are different from the old yard stick, and (3) will perhaps harm some of the users. In this instance it is the National Association of Broadcasters (NAB)

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[25] FCC 14-50, § III.B.2.b(128).
[26] FCC 14-50, § III.B.2.b(130).

and several broadcasters that are calling the FCC's move to *TV Study* as a changing of the rules that violate the Spectrum Act.[27]

The NAB has strongly objected to the use of *TV Study*, stressing that the Spectrum Act specifically calls for the use of OET-69 as it existed in February 2012 without any updated data and their interpretation of "all reasonable efforts" is a "hold harmless" provision, i.e., that in no way should the repacking of the UHF spectrum have any detrimental impact on the stations that are relocated because of the repurposing of the spectrum to wireless broadband.[28] The NAB interprets "all reasonable efforts" as stated in the Spectrum Act to mean the Commission is required to "precisely and strictly preserve broadcasters' coverage areas and population served without considering the other objectives of the Spectrum Act."[29]

The FCC interprets "all reasonable efforts" to mean the Commission should take into account all of the objectives set forth in the Spectrum Act including the repurposing of the 600 MHz Band for uses other than television broadcast. In the Commission's interpretation, they (FCC) must consider all the objectives set forth in the Spectrum Act and weigh the objectives on the greatest impact each objective would have to the general public.[30] A further discussion of broadcaster objections to the FCC's use of *TV Study* and the FCC's databases is found later in the document under National Association of Broadcasters.

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[27] FCC 14-50, § III.B.2.b.(129).
[28] NAB *TV Study* Public Notice Comments, April 4, 2014.
[29] FCC 14-50, § III.B.2.a.(123).
[30] FCC 14-50, § III.B.2.a.(126).

Catalog of Costs

Television stations that chose not to participate in the reverse auction, or which were not winning bidders in the reverse auction, will be "repacked" or relocated into the remaining UHF spectrum. Stations that are involuntarily repacked are entitled to compensation for reasonable transition expenses, i.e., cost of a new antenna, cost of installation of a new antenna, cost of a new transmitter, with installation, and similar expenses as outlined in the "Catalog of Potential Expenses and Estimated Costs" that is included in Widelity, Inc.'s 2013 report to the FCC. The "Catalog" identifies potential expenses that a repacked television station may incur as part of the relocation process and provides an estimated cost range for the identified expense. Television broadcasters are encouraged to use the Catalog as a planning tool for estimating the anticipated expenses that they may incur as well as a guideline for filing for initial funding based upon estimated costs provided in the Catalog. The final reimbursement to the broadcaster will be based upon actual expenses incurred, documented by the broadcaster with invoices and contracts for services provided. The FCC will use the Catalog to review broadcasters' requests for initial funding and in the review of the actual expenses incurred. While the Catalog does not include all possible costs that may be associated with a possible repacking, it addresses the most likely costs associated with the repacking process.

The Catalog breaks down the expenses into logical groupings based upon the equipment types and services anticipated in the repacking process. These include: (1) Transmitter and In-Building Expenses, which would include retuning of existing transmitters, replacement of existing transmitters with new transmitters, and other transmitter related expenses, (2) Antennas, including the cost of a replacement antenna, the cost of removal and disposal of the existing antenna, and the cost of installation and proof of performance for the replacement (new) antenna, (3) Transmission Lines, including the cost of removal of the existing transmission line, the cost of the new transmission line, and the cost of installation of the new transmission line, (4) Tower Equipment and Rigging, including the cost of structural analysis on existing towers, the cost of strengthening existing towers to meet the latest Revision G standard for towers, and rigging costs associated with the removal and installation of existing and new antennas and transmission lines, (5) Interim Facilities, including costs that may be incurred by a broadcaster that has to construct and operate an interim facility on either their existing channel or their repacked allocated channel to facilitate broadcast operations until the final construction can be completed on their full-power facility on the repacked channel, (6) Special Cases, which includes extraordinary expenses directly related to operations on channel 14 and distributed transmission services[31] (DTS) both of which have expenses not usually found with channels or traditional transmission services, (7) Miscellaneous Expenses not addressed in the previous categories, and (8) Professional Services including the services of structural engineers, consulting RF engineers, engineering services for installation and proof of performance of specialized equipment, and legal fees.[32] The list of anticipated expenses is extensive, but since every broadcast installation is unique, there will be expenses that are not directly addressed in the Catalog. The following sections look at each of the expense categories in more detail. For the purpose of this discussion, all examples will be based upon UHF television stations, the most likely stations to be repacked.

[31] Distributed transmission services rely on multiple transmitter and antenna systems all operating on the same channel to distribute, or broadcast, the over the air signal. There are only a handful of stations in the U.S. using a DTS transmission platform and most of these stations are located in the Western U.S. and are in locations with challenging terrain issues. Additional equipment and consulting RF engineering services are required for such an operation.

[32] Widelity, Inc., *Catalog of Potential Expenses and Estimated Costs*, 2013.

Transmitter and In-Building Expenses

The transmitter is the engine of a UHF television station. The transmitter takes the electronic signal produced at the studio and places the signal into a carrier wave based upon the assigned frequency of the station, then amplifies the signal and "pumps" it up the transmission line to the antenna where it is radiated over the air. Modern UHF television transmitters are typically one of two types, an Inductive Output Tube (IOT) type or a Solid State type transmitter. Both transmitter types perform the same function. IOT transmitters rely upon a large inductive output tube to generate the final output power. These IOT transmitters are generally found in configurations of one, two, or three IOT cabinets and have output power ranges of between 20 kilowatts (kW) to 90 kW. Solid State transmitters rely on banks of solid state devices, large output transistors, ganged together to produce the desired output power. These transmitters may be air-cooled or liquid-cooled and have output power ranges between 1 kW to 20 kW for air-cooled transmitters and 1 – 50 kW for liquid-cooled transmitters. Traditionally, IOT transmitters have been more efficient in the use of electrical power, and generally more cost effective to purchase and operate. That has changed in recent years and Solid State transmitters are now achieving the same levels of efficiency as the IOT transmitters and may be more cost efficient in the long run due to the high cost of replacing IOTs. A single IOT can cost between $35,000 - $45,000, while failure of a high output power transistor is usually in the range of $1,500 - $2,500 each.

A television station that has been assigned a new channel, or repacked, may be able to have its transmitter retuned rather than replaced. There are a number of factors that will determine whether a transmitter can be retuned. The first question to consider is how close the newly assigned channel is to the original channel. If the channel is adjacent, say channels 33 and 34, then it is reasonable to assume that the station can have its transmitter retuned. This type of channel change would be considered a "minor banding issue" change and the cost for retuning the transmitter would be dependent upon the type of transmitter. For an IOT type transmitter the cost of a minor banding issue retune would be in the range of $115,000 - $315,000, depending on the number of IOT cabinets in the transmitter. For a Solid State transmitter that same retuning would be in the range of $10,000 - $100,000, depending on the power level and the number of solid-state transistor banks involved. In both cases, anytime a transmitter changes from one channel to another a new mask filter will be required. The cost for a new mask filter will range from $3,000 - $90,000, depending on the channel and the output power of the transmitter being retuned.[33] An RF engineer who specializes in major transmitter modifications may perform the retuning of an existing transmitter. These types of modification can take one to two weeks of engineering time, during which time the transmitter being retuned is off the air. Thus there is the need for the station to either operate on an existing backup transmitter, if one exists, or the need to build an interim transmitter facility for the station to continue to broadcast while the retuning of the main transmitter is taking place.

If the transmitter cannot be retuned because the "distance" between channels is too great, say channel 51 to channel 22, or because the design of that particular transmitter does not support retuning of the transmitter, or the transmitter is no longer supported by the manufacturer, or the cost of retuning would exceed the cost of a new transmitter, then the transmitter must be replaced. As with the retuning, the original transmitter will be out of service while being replaced, so the station must either operate on its existing backup transmitter, if the station has

[33] *Catalog of Costs*, 2013, 3-4.

one, or build and operate an interim transmission facility while the original transmitter is being replaced (a recurring theme in the discussion of the repacking process). While the expense associated with the replacement of an existing transmitter with a new transmitter again will depend on the configuration of the original transmitter plant as well as the power requirements of the new assigned channel, the FCC is generally looking to replace the original transmitter with one of like kind and utility. The expense range for IOT transmitters; including installation, new mask filter, and proof of performance, is between \$450,000 - \$1,205,000. The expense range for Solid State transmitters; including installation, new mask filter, and proof of performance, is between \$35,000 - \$1,075,000.[34] A current estimate of delivery time from transmitter manufacturers is 90 to 120 days from placing the order with a 50 percent deposit and delivery to the station. The delivery schedule will change when the FCC announces the number of stations impacted by the repacking process and orders flood in.

Other possible expenses in the Transmitter and In-Building Expenses category include possible electrical work required for the new transmitter, air handling upgrades, if needed, and additional building space, if required.

Antennas

Television broadcast antennas come in two classifications: (1) frequency and pattern specific and (2) broadband pattern specific. The majority of domestic television stations rely on frequency and pattern specific antennas. As the name implies, the antenna is manufactured for a channel's specific characteristics for that particular geographic location and is not designed for

[34] *Catalog of Costs*, 2013, 4-5.

operation on another channel, much less at a different location. In some instances it is possible to use a frequency and pattern specific antenna for an adjacent channel, i.e., channels 22 and 23, but those instances are very infrequent and the cost of determining if an antenna can be used on an adjacent channel are prohibitive. Broadband pattern specific antennas are designed for multiple stations operating within a given channel range, i.e., channels 24 – 36, to share the antenna. In this instance each station provides their signal to a combiner system that combines the signals together and delivers the combined signals to the broadband antenna for propagation. In this antenna design, all of the stations must share the same coverage pattern – one cannot have two directional channels and two omnidirectional channels on the same antenna. It is estimated that between 10 – 15 percent of all full-power domestic television stations operate on broadband antennas.

The Spectrum Act requires the FCC to use "all reasonable efforts to preserve" a repacked station's coverage area and population served. To do this, the FCC is not considering relocating stations from their existing transmitter sites, but using "all reasonable efforts" to look at the cost of replacing the equipment necessary to replicate the existing coverage. Therefore, if a station is operating with a frequency and pattern specific antenna, the FCC would consider the cost of replacing a frequency and pattern specific antenna.

The estimated costs for frequency and pattern specific antennas range from $50,000 - $270,000, depending on whether the antenna is side mounted or top mounted on the tower or support structure and the pattern, polarization, and power handling characteristics of the antenna.[35]

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[35] *Catalog of Costs*, 2013, 7.

The estimated costs for broadband pattern specific antennas range from $450,000 - $1,000,000, depending on the number of stations ported into the combiner/antenna system.[36]

In all instances, the estimated cost for antennas does not include the cost of tower rigging, installation, and the cost of removing the existing antenna from the tower. Special consideration must be given to stacked antennas, where one antenna is mounted onto the top of another antenna. The cost of the bottom antennas, "will likely double due to the increased cost of structural components, such as heavier steel and longer structures".[37]

A current delivery time estimate for a single station frequency and pattern specific antenna is 90 – 120 days depending on the size and pattern characteristics of the antenna. A current delivery time estimate for a multi-station broadband antenna with combiner system is 120 – 150 days, depending on the number of stations, pattern characteristics of the antenna, and the antenna gain characteristics.

Transmission Lines

As with antennas, there are different types and sizes of transmission line. The transmission line, typically of a coaxial design, is used to carry the output signal from the transmitter to the antenna. Transmission line can be flexible or rigid. Flexible transmission line can have either a foam or air dielectric in the coaxial design. Flexible transmission line is a single continuous piece running from the transmitter to the antenna. Rigid transmission line comes in sections that are 19.5, 19.75, or 20 feet in length. Rigid transmission line is bolted together section by section, and the different sections lengths have properties that are best for

[36] *Catalog of Costs*, 2013, 7.
[37] *Catalog of Costs*, 2013, 8.

certain frequencies or channels. In some instances a station may be required to change out its transmission line when it is repacked to a different channel because the existing transmission line sections interfere with the new channel. Transmission line is typically priced out in a cost per foot based upon the type of line, flexible or rigid, and the diameter of the line, 7/8" to 8 3/16". The cost per foot of transmission line ranges from $10 per foot to $327 per foot. The price per foot estimates includes hangers and elbows, but does not include the cost of installation, which is covered in the tower section of the Catalog.[38] As an example, a station having to replace 2,200 feet of 6 1/8" rigid transmission line would have an estimated expense of $330,000 - $407,000, plus the cost of removing the existing transmission line and installing the new transmission line. Pricing of transmission line is subject to change based upon the commodity prices of copper.

A current estimated delivery time for flexible transmission line is 45 – 90 days, depending on the size and length of the transmission line and the availability of copper. A current estimated delivery time for rigid transmission line is 60 – 120 days, depending on the number of sections required, the diameter of the line, and availability of copper.

Tower Equipment and Rigging

Television broadcast antennas require a support structure to hold the antenna. Like FM radio television is a line of sight service. The height of the antenna to the horizon is the typical coverage area; the higher the antenna is above ground, the greater the coverage area. This can be achieved by mounting the antenna to a tower, a tall building, or even the top of a mountain. Antenna heights are listed as both a height above average terrain (HAAT) and a height above

[38] *Catalog of Costs*, 2013, 8-9.

ground level (AGL). The height above ground level gives the height at which the antenna is physically above ground while the height above average terrain gives an indication of the antenna's relative height when compared to the average terrain in the station's coverage area. An antenna may have a HAAT of 1,900 feet, but an AGL of only 400 feet because it is mounted on a 400-foot tower located on the top of a mountain or high ridge.

The expenses associated with the Tower Equipment and Rigging category focus directly on expenses related to a station's tower and the installation or removal of equipment on the station's tower. A station may have more than one tower and may incur expenses related to equipment on more than one tower.

Towers, as structures, are subject to engineering design parameters and over time the engineering requirements change. There are numerous towers in existence that were constructed between the 1950s and early 2000s that do not meet current standards of the Electronics Industries Alliance/Telecommunications Industry Association (EIA/TIA) RS-222-G "Structural Standards for Antenna Supporting Structures and Antennas", commonly known as Rev. G.[39] If the broadcaster is required to make a major modification on an existing tower, such as changing out an antenna and transmission line, or adding an additional antenna to an existing tower, then the tower will require at least a structural engineering tower load study. If the tower does not have current documentation (design specifications), a tower mapping study will be required as well. Based upon the outcome of the structural engineering load study, the tower may require modifications to bring it into compliance with Rev. G, and to be able to support the proposed changes or additions to the tower. Estimated expenses for an engineering load study range from $5,000 - $10,000, depending on the configuration of the tower. Current costs for mapping an

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[39] Widelity, Inc., *Response to the Federal Communications Commission for the Broadcaster Transition Study Solicitation – FCC13R0003*, 2013, 9.

undocumented tower are estimated at $12,000 - $16,000. Modifications to a tower can range from minor to serious and the pricing for those modifications can range from $100,000 - $1,000,000.[40]

If a tower cannot be modified to bring it into compliance, the construction of a new tower may be required. The pricing of new towers is difficult to estimate because of the variables associated with each construction. Some of the factors include the type of soil the tower is being constructed on, the height of the tower, the loading of the tower, and the location of the tower. Location can actually have a significant impact on the cost of tower. For example, towers located in hurricane zones are more costly to construct than similar towers in non-hurricane zones. Local building permits and zoning requirements can also play a major role in the cost of constructing a new tower. A new 1,500 foot tower, without an elevator, and normal soil conditions would have an estimated cost of $2,500 per foot of tower height, or $3.75 million.[41] The time to construct such a tower, assuming the land is available and zoning is not an issue, is typically between four and six months. As would be expected, weather can cause major delays in the construction of a tower.

Other costs associated with towers include the cost of rigging the tower for the removal of an existing antenna and/or transmission line, the installation of a new antenna and/or transmission line, additional costs associated with complex towers such as towers with candelabras and/or stacked antennas, and remote locations or tall buildings where helicopter lifts are required. These costs are highly variable and are dependent on the requirements for each site.

[40] *Catalog of Costs*, 9.
[41] *Catalog of Costs*, 9.

Interim Facilities

As the title implies, these expenses would be associated with the construction of interim facilities necessary in the repacking transition from the originally assigned television channel to the newly assigned television channel. There are no guidelines provided by the FCC as to whether these interim facilities should be on the existing channel or on the new channel. For some broadcasters it may be more appropriate to build an interim facility on the newly assigned channel to facilitate a quick transition to the new channel while the main transmitter and antenna system are converted over to the new channel. Other stations, due to delays in the transition in adjacent markets, may opt to build an interim facility on the old channel and operate on the interim facility while the transmitter and antenna facilities are converted to the new channel.

Unlike the transition to digital television, where stations operated both an analog and a digital signal simultaneously and made the final transition to digital on the same day, this repacking will occur over time with each market making the change at a different time. A delay in an adjacent market will have a domino effect causing delays to other markets and compounding the delays in the transition. At the present time there is no foreseeable solution but the extended rollout or repacking transition.

Interim facilities may include transmitters, antennas, transmission line, tower engineering load studies, tower rigging, interior RF system components, professional services including consulting RF engineers, lawyers for FCC filings, and experts for required specialized studies, zoning hearings, and the like. Typically an interim facility would not mirror a full-power station's transmitter and antenna facility, but be of a lower power capability, sufficient to provide coverage of the majority of the station's current coverage area and population served. Delivery times for the components necessary for an interim facility are difficult to estimate without having an idea of the number of stations that will be impacted by the repacking, and how many of the stations that are impacted have current backup facilities that could be used as an interim facility during the transition. Part of this chapter includes two examples or case studies of repacking scenarios.

Special Cases, Miscellaneous Expenses, and Professional Services

Most special cases are difficult to identify and estimate. The Catalog includes three specific examples of special cases: (1) channel 14 related expenses, (2) distributed transmission service related expenses, and (3) AM pattern disturbance expenses. In each case these expenses are predominately professional engineering fees directly related to special characteristics of these three examples.[42] Miscellaneous expenses are, by their very nature not easily categorized and are variable with the facts and circumstances of each particular broadcaster. Professional services expenses are directly related to FCC filings, transition project management services, field engineering services, and tower and/or antenna structural height services (FAA consultants, NEPA Section 106 environmental review, and environmental assessments, if required). The Catalog provides guidance regarding typical fees, but each station's fee structure will be based upon the services required.

[42] *Catalog of Costs*, 2013, 11.

Repacking Case Studies

Widelity, Inc. granted permission for the inclusion of these two case studies in this thesis. The thesis author is a co-author of the Widelity, Inc., *Response to the Federal Communications Commission for the Broadcaster Transition Study Solicitation – FCC13R0003* report published December 9, 2013. The first case study looks at an extreme move, channel 50 to channel 15 where the second case study looks at a super complicated move involving multiple stations operating on the Mount Sutro tower in San Francisco. All cost estimates in the case studies are based upon the *Catalog of Costs,* and the time estimates are based upon discussions with engineering sources, manufacturers, and in the case of the Mount Sutro case study, the vice president in charge of the Mount Sutro facility.

Case Study 1

Channel 50 moves to Channel 15

Assumptions

Channel 50, top mounted single channel slot antenna top mounted on a 1,500' tower with 100' horizontal run from base of tower to transmitter building.

- 8 3/16" rigid transmission line, 19.5' sections
- No auxiliary antenna or transmitter
- Transmitter, 90 kW three cabinet IOT (tube) transmitter
- There is space, electrical service and HVAC capacity for a lower power auxiliary transmitter
- Repacking moves the station to Channel 15
- Channel 15 requires 20' line sections
- Consulting RF Engineer determines Transmitter TPO of 90 kW, transmission line of 7 3/16" diameter, replacement antenna included vertical polarization
- Structural Engineer determines necessary tower reinforcement/modifications for new antenna (top mounted) and for rented side mounted interim antenna and flexible transmission line

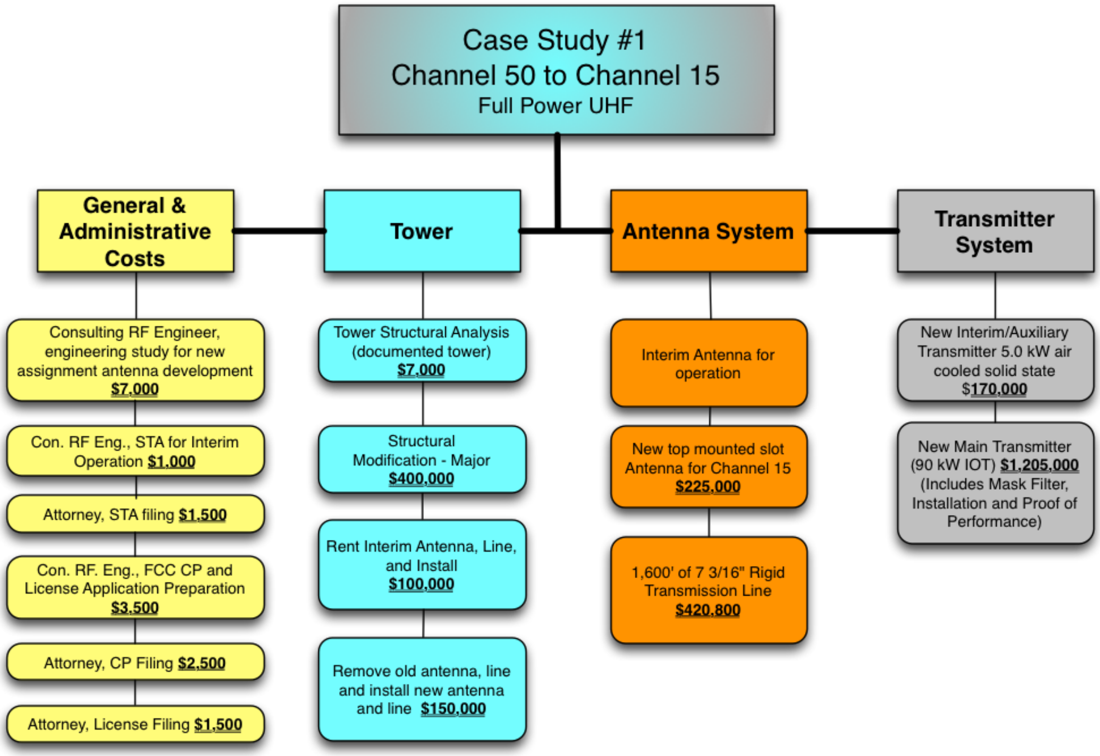

Figure 1 Cost Elements Channel 50 to 15

Cost Estimates By Category		
General & Administrative	$	17,000
Tower		657,000
Antenna System		645,800
Transmitter System		1,375,000
Total (Rounded)	**$**	**2,695,000**

Figure 2 Cost Estimate Channel 50 to 15

Estimated timeline after receipt of the new assignments:

1. **3 months** for pre-project planning including structural analysis for new antenna systems and of the tower, consulting RF Engineer assignment analysis, discussion with transmitter and antenna manufacturers, structural engineer identifies tower deficiencies and develops plan for reinforcement. Place order to rent interim antenna and transmission line. Order new antenna, transmission line, interim/auxiliary transmitter and new main transmitter. File for CP for main operation. Order reinforcement steel, receive anticipated delivery date, schedule crew to reinforce the tower.
2. **2 months**. Tower reinforcement work, receive rental antenna and transmission line. Install interim antenna and transmission line.

3. **3 months**. Wait for delivery of new antenna, transmission line, auxiliary transmitter and main transmitter. With anticipated delivery dates, schedule tower crew and field engineers. File for STA for interim operation.
4. **3 months**. Receive ordered equipment, install interim/auxiliary transmitter, sweep interim antenna/line, proof of performance on interim/auxiliary transmitter. Commence interim operation under STA. Remove existing main transmitter, install new main transmitter. Remove existing top mounted antenna and transmission line, install new top mounted antenna and new transmission line. Sweep antenna and line. Proof of performance on new transmitter.
5. **1 month.** Switch over to new main operation. File for new station license.
6. **1-2 months.** Schedule tower crew to remove interim antenna and transmission line In some cases, not covered in this study, a station may plan to keep the interim antenna as a permanent auxiliary antenna that can serve as a backup in the future.

Estimated total time, assuming no glitches, 12 to 14 months.[43]

[43] Widelity, Inc., *Response to the FCC Solicitation – FCC13R0003*, 2013, 46-48.

Case Study 2

This case study (Sutro Tower) is an example of a super-complicated site with multiple channel reassignment. The cost elements and time estimates used in this case study were derived from direct interviews with individuals responsible for the site. As a super complicated site, the costs are not typical and are specific to this site and, as such, are not directly reflected in the *Catalog of Potential Expenses and Estimated Costs*.

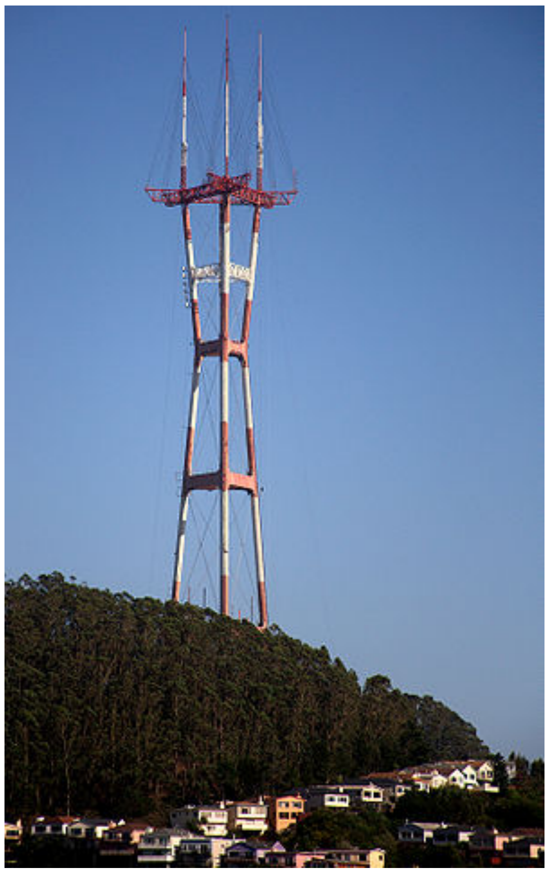

Image 3 Sutro Tower at Mount Sutro, San Francisco, CA

Assumptions:

- Five of the ten UHF stations on Sutro Tower are repacked (four from one combined antenna) and one on another combined antenna.

- The four station combined antenna must be replaced with a new antenna and a new dual transmission line (6 1/8") – this panel antenna is currently supporting KGO's Channel 7 VHF antenna (stacked antennas).
- The one UHF station able to reuse an existing antenna will require a new combiner module for both the main antenna and also for the auxiliary antenna.
- A new auxiliary antenna and transmission line will be required for four of the stations.
- Three of the five stations will have to replace their existing main and auxiliary transmitters, two of the stations can retune their existing main and auxiliary transmitters.
- New mask filters will be required for all five stations, total of ten mask filters (main and auxiliary for each station).
- New interior transmission line (interior RF plant) will be required for both the main and auxiliary transmitter plants for three of the five stations – two stations can use existing interior RF plant with the exception of the mask filters.

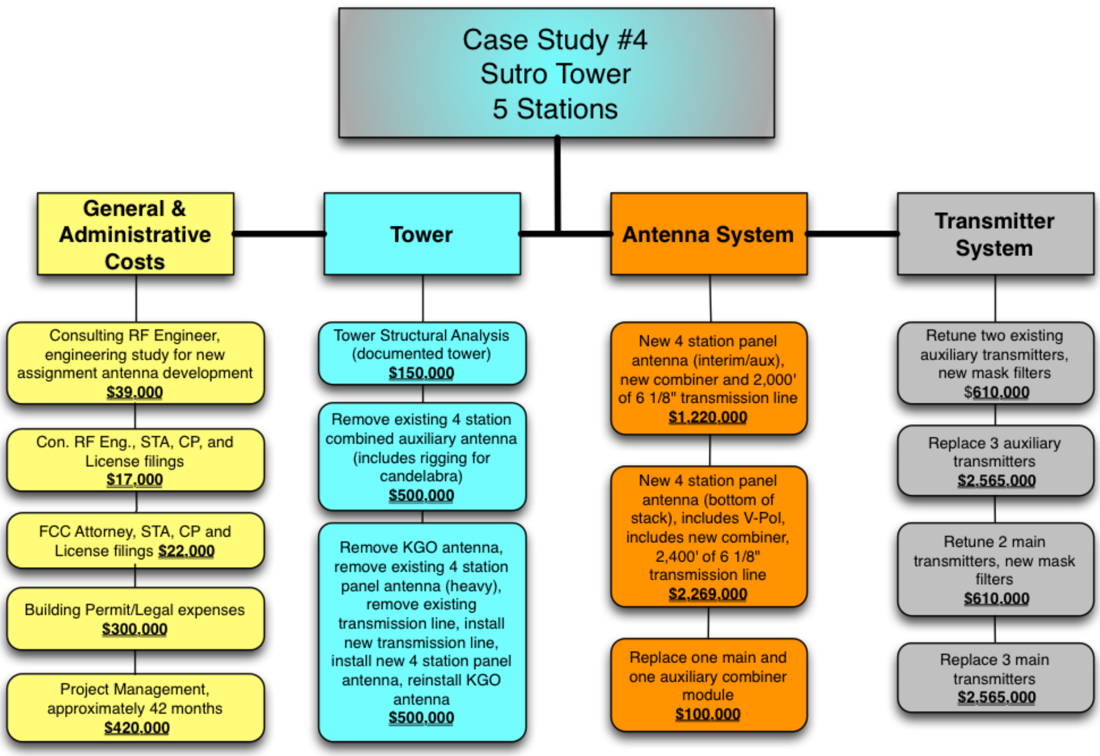

Figure 4 Cost Elements Sutro Tower

Cost Estimates By Category		
General & Administrative	$	798,000
Tower		1,150,000
Antenna System		3,589,000
Transmitter System		6,350,000
Total (Rounded)	**$**	**11,887,000**

Figure 5 Cost Estimate Sutro Tower

Estimated timeline after receipt of the new assignments:

1. **9 months** for pre-project planning including legal for building permit filing, structural analysis for new antenna systems, consulting RF Engineer assignment analysis, discussion with transmitter and antenna manufacturers. File for building permit, file for CP for main operation.
2. **18 months** to prosecute the building permit through the City of San Francisco. Receive building permit.
3. **6 months** to order and receive equipment, schedule tower crew and field engineers. File for STA for interim operation.
4. **2 months** for initial tower crew work for interim operation (remove old interim antenna and transmission line, install new interim/auxiliary antenna and transmission line), retune two auxiliary transmitters including replacing mask filters, install new combiner module, replace three existing auxiliary transmitters with new solid state interim/auxiliary transmitters, install new combiner for four station interim/auxiliary antenna system, proof of performance on all transmitters, sweep new antenna/combiner, sweep existing antenna/combiner with new module. Commence interim operation under STA.
5. **6 months** to build out new main operations including removal and installation of three main transmitters, retuning of two main transmitters with new mask filters and one new combiner module, remove KGO VHF antenna (KGO will now operate on their auxiliary antenna), remove old 4 station panel antenna and transmission line, install new dual 6 1/8" transmission line run, install new (bottom of stack) 4 station combined panel antenna, reinstall KGO VHF antenna on top of stack, proof of performance on all transmitters, sweep new antenna/combiner/line, sweep existing combiner/line system with new combiner module. File for new station licenses.

Estimated total time, assuming no glitches, 41 months.[44]

According to the *Report and Order*, the FCC has allotted 39 months for repacked television stations to complete the transition. The first 90 days are set aside for all of the impacted television stations to file their Construction Permits (CPs). There is difficulty with the timeframe established by the FCC because the stations will not know their allocated station assignments until the completion of the forward auction. If, as expected, there are several hundred television stations all clamoring for structural engineers to assess towers and consulting RF engineers to prepare engineering exhibits for new CPs, there will be a much greater demand for services than can be addressed by the limited number of resources. The FCC recognizes the problem, but is holding firm to the 90 day window for filing CPs.

[44] Widelity, Inc., *Response to the FCC Solicitation – FCC13R0003*, 2013, 52-55.

As shown in Case Study 1, assuming there are no "glitches", the station would be able to accomplish the transition at a cost of approximately $2.7 million. If one assumes that 500 television stations would require repacking at an average cost of $3 million per station, the direct costs of the transition would be $1.5 billion. Congress, through the *Spectrum Act (2012),* gives the FCC a maximum of $1.75 billion to cover all of the costs associated with the repacking. If the assumed number of stations impacted by the repacking is 600, amounting to approximately one third of the full-power stations licensed in the U.S., at an average cost of $3 million per station, then the $1.75 billion will be insufficient.

Super complicated sites, such as Mount Sutro, the Empire State Building, and Willis Tower in Chicago will have much longer timelines and potentially higher expenses than the average broadcaster due to extraordinary factors such as zoning requirements, the use of helicopters for lifting antennas to the rooftop masts, union labor, and work scheduling requirements (the Empire State Building limits work on the broadcast antennas to between 3 am and 5 am, requires union labor and the laborers are paid for an 8 hour day).

The timeline indicated in Case Study 2 is an example of a "quick" process at a super complicated site. While the estimated costs for Case Study 2 are below average when divided by the number of stations involved ($2.4 million per station), the timing required to accomplish the transition goes beyond the FCC's mandated 39-month window.

At the present time there is no indication from the FCC as to how they will deal with stations that are caught up in litigation, zoning issues, environmental studies, transition delays in adjacent markets, or other delays caused by factors outside of the station's control.

The World's Most Groundbreaking Spectrum Auctions

The upcoming incentive auctions for the 600 MHz band are, as described in the Federal Communications Bar Association's (FCBA) continuing legal education seminar on June 16, 2014, "the World's Most Groundbreaking Spectrum Auctions". As Americans, we see hype as a good thing - the greatest, most stupendous, colossal, phenomenal whatever it is; but in the case of the upcoming 600 MHz band auctions, the FCBA may have gotten the adjective right. The proposed forward and reverse auctions have garnered their fair share of comments, both pro and con, from numerous industry pundits and trade associations. This chapter will address some of those comments and the proposed timelines that are currently being discussed.

National Association of Broadcasters

The National Association of Broadcasters (NAB) has been one of the most vocal industry associations regarding the proposed auctions. The latest focus has been on the recent *Report and Order* (June 2014). The NAB points out that the *Report and Order* identifies technical and policy issues that need to be addressed to conduct a successful auction, but also correctly points out that the FCC has deferred those decisions to some "yet to be determined" future date(s). According to the NAB, this lack of clear direction by the FCC has placed the broadcasting industry into a"confused, perplexed, and unsure" state. The NAB, in its June 16, 2014 presentation at the FCBA Spectrum Auctions seminar, identified six broadcaster concerns: (1) repacking – how it will impact member stations, (2) coverage area – concern over a reduction in coverage area based upon the use of *TV Study*, (3) translators – at the present time the FCC has provided no guidance regarding the use of translators, (4) FCC inaction, (5) uncertainty – unrealistic construction timetables that do not guarantee timely relocation or full compensation, and (6) wireless microphones – wireless microphones currently operate on spectrum that will be subject to repurposing in the 600 MHz band auction.[1]

At the present time there are no real estimates of how many television stations will voluntarily relinquish their spectrum rights in the reverse auction or how many television stations will be impacted by the repacking of the 600 MHz band. The NAB is raising legitimate concerns, that at the present time the FCC has not addressed.

The NAB has raised concerns over the replication of coverage area and population served for repacked stations, in particular the FCC's proposed use of the new *TV Study* computer model to accomplish the calculation of the pre-auction coverage and the post-repacking coverage. As mentioned earlier, the NAB's position is that the Spectrum Act calls for the use of the old Longley-Rice model originally used for developing digital television coverage estimates. The old model relies on 2000 census data and three arc-second terrain data mapping. The new *TV Study* computer model relies on 2010 census data and one arc-second terrain dataset for terrain elevation mapping – the FCC's computer model uses the most recent census data and a finer degree of accuracy in terrain mapping.

Regarding the coverage area component, the original OET-69 methodology relied upon a three arc-second terrain dataset that is no longer distributed, maintained, or supported by the U.S.

[1] National Association of Broadcasters, *Spectrum Auctions*, June 16, 2014, Powerpoint slides provided to participants at FCBA seminar "Broadcast Spectrum Incentive and Forward Auctions".

Geological Survey (USGS).[2] The nominal resolution, or accuracy, of one arc-second is approximately 30 meters. The nominal resolution of three arc-seconds is approximately 90 meters.

To test the validity of the change from a three arc-second resolution to a one arc-second resolution, the FCC conducted a test of predicted field strength values using both a three arc-second dataset and a one arc-second dataset for terrain elevations. The FCC compared the predicted field strength values for eight full-power UHF television stations to actual field strength values for the same eight television stations that were collected in the 1950s by the Television Allocations Study Organization (TASO). The actual field strength values from the TASO study are publicly available. In all instances the mean error between predicted and measured field strength values either decreased or remained constant in every case with the one arc-second data. Therefore, the one arc-second dataset predictions are more accurate than those using a three arc-second dataset.[3] Even with the FCC's validity test via the predicted and actual field strength values, the NAB wants to force the FCC to rely on an outdated dataset that is no longer maintained, supported, or distributed by the U.S. government agency responsible for all official mapping.

In regards to the population component, the NAB believes that the only valid measurement of the population within a station's coverage area is to use the 2000 census data and the old Longley-Rice methodology described in OET-69. The "NAB argues that we (FCC) should continue to use 2000 Census data, claiming that its preliminary analysis of *TV Study* with 2010 population data shows that 14 percent of broadcast licensees will experience a decrease in

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[2] Federal Communications Commission, *Report and Order Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, 2014, FCC 14-50, § III (B)(2)(b)(150).

[3] FCC 14-50, § III (B)(2)(b)(152).

predicted population served."[4] The FCC's evaluation, using the same data, showed a similar reduction in predicted population served, but also showed that 88 percent of full-service broadcasters will experience an *increase* in predicted population served.[5] The NAB appears quite adamant that the 2000 Census data be utilized in the calculation of predicted population coverage while ignoring the Spectrum Act's dictate that the population to be replicated for repacked stations is based upon the coverage as of February 22, 2012; this point in time is well past the year 2000. The 2010 Census data would be much more appropriate for predicting the population being served on February 22, 2012. As pointed out by the FCC, "broadcast stations experiencing a "loss" in predicted population served were, in fact, serving a smaller population on February 22, 2012, than predicted using 2000 Census data because the 2000 Census data is outdated."[6]

Lastly, the NAB's insistence on relying on 2000 Census data ignores actual population migration that has been occurring over the last twenty to thirty years. The NAB's methodology rewards stations that have actually lost population with "phantom" population based upon 2000 Census data and denies the benefits of increased population to stations that have seen actual population growth, based upon 2010 Census data, by relying upon the outdated 2000 Census data. If the FCC's evaluation of *TV Study* is correct, and 88 percent of full-service television stations saw an increase in predicted population served based upon 2010 Census data, then the NAB is ignoring their members in the 88 percent that saw population growth and only advocating for their members in the 12 percent that saw a population decrease when comparing the 2010 Census data to the 2000 Census data.

[4] FCC 14-50, § III (B)(2)(b)(149).
[5] FCC 14-50, § III (B)(2)(b)(149).
[6] FCC 14-50, § III (B)(2)(b)(149).

The NAB raises other issues of a very technical nature that due to the engineering expertise required to address, discuss, and comprehend, are beyond the scope of this paper. Suffice it so say that the NAB, in its role as an advocate for radio and television broadcasters in the U.S., wants to assure its members that it is doing all it can to ameliorate the impact the repacking will have on stations that are involuntarily repacked due to the reverse and forward auctions.

Diminishing Resources

As a result of the FCC's announced spectrum auctions and the subsequent repacking of the UHF television spectrum, television stations are postponing any investments in transmission infrastructure (towers, transmitters, antennas, and transmission line). The impact of the FCC's decisions to auction off the 600 MHz band and subsequently repack the remaining UHF stations is being felt by not only the television broadcasters, but more so by the companies that provide both the equipment and the underlying support services related to the transmission infrastructure. Since the completion of the move to digital television in 2009, there has been a marked decline in the demand for new television antennas, transmitters, and related equipment. This decline has been compounded by the FCC's announced spectrum auctions and a freeze on any new construction permits – thus freezing out the equipment manufacturers.

Dielectric, the manufacturer of approximately 65 percent of all full-power television antennas in use in the U.S., announced that it was closing its doors right after the NAB convention in Las Vegas in April 2014. Dielectric announced that they would complete the fabrication of the current antennas in production, but would not produce any more antennas or transmission lines that were ordered but not currently in production. Dielectric also announced that all support and consulting services would be terminated and all the staff would be let go. The impact of this announcement by the largest domestic television antenna manufacturer sent shockwaves though the industry. Fortunately for the industry, Sinclair Broadcast Group announced the acquisition of Dielectric from SPX Corp. in June of 2014, and Dielectric, LLC, as it is now known, will continue to provide its full compliment of products and services to the broadcast industry.[7] While the Dielectric story has had a happy ending, thus far, that has not been the case for all.

In March 2014, "Electronic Research Inc. (ERI), a Chandler, Indiana based manufacturer of RF components, waveguide, and antennas, laid off 22 employees (18 percent of its workforce), an apparent consequence of the FCC's policy aimed at freeing up TV spectrum for the wireless industry."[8] ERI, a direct competitor to Dielectric, has cut its workforce by almost one-fifth to try and weather the drought in RF equipment acquisition. ERI has the advantage of being more diversified than Dielectric, with its main businesses being FM radio antennas and combiner systems and broadcast tower construction. While ERI is a player in the television antenna arena, especially after buying Andrew Corp.'s television antenna and transmission line businesses in 2003, it historically has only a 15 – 20 percent penetration in the television antenna business. With Dielectric's announcement in April of closing down the business, the industry was looking at ERI to take up the slack. But with Sinclair Broadcast Group's acquisition of Dielectric, ERI

[7] Andrew Dodson, "Sinclair Steps In To Buy Dielectric," *TVNewsCheck* (June 18, 2014): http://www.tvnewscheck.com/article/68321/sinclair-steps-in-to-buy-dielectric (accessed June 28, 2014).

[8] Phil Kurz, "FCC Auction Taking Toll On TV RF Vendors," *TVNewsCheck* (March 13, 2014): http://www.tvnewscheck.com/article/74793/fcc-auction-taking-toll-on-tv-rf-vendors (accessed June 29, 2014).

has had no impetus to ramp up production and continues to operate with the current smaller workforce.

The latest blow to the RF equipment field comes with the July 15, 2014 announcement that LARCAN, the Canadian manufacturer of both solid state and vacuum tube television transmitters closed their doors on July 10, 2014.[9] LARCAN had been a provider of television transmitter equipment since the 1950s and was a leading proponent and manufacturer of solid state television transmitters. This latest closing leaves three current manufacturers of television broadcast transmitters – Gates Air, formerly Harris Broadcast, COMARK, and Rohde Schwarz.

Both Gates Air and COMARK are domestic manufacturers while Rohde Schwarz is based in Germany. Gates Air represents about two-thirds of the digital television transmitters currently on the air in the U.S., with COMARK running a distant second. Both Gates Air and COMARK offer both solid state and inductive output tube (IOT) television transmitters. Rohde Schwarz manufactures only solid-state television transmitters and has recently developed a line of high power solid state transmitters that rival the IOT transmitters in output power and efficiency, making them a viable option for consideration in the repacking.

Other resource groups that have diminished since the completion of the transition to digital television include consulting RF engineers, field service and installation engineers, tower crews that are certified for tall towers, tower manufacturers, and structural engineers specializing in broadcast tower design, analysis, and construction. All of these groups will be required to facilitate a timely repacking of the television spectrum upon the completion of the reverse and forward auctions. The decline in these resources has been caused by multiple factors, with retirement being the largest contributor in the professional engineering areas. Lack of demand

[9] James E. O'Neal, "LARCAN Closes Its Doors," *TV Technology*, (July 15, 2015): http://www.tvtechnology.com/article/larcan-closes-its-doors/271300, (accessed July 15, 2014).

for tower construction, especially tall tower construction, has seen many of the working crews disbanded. It is estimated by industry experts that only twelve to fourteen tall tower crews remain actively working in the U.S., and these crews are currently providing maintenance and repair services to existing television and FM radio broadcasters.[10]

Current demand for these services are insufficient for the remaining providers to increase staffing, especially since the FCC has provided neither a definitive number of stations identified for the repacking nor a timetable for the commencement of the reverse auction.

Timeline for Broadcast Incentive Auction

The estimated timeline provided by the FCC on June 25, 2014 outlines the major mileposts to the completion of the Incentive Auction. The remainder of 2014 will include proceedings to address (1) the potential impact the Incentive Auction may have on low power television stations (LPTV) and television translator stations (currently not included in the Incentive Auction), (2) the revision of Part 15 of the rules for the use of unlicensed devices in the 600 MHz guard bands and remaining television spectrum, (3) the needs of wireless microphone users, and (4) a methodology to prevent harmful "inter-service interference" between television and wireless broadband operations as well as outreach to broadcasters to provide informational materials including estimated auction values.[11]

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[10] Jay C. Adrick, "Television spectrum repacking," *TV Technology* (April 22, 2012): http://www.tvtechnology.com/regulatory/0113/television-spectrum-repacking/268377 (accessed July 1, 2014).

[11] Federal Communications Commission, "Estimated Timeline of Key Events Leading Up to FCC's Broadcast Incentive Auction," June 25, 2014, 1.

In the first quarter of 2015, it is anticipated that the FCC will adopt its "Auction Procedure Public Notice" establishing the final auction protocols for auction participants. The Media Bureau will then announce the Pre-Auction Licensing Deadline. This deadline is for stations that were issued construction permits (CPs) prior to the April 2013 freeze, Class A stations making a digital conversion, and any other stations with modifications that were pending prior to the freeze. These stations must complete their conversions and modifications prior to the Pre-Auction Licensing Deadline in order to be protected in the repacking process. Stations that fail to meet the deadline are not guaranteed protection in the repack.[12]

In the first half of 2015 the FCC will (1) issue orders related to LPTV, TV translators, Part 15 of the rules, and wireless microphone spectrum use, (2) the Media Bureau will issue the final catalog of repacking costs, the reimbursement process, and the post-auction transition to new channels, (3) Office of Engineering and Technology (OET) will publish an updated baseline list of broadcast facilities with their coverage areas and population served, and (4) conduct bidder educational tutorials regarding pre-auction and post-auction procedures.[13]

Mid 2015 the FCC will begin the Incentive Auction. The Incentive Auction will roll out in a four-step process. In step one the FCC will open the application process for the reverse auction. This step will include: (1) opening prices for each bidding option to each eligible broadcaster, (2) review broadcasters filings to participate in the auction, (3) notify qualified applicants that they have qualified as bidders and provide them with their registration materials, (4) based upon the number of committed qualified bidders, set the national spectrum clearing target (e.g., 120 MHz), and (5) conduct a mock auction for qualified bidders.[14] In step two the

[12] FCC, "Estimated Timeline," June 25, 2014, 1.
[13] FCC, "Estimated Timeline," June 25, 2014, 2.
[14] FCC, "Estimated Timeline," June 25, 2014, 2.

FCC will conduct the reverse auction to determine how much money will be required to make incentive payments to broadcasters that relinquish some or all of their spectrum usage rights.[15] In step three of the process the FCC will conduct the forward auction for the wireless providers. In step four the process the FCC will evaluate the results of the reverse and forward auction to determine if the auction closes or continues at a lower clearing target. If the proceeds from the forward auction cover the incentive payments to the broadcasters relinquishing some or all of their spectrum usage rights and meet the other revenue requirements (repacking and administrative costs, to name two), then the forward auction will continue until there is no more demand for licenses, and the Incentive Auction closes. If the proceeds from the forward auction are not sufficient to satisfy the Final Stage Rule, the FCC will lower the spectrum clearing target and repeat steps two and three until the Final Stage Rule is satisfied.[16]

Upon the successful completion of the Incentive Auction, the FCC will issue the Channel Reassignment Public Notice announcing the final TV channel assignments for the stations that have not voluntarily participated in the Incentive Auction.[17] The FCC will then issue licenses to the wireless providers that won spectrum usage rights in the forward auction as well as distribute the auction proceeds to the broadcasters that voluntarily participated in the reverse auction and relinquished some or all of their spectrum usage rights.[18]

For stations that participated in the Incentive Auction, they most terminate their broadcast operations on their pre-auction channel within three months of receipt of the auction proceeds.[19]

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[15] FCC, "Estimated Timeline," June 25, 2014, 2.
[16] FCC, "Estimated Timeline," June 25, 2014, 2.
[17] FCC, "Estimated Timeline," June 25, 2015, 2.
[18] FCC, "Estimated Timeline," June 25, 2015, 3.
[19] FCC, "Estimated Timeline," June 25, 2014, 3.

Three months following the release of the Channel Reassignment Public Notice, broadcasters eligible for reimbursement of channel relocation costs (repacking costs) must provide an estimate of those costs to the Media Bureau. Television stations that have been assigned a new channel must also file their construction permit (CP) applications to operate on their new channel.[20]

At this point the Media Bureau will: (1) go through their review process of the estimated relocation costs submitted by the broadcasters being relocated, (2) issue initial funding to the relocated broadcasters, (3) establish construction deadlines for relocated television stations, (4) review actual relocation expenses, and upon approval of these expenses, release additional funding to the broadcasters, and (5) open a limited window for operating LPTV and TV translator stations to submit displacement applications.[21]

No later than 39 months after release of the Channel Reassignment Public Notice broadcasters remaining on the air must complete their post-auction transition or go dark on their pre-auction channels.[22] It is this 39 month window that poses the greatest hurdle for the relocated (repacked) broadcaster, and this "go dark on their pre-auction channels" requirement that will push most broadcasters, in my opinion, to build interim facilities on their reassignment channel as opposed to building an interim facility on their pre-auction channel.

The winning wireless providers will not be allowed to commence operations on their newly acquired spectrum until the broadcasters have migrated to their post-auction channel assignments.

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[20] FCC, "Estimated Timeline," June 25, 2014, 3.
[21] FCC, "Estimated Timeline," June 25, 2014, 3.
[22] FCC, "Estimated Timeline," June 25, 2014, 3.

CHAPTER 5

CONCLUSIONS

What will television broadcasting and wireless communications look like after "The World's Most Groundbreaking Spectrum Auctions" are done? Will the *Middle Class Tax Relief and Job Creation Act of 2012* have accomplished the second half of its title? Will the 600 MHz spectrum auction create jobs?

The first thing we know, there will be fewer television stations operating over the air. The FCC cannot achieve the goals set forth in the *Spectrum Act of 2012* without several hundred television stations relinquishing some or all of their spectrum usage rights. This may not have as much of an impact on television viewers as one would initially think. In 2011, then FCC Chairman Julius Genachowski said the percentage of viewers watching broadcast over the air, rather than through cable or satellite, has fallen to less than 10 percent.[1] So, while fewer consumers get their television broadcasts over the air, that does not address the loss of programming that would occur when these stations go off the air. Some of that programming may be duplicated within a television market. As noted in **Table 2**, there are four PBS affiliated stations in the New York television market. One would assume that there is some duplication of programming occurring between the four stations.

[1] Christopher Stewart, "Over-the-Air TV Catches Second Wind, Aided by Web," *Wall Street Journal*, February 21, 2012.

With digital television, it is possible to provide more than one programming stream within the assigned 6 MHz television channel. Many stations currently provide alternative programming on secondary and tertiary channels, usually identified as channel number dot one or dot two (26.1, 26.2, and 26.3). If there is sufficient demand within a market for the programming from a station that voluntarily relinquishes its spectrum usage rights, a savvy broadcaster will see the business opportunity and look to fill the need.

Consumers of wireless broadband will not initially see any benefit to the 600 MHz auction. Wireless providers will not be able to begin using the spectrum usage rights they won in the Incentive Auction until the broadcasters operating in the 600 MHz band have moved to their new channels or gone off the air. Wireless providers will also have to build out the necessary infrastructure for the new 5 + 5 MHz paired channels for the uplink and downlink operations. While it is possible to begin building out the initial infrastructure while broadcasters continue to operate in the 600 MHz band, the wireless providers will not be able to fully test their new infrastructures capabilities until after the post-auction transition. The rollout of new services will begin in the major markets and will help alleviate current wireless broadband congestion in these markets. One should not expect to see widespread use of the 600 MHz band by wireless carriers before the mid 2020s.

It is currently unknown whether the wireless providers will use the 600 MHz band channels to provide support for their existing 2 GHz operating cellphone transmit and receive operations, will use the 600 MHz channels as “trunk lines” carrying traffic between operating cell towers, or will convert new cellphones to the new 600 MHz channels and utilize them for transmit and receive operations. Many current cellphones have quad band capabilities. It is possible to build new cellphones with five band (quint band) capabilities.

What about job creation? If several-hundred television stations go off the air to free up spectrum for wireless carriers, what happens to the jobs at the TV stations? Will the wireless carriers pick up these displaced jobs? That is not likely. While the wireless carriers will require some additional technical staff for building out the new 600 MHz infrastructure, most of the newly created jobs will require applicants to have strong technical backgrounds. The majority of the jobs lost by the TV stations going off the air are not technical, but are operational, administrative, sales, and in some cases, news staff. The broadcast stations that remain on the air after the repack will not be able to absorb the displaced jobs that will be created by the *Middle Class Tax Relief and Job Creation Act of 2012*.

The goals that will be accomplished by *Middle Class Tax Relief and Job Creation Act of 2012* are: (1) revenue to the U.S. Treasury (estimated between $10-45 billion), (2) more spectrum for wireless broadband, and (3) a consolidated, more efficient use of the remaining UHF band for television broadcasting.

What about the future of "over the air" broadcast television in twenty to twenty-five years? With CBS's recent announcement that consumers can subscribe to a monthly service and access all of the network's programming via broadband video streaming, what becomes of the local network affiliate? The local network affiliate currently provides viewers with access to the network programming as well as local news, weather, and sports. The question for the future will be whether consumers are going to continue to "tune in" to the local station for network programming or seek another source, to the demise of the local network affiliate.

It is the author's opinion that the 600 MHz incentive auction and the subsequent repacking of the remaining "over the air" television broadcasters will be the initial crack in the foundation of the current commercial television business model that will ultimately lead to the collapse and demise of "over the air" television, as we know it, within twenty-five years. This opinion is based on the fact that the current commercial television business model relies heavily on the "must carry" rules for cable and satellite television providers and the payments the local stations receive for allowing the cable and satellite operators to carry the local network affiliates. If, as CBS has proposed, consumers can "cut the cable" and bypass both cable and satellite distribution for the network programming by subscribing directly with the network, there is little impetus on the part of the cable and satellite industry to continue to pay for "must carry" rights. It is estimated that current "over the air" viewership of broadcast television hovers around 10 percent, an insufficient viewer base to build a successful business model on. If the consumer can get the programming they want directly from the programming source, i.e., the television network, on broadband devices that do not require access to cable or satellite television providers, at a price that allows the consumer to "cut the cable", then what purpose does the local network affiliate provide?

Thus, the consequence of the *Middle Class Tax Relief and Job Creation Act of 2012* will be to artificially create an early end to commercial television, and also create a total upheaval for the television broadcast industry. This upheaval will last for years as the industry changes and ultimately dies off.

Ideas of implementation on paper will certainly be different when set in motion, and there will be no turning back once the paper process is started.

Once the 600 MHz band is converted to wireless broadband, what will be the next spectrum block to be repurposed?

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APPENDIX

Illustrations of FCC's 11 Band Plans

The following illustrations show each of the FCC's Band Plans for repurposing of the 600 MHz Band. Each band plan ends at the beginning of the 700 MHz band (channel 52). I have removed the 700 MHz portion from the illustrations to increase the size and readability of the illustrations. The color key identifies uplink, downlink, and guard bands.

- Downlink Blocks
- Uplink Blocks
- Guard Bands

42 MHz (2 pairs) Scenario

21	22	23	23	24	25	26	27	28	29	30	31	33	34	35	36	37	38	39	40	41	42	43	44	11 MHz	A	B	11 MHz	A	B

48 MHz (3 pairs) Scenario

21	22	23	23	24	25	26	27	28	29	30	31	33	34	35	36	37	38	39	40	41	42	43	7 MHz	A	B	C	11 MHz	A	B	C

60 MHz (4 pairs) Scenario

21	22	23	23	24	25	26	27	28	29	30	31	33	34	35	36	37	38	39	40	41	9 MHz	A	B	C	D	11 MHz	A	B	C	D

72 MHz (5 pairs) Scenario

21	22	23	23	24	25	26	27	28	29	30	31	33	34	35	36	37	38	39	11 MHz	A	B	C	D	E	11 MHz	A	B	C	D	E

78 MHz (6 pairs) Scenario

21	22	23	23	24	25	26	27	28	29	30	31	33	34	35	36	37	38	7 MHz	A	B	C	D	E	F	11 MHz	A	B	C	D	E	F

84 MHz (7 pairs) Scenario

21	22	23	23	24	25	26	27	28	29	30	31	33	34	35	36	37	3	A	B	C	D	E	F	G	11 MHz	A	B	C	D	E	F	G

108 MHz (8 pairs) Scenario

21	22	23	23	24	25	26	27	28	29	30	31	32	11 MHz	A	B	3	37	3	C	D	E	F	G	H	11 MHz	A	B	C	D	E	F	G	H

114 MHz (9 pairs) Scenario

21	22	23	23	24	25	26	27	28	29	30	31	7 MHz	A	B	C	D	3	37	3	E	F	G	H	I	11 MHz	A	B	C	D	E	F	G	H	I

126 MHz (10 pairs) Scenario

21	22	23	23	24	25	26	27	28	29	9 MHz	A	B	C	D	E	F	3	37	3	G	H	I	J	11 MHz	A	B	C	D	E	F	G	H	I	J

136 MHz (11 pairs) Scenario

21	22	23	23	24	25	26	27	11 MHz	A	B	C	D	E	F	G	H	3	37	3	G	H	I	J	11 MHz	A	B	C	D	E	F	G	H	I	J

144 MHz (12 pairs) Scenario

21	22	23	23	24	25	26	11 MHz	A	B	C	D	E	F	G	H	I	J	3	37	3	K	L	11 MHz	A	B	C	D	E	F	G	H	I	J	K	L

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