March, 2016

Response to T-Mobile & CCA Reports on the Broadcast Spectrum Repacking Timeline, Resource and Cost Study

Digital Tech Consulting, Inc.

Prepared by

Digital Tech Consulting, Inc.
918 Dragon Street
Dallas, Texas 75207
214.915.0930

www.dtcreports.com

Response to T-Mobile & CCA Reports on the Broadcast Spectrum Repacking Timeline, Resource and Cost Analysis Study

Digital Tech Consulting, Inc.
918 Dragon Street
Dallas, TX 75207
USA
214-915-0930
www.dtcreports.com

Table of Contents

Executive Summary 4

Required Channel Change Steps 6

Antenna Systems 11

Antenna Suppliers 14

Broadcaster Preparations 16

The Number of Stations Likely to Change Channel 16

Available Resources: Tower Crews 17

Available Resources: RF Consulting Engineers & Other Consultants 21

Transmitter Needs and Costs 23

Appendix 26

Executive Summary

The subject of this paper is to identify inaccuracies, omissions and incorrect assumptions in the February 17, 2016 *"On Time And On Budget: Completing The 600 MHz Incentive Auction Repacking Process Within The FCC's 39-Month Relocation Deadline And The Budget Established By Congress"* study by T-Mobile, as well as the *"Repacking of Broadcasters Can Be Completed in 39 Months"* report filed by Competitive Carriers Association (CCA) on February 10, 2016. Both reports drew the same unsubstantiated conclusion. DTC's examination of this conclusion, in general, refers to both reports, and to the specific reports where noted.

The above-referenced studies dispute some of the findings in Digital Tech Consulting's (DTC) *"Broadcast Spectrum Repacking Timeline, Resource and Cost Analysis Study"* of October, 2015 prepared on behalf of the National Association of Broadcasters (NAB),

The most fundamental inaccuracies, omissions and incorrect assumptions made in the studies are briefly outlined below. DTC goes into greater technical and operational detail in the body of this paper, as well as documenting additional inaccuracies, omissions and incorrect assumptions.

- The T-Mobile report appears to ignore a significant number of fundamental steps that must be taken for TV stations to move from one channel assignment to another. Among them is the necessity for auxiliary antennas for a majority of the stations, as well as the time required to build and optimize those antennas, the acquisition of zoning and/or building permits, and renegotiating contracts with tower owners. (See Required Channel Change Steps on pages 6-9).

- The T-Mobile report appears to have made the erroneous assumption that because an antenna is classified as broad banded, that it can operate on all channels within the band as if it were a plug-and-play device. This is incorrect. Many broadband antennas are optimized to work on a specific channel, or a small range of channels, and must be shipped back to the factory to be "re-channelized" to operate properly on new lower channels.

  This erroneous assumption is evident in T-Mobile's failure to research the capabilities of the antenna systems associated with the antennas cited in the FCC Form 2100, Schedule 381 data. DTC worked directly with the antenna manufacturers cited in the data to determine that T-Mobile incorrectly identified 49 to 76 stations (depending on the clearing target) to have antennas that could operate in the remaining spectrum. Additional antennas used by stations below the clearing target(s) have also been incorrectly characterized as being capable of full-channel use, when in fact they are optimized to specific channels. In addition, most stations will require standby or temporary antennas to keep stations on air while new antennas are being installed or old antennas are being re-installed after their time at the factory, or to replace existing standby or temporary antennas.

- Because the T-Mobile study's criteria for defining qualified tower crews did not appear to match what is required to remove and install heavy broadcast TV antennas, it was not possible to take its reporting of 25 additional crews at face value. Therefore, DTC interviewed the majority of the tower services companies that it had not identified in its report. Our research revealed that some of them had not installed TV antennas for as many as 10 years, some did not own the necessary specialized rigging equipment, or some primarily installed FM radio, microwave, and cellular antennas. In addition, some are limited to specific geographic areas. DTC could only confirm that there are five additional crews that may have the necessary experience and ownership of the specialized equipment in addition to those cited in its original report – far from the additional 25 claimed in the T-Mobile report. (Please see Available Resources: Tower Crews on page 17.)

It is not clear how T-Mobile and the CCA reached the conclusion that the repack can be accomplished within the FCC's 39-month timeline, as neither report provided methodology on how they came to their findings. It appears as if they did not go through the same process as did DTC, which was comprised of the following: documenting every task required for stations transitioning to new channels; identifying all qualified industry resources available by a set of broadcast-industry standards; averaging amount of time required for the individual tasks calculated against likely available resources; and building a model resulting in an interdependent timeline that accounts for all phases and the areas in which bottlenecks will occur.

Not only did the reports fail to produce an interdependent timeline, many assertions made to justify their conclusions ignore, or significantly underestimate, the complexities involved in a large number of high-power TV stations transitioning to new spectrum assignments in a compressed time period.

Required Channel Change Steps

T-Mobile appears to have not considered several important tasks required for most stations transitioning to a new channel. The DTC study laid out the individual step-by-step tasks required. The following reiterates those tasks and comments on the ones that do not appear to have been considered in the T-Mobile report.

- Station is informed by FCC of the new channel assignment. Station engages RF consulting engineer to analyze and propose a solution that includes the determination for requirements of a replacement antenna, transmission line, transmitter and other RF system components. If the station does not own a standby antenna, requirements for a temporary antenna must also be developed. The solution must be engineered to meet the FCC coverage and interference tolerances specified under the rules for repack. Every station required to relocate will be asking for these resources at the same time.

Assuming that it is determined that at least the antenna, and likely the transmitter, must be replaced, the following steps will be taken:

- Station engineers and RF consultant engage equipment vendors to propose equipment solutions that meet the engineered requirements. Technical specifications and pricing are provided by the vendors.

- If the station owns its tower and antenna, it must engage a tower structural engineer to analyze the tower's capability to support the new antenna and if needed, a temporary antenna + transmission line, while meeting the current acceptable level of tower loading specifications. Depending on the outcome of the tower analysis, either a smaller antenna, thus requiring more transmitter power, or tower modifications might be necessary.

    - *T-Mobile claimed that this would not have to be done for all stations making a channel change, since many towers already meet the Rev G or F tower specifications. That is not the case, since modifications to the tower loading are very likely to change the ability of the tower to continue to meet the required specifications.*

Or

- If the station is leasing antenna space on a tower, the tower lessor must be engaged to help determine a possible and acceptable antenna solution, the need to modify the tower structure to accommodate the new antenna(s), and the impact on other tower tenants. The nation's largest tower owner, American Tower Corporation (ATC), confirmed DTC's previous estimate of an average of 90 days for contract negotiation between the tower owner and the broadcaster once the new antenna requirements have been determined. [1]

    - *The T-Mobile report makes no allowance for this activity.*

Or

- If the station operates on a shared antenna and tower with other stations, it must be determined that the multi-channel antenna is capable of operating on the station(s) new channel(s) assignment(s). If not, the RF consulting and tower analysis process must be carried out for all of the stations on the antenna to determine a new solution.

    - *The T-Mobile report did not properly analyze the channel change capabilities of many of the shared antennas, thus underestimating the need to change out these antennas.*

- Once the tower and antenna requirements for any of the three previous scenarios are determined, a tower rigging company must be engaged to provide pricing for the necessary work. Also, any other service providers such as the transmitter and RF system installers will be engaged to provide pricing.

- Once the antenna and RF system planning is completed and final pricing is obtained from all vendors, the RF consultant, working with the station engineers and the station's legal representation, will prepare the Construction Permit (CP) application and the repack budget that also must be provided at the time the CP application is submitted.

    - *The T-Mobile report fails to recognize the interaction and interdependencies between the many different consultants and information providers needed to get to this point. The large number of stations engaged in this process, all at the same time, will tax and overwhelm the resources. With a three-month CP and reimbursement filing deadline, it is likely that many applications might be incomplete and require amendments before construction on some station's new transmission systems could begin.*

- The CP application and repack budget is filed, and the waiting process begins while the FCC reviews and approves both.

- While waiting for the FCC approval, the station and/or tower owner can apply for the necessary building permits, zoning changes if required, and land use

[1] *"Broadcast Spectrum Repacking Timeline, Resource and Cost Analysis Study"*, page 34

approval if the transmission site is located on state or federal land. Also during this time, a project schedule and plan can be finalized.

- *The T-Mobile report makes no allowance for the likely lengthy time period it will take to receive these approvals. There are many prior examples of lengthy delays.* [2]

- FCC issues CP and advanced payment for channel change**.**

- The station places orders for the required equipment and services including the new main antenna, transmission line, RF system components, transmitter(s) and, if needed, a temporary or standby antenna and transmission line.

- Wait for equipment deliveries, permits, zoning, or land-use permission**.**

  - *T-Mobile appears to assume that antenna and RF system deliveries will be short, since they believe that antenna manufacturers will be building antennas for stock. This is not the case, as verified by the antenna manufacturers.*

    Antenna manufacturers confirm at least 12 week delivery for a standard-design antenna, and up to 24 weeks for custom or modified designs. They also state that the delivery times will increase when a large volume of orders are placed during the same time period.

- If needed, the tower rigging crew makes tower modifications and reinforcements as determined by the structural engineering consultant once permits, zoning or land use permission is granted.

- Tower crew installs temporary or standby antenna + transmission line (if needed) if the station does not already own this type of antenna.

- Station switches operation over to standby or temporary antenna.

- For those stations that are unable to retune their transmitter and RF system during a brief overnight period, the replacement transmitter(s) and RF system are received, installed and tested by the RF systems installers**.**

  - *T-Mobile underestimates the need to replace transmitters, and does not recognize the requirement to replace standby transmitters for the stations that currently own one. This has an impact on both their time and cost estimates.*

- Tower crew removes main antenna and possibly the transmission line.

- Tower crew installs new main antenna and possibly a new transmission line.

[2] *"Broadcast Spectrum Repacking Timeline, Resource and Cost Analysis Study,"* pages 36-37

- RF system installation crew installs new RF system, and tests new RF system and main antenna for proper performance.

- RF system crew retunes and tests the station's transmitter if a new transmitter is not required.

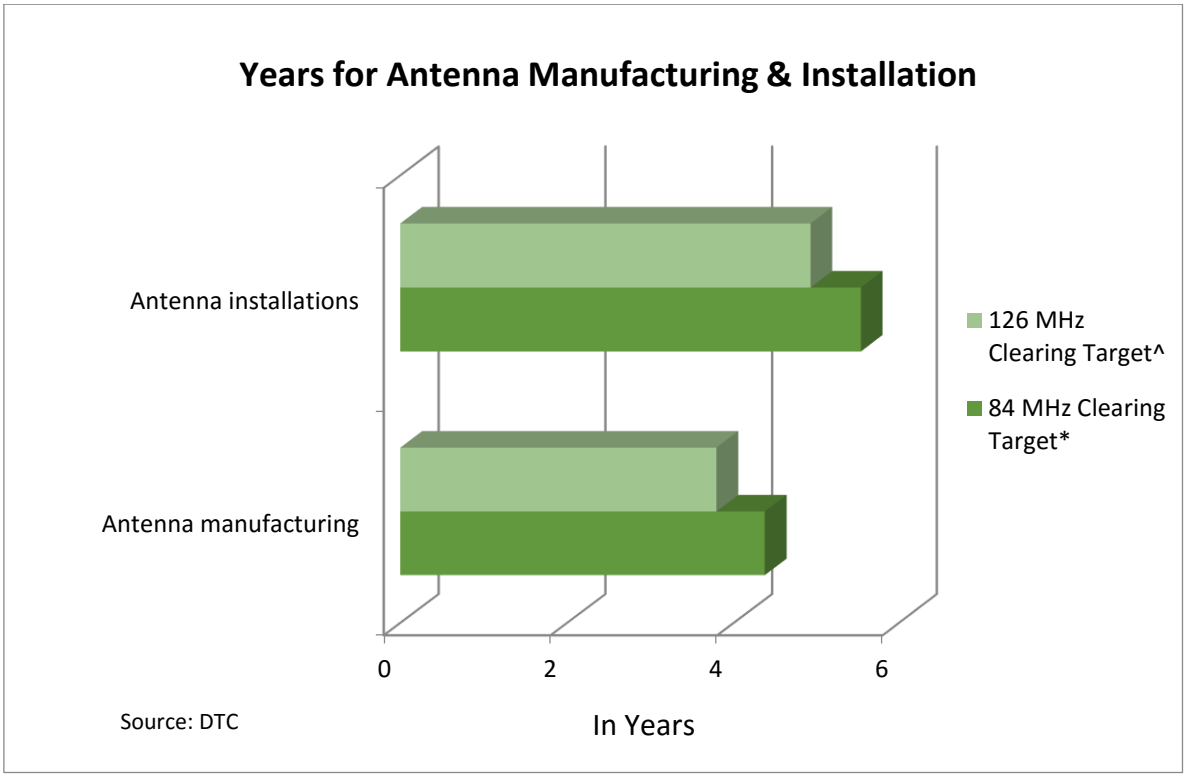
- Station switches operation to new channel, operating on new or retuned transmitter, RF system and new main antenna.

- Tower crew returns to remove temporary antenna and transmission line, if rented or no longer needed.

- Station personnel assemble final invoices for submission to true up channel change compensation.

These steps illustrate the process of adding, removing and replacing antennas (and, to a lesser extent, transmitters) to facilitate transitions to new channel assignments. The following graphic illustrates only the raw amount of time to manufacture and install the required antennas. It does not even take into consideration manufacturing ramp-up time, the bottleneck that will occur in the CP application phase, and interdependencies among all the resources that are required to complete the repack. Therefore, these timelines, as explained in the DTC 2015 report, will be much longer than what is presented in Figure 1 shown on the next page.

Figure 1



^ Based on approximately 1,300 antennas
* Based on approximately 1,500 antennas
Note: Analysis factors DTC's most recent resources estimates with T-Mobile's estimates of number of stations that will change channels. The analysis includes an additional 31 stations not factored in by DTC's or T-Mobile's reports, antennas that T-Mobile incorrectly identified, standby antennas, and interim antennas.

Another major timeline factor that was not covered in the first DTC report, or the T-Mobile and CCA reports, has been emerging in recent months. The ability for stations to cut over to their new channel may very likely be limited to a flash cut, which can be implemented only when all stations in the region or market are ready. This restriction will be driven by the remaining UHF station count, the density and close proximity of markets within a region, and the need to accommodate border channel allocations. Examples where this situation is likely to occur will be the Northeast region, the upper Great Lakes region and the Southern California region. The timing for channel change in these areas may well be constrained by the length of time needed for every station to be installed, tested and ready to make the cutover on a single night.

A failure to consider such time-intensive elements such as installing and removing temporary antennas and transmitters, obtaining proper local building permits, and other fundamental steps in the process, calls into question the foundation from which the two reports make their claims.

Antenna Systems

T-Mobile's analysis of new antennas needed for repacking television stations is flawed. Here we lay out three factors that illustrate why T-Mobile's estimates are significantly understated.

- In its Appendix B, T-Mobile is showing its analysis of the antenna data gathered from FCC Schedule 381. T-Mobile's analysis shows each station's antenna with capability to operate over a range of channels. DTC, working directly with the manufacturers, has identified 76 stations (73 Full Power and 3 Class A) that are assigned above the 126 MHz clearing target (49 if the target is 84 MHz) using antennas that T-Mobile incorrectly identified as being capable of proper operation in the post-auction remaining TV spectrum. The manufacturers have further stated that these antennas would have to be removed from the towers and returned to their factories for remanufacturing if they were to be used in the post-repack channels, or replaced with new antennas. This adds additional cost and time for the antennas, as well as for an interim antenna and the tower crews needed for removal and installation of the new and interim antennas.

  Stations operating above the clearing target(s) will most certainly be forced to channel change during repack.

  ATC, upon reviewing the T-Mobile report, cited two prominent examples where T-Mobile incorrectly identified antennas on its Los Angeles Mt. Wilson tower as capable of operating on channels below the clearing target.[3] A shared antenna on ATC's tower for broadcasters KDOC-TV and KOCE-TV was specifically built for Channels 32 to 51, and cannot operate in the lower portion of the band.

  On the same ATC tower, a shared antenna for KXLA-TV and KJLA-TV also has been optimized for specific channels, and is unable to operate in the lower portion of the band. In these cases, as with the majority that T-Mobile incorrectly identified, the antennas will have to be removed from the tower and returned to the antenna factory for rebuilding, or be replaced with new antennas, since they are used by stations operating above the clearing target(s). ATC estimates that replacing or rebuilding these antennas will cost several million dollars and will be time-intensive jobs. These are only two examples, from the estimated 49-76 in use by stations within the likely clearing target, that the antenna manufacturers cited as incorrectly identified by T-Mobile.

- The report does not account for replacement of antennas that stations have installed as standby systems. Based on the FCC Form 177 data, there are 192 licensed auxiliary antennas in use by both UHF and VHF stations. Some experts, including several antenna manufacturers, estimate that there may be another 30 or more auxiliary antennas which are not licensed, but used by the stations for short periods of time, or under a Special Temporary Authority (STA) for longer periods. About 80% (178) of these are UHF antennas, and virtually all are in use

[3] *"On Time And On Budget: Completing The 600 MHz Incentive Auction Repacking Process Within The FCC's 39-Month Relocation Deadline And The Budget Established By Congress"* report, page 13

by Full Power stations. Class A stations typically do not have this level of back up antenna systems.

The manufacturers of these antennas estimate that there is about an even split between broadband and single-channel antennas. The good news is that the stations with broadband antennas will be able to use them during the repack transition while their main antennas are changed out. The bad news is that there could be up to about 90 single-channel standby antennas that will have to be replaced during repack, thus adding to T-Mobile's estimated cost for repack.

- The T-Mobile analysis does not take into consideration the number of temporary antennas that will be required to allow stations to maintain operation while they change out their main antenna. Those stations, which do not have a standby antenna or a broadband antenna that is capable of lower UHF channel operation and are required to change channels, will need an interim antenna and transmission line to allow the stations to continue operation while their main antenna is removed and replaced with a new antenna.

  About 1,050 or more Full Power stations operate with only a single antenna that is not capable of operating on a new channel assignment. About 70% of these antennas are in use by Full Power stations currently operating within the clearing target(s). Depending upon the estimated number of stations required to change channels, up to 700 interim antennas and transmission lines will be needed to keep stations on the air during the change out of their main antenna system.

T-Mobile also assumed that many stations will migrate to wideband panel antenna arrays that are shared by multiple stations. This, T-Mobile says, will afford both a cost and time savings effect. While DTC believes that this approach will be used in some markets where towers are owned by vertical real estate companies that currently serve multiple stations, T-Mobile's analysis fails to consider the following critical factors detailed by the two largest suppliers of high-power antennas in the U.S. – Dielectric and Electronics Research, Inc. (ERI).

- Panel antennas create at least four times the wind loading on towers, increasing the likelihood for significant tower modifications.
- Panel antennas typically weigh more depending on their complexity. Weight becomes a factor for towers when antennas are side mounted, or are mounted on towers with a smaller cross section.
- RF system complexity is greater for panel antennas, and thus they are more prone to reliability problems. That is because slot antennas have a single feed point, thus typically a single point of failure, while panel antennas have at least as many feed points as there are panels, plus power dividers and interconnect cabling. Over time, the opportunity for failures and subsequent service calls result in greater maintenance needs for panel antennas.
- Panel antenna arrays can provide more unique azimuth patterns, but they will not be as consistent (smooth) as a slot array. Panel antenna patterns can vary widely over many channels, unlike the patterns of slot antennas. (This explains why some of the existing directional panel arrays will need to be modified or replaced.) Slot antennas also can be more creative with "elevation" patterns, since individual elements can be adjusted.

- The ability to create or manage cross polarization ratios is easier to fine tune on slot array antennas.

Depending upon each station's specific coverage areas, tower considerations, and interference protection on each station's channel, as well as other factors, this can be a much more complex solution when it comes to satisfying the coverage and interference parameters of each of the participating stations. Thus, T-Mobile's assumption that many stations being repacked will choose the shared wideband panel arrays overlooks the many complexities inherent in this system.

This type of system, for the stations that do choose it, is likely to result in the need for additional information and technical studies produced after the three month CP application filing window to demonstrate that proposed changes will not exceed the coverage and interference levels established for the repack. This will require increased engineering study on the part of the stations, and increased review time on the part of the FCC before final approval can be granted and construction started.

Further, this type of antenna system might drive additional tower modifications or even new tower construction, none of which are factored into T Mobile's assumption that repack can occur in 39 months.

Antenna Suppliers

T-Mobile overestimates the availability of antenna suppliers (and their production capacities) to provide new antennas and rebuild existing antennas for those stations that are likely to receive new channel assignments – especially high-power stations.

Our analysis, which puts greater weight on those stations most likely to move, and less weight on those unlikely to be part of the repack, presents a more realistic picture of the primary antenna manufacturers. And, additional interviews with these antenna suppliers confirm our earlier timeline analysis[4].

DTC's additional analysis of Full Power and Class A stations reveals the following:

- A detailed analysis of 1,320 Full Power UHF TV stations reporting on their facilities via FCC Schedule 381 shows that 89.1% of these stations employ antennas from either Dielectric or ERI. A third supplier, RFS, has 2.2% of the Full Power business, while the remaining suppliers have between 1 and 2% of the market.

- A detailed user analysis of the remaining companies other than Dielectric and ERI listed in the T-Mobile report shows that these companies primarily serve the Class A stations. Further, the analysis of the category listed as "Other" includes several manufacturers that have exited the antenna business, such as Bogner or have closed their US manufacturing facility such as Kathrein-Scala.

- Many of the manufacturers, other than two primary companies, specialize in antennas for lower-input power levels, and do not have the experience or track record with the requirements of Full Power stations. These companies are indeed widely accepted as suppliers of antennas for Class A, LPTV and translator stations. With only 386 Class A UHF stations, this market segment is more than adequately served by these antenna manufacturers.

Our recent interviews with Full Power broadcasters confirm that their selection for new antennas will remain with the two primary antenna suppliers. They cite these two companies' experience with high-power slot array and panel antennas, along with product reliability, as their reasons for choosing these suppliers.

Any assumption that the overall number of antennas required for repacking the television stations would be more evenly spread across a much wider group of manufacturers is false, especially for the largest group of stations – Full Power.

T-Mobile's assertions that antenna suppliers have ample time for antenna engineering and manufacture are wrong, in part, because T-Mobile underestimated the number of stations that would need new or rebuilt antennas, including both main and standby. It also failed to consider how highly customized and time intensive producing antennas is, and the primary manufacturers' cautious business practices

[4] *" Broadcast Spectrum Repacking Timeline, Resource and Cost Analysis Study",* pages 38-42

for making additional capital investments until it is time to fill a significant number of orders.

The antenna manufacturers' first deliveries are likely to come five to six months into the repack time window. The process begins with the RF study and recommendation for the new antenna, followed by the CP and budget filing to the FCC. The stations must then wait for FCC compensation approval before ordering the antenna. That covers, at the very least, the initial three months of the repack time window.

Most broadcast television antennas are custom products, not built or stock. Extensive interviews with major antenna suppliers reconfirmed DTC's earlier analysis that once an order is placed, the typical lead times will range from 12 to 24 weeks for design, modeling, manufacturing and testing of an antenna.

This, along with the major antenna suppliers' plans for preparing for the repack, illustrates the complexity and time intensity for providing antennas for such a large group of stations within a compressed amount of time.

T-Mobile's claim that antenna suppliers are making preparations for the eventual increased demand is not disputed by DTC. It is certain that some measures are being taken, after a long run of greatly minimized production capacity over the last seven to eight years since the DTV transition was completed.[5]

However, the two primary antenna manufacturers that make up at least 75% of the overall U.S. market (89% of the high-power station market) reported to us that they will not make any significant increases to their capabilities until sufficient orders warrant the expansion. "I can't afford to hire, train, and equip technicians and crews that will be sitting around waiting for the work to begin," said Tom Silliman, President of ERI which has the second-highest U.S. market share in the high-power antenna market, and also operates a division that services TV broadcast tower owners for antenna installation and removal.

They also pointed out that their delivery times of 12-24 weeks are very likely to lengthen when a large number of orders are received. Antenna production ramp-up time has been estimated to take 12 or more months once started, to achieve maximum production.

Another element in antenna production has to do with standby antennas that suppliers typically keep in inventory, to provide to their customers in the event of an emergency outage or the urgent need to get its customers back on the air. Both primary antenna suppliers indicated that they each keep about a dozen in stock for short-term rental, and although there will be a great demand for these auxiliary antennas, they will not build up their "rental" inventory. They say there is too much financial risk in building up this inventory, and then being unable to monetize these antennas once the repack has concluded. Therefore many stations will be forced to purchase interim antennas.

[5] *"Broadcast Spectrum Repacking Timeline, Resource and Cost Analysis Study,"* page 16

Broadcaster Preparations

In its report, T-Mobile suggested that there is a significant amount of planning and preparation broadcasters can do before receiving a new channel assignment, such as "engaging with consultants to audit equipment inventories and determine delivery schedules for replacement equipment." This was presented as a way for broadcasters to maximize the amount of time allotted for planning and implementing channel transitions during the repack work.

As an example, T-Mobile recommends that broadcasters who are located within the clearing target and are not eligible to participate in the auction, or have elected to not enter the auction, should begin repack preparation work now.

The repack rules specify that broadcasters must submit detailed budgets at the time they submit their CP applications for the FCC's approval. Expenses incurred without prior FCC approval will not be eligible for reimbursement unless the FCC modifies the current rules. Likewise, a meaningful budget cannot be submitted until broadcasters know their new channel assignments. Even if the FCC modifies its rules to allow for reimbursement of pre-auction expenses, stations would still be at risk for non-reimbursement of any costs incurred prior to the auction if the auction fails to close.

In addition, these stations would not know what channel they will be relocated on, and therefore could not obtain meaningful quotes from suppliers for the key components, such as antennas, that are channel specific. This also impacts their ability to conduct a meaningful tower structural analysis, since no accurate antenna weight or loading information for the new antenna will be known.

The Number of Stations Likely to Change Channel

DTC, which documented its work on estimating the number of stations that may be required to repack post auction, does not know what assumptions were made for the CCA's estimate of the likely number of stations that will transition to new channels. Based on the FCC stated spectrum-clearing targets and the number of high-power and Class A stations that may be affected, the CCA estimates appear to be unreasonably low.

As DTC stated in its 2015 study, only when the auction is concluded will anyone know the exact number of stations that will be required to transition to new channel assignments. In order to build an interdependent timeline model that factored in all tasks, available resources and their interdependencies, DTC analyzed FCC simulations and offered two reasonable spectrum clearing target scenarios to plug into the timeline model. This resulted in an estimated range for the number of stations likely to change channels during repack. The CCA simulations understated the number of stations that are likely to be repacked by only focusing on the 1,675 stations that the FCC originally deemed to be eligible to participate in the auction process. There are actually 1,706 Full Power and Class A stations that have been documented in the FCC Form 2100 Schedule 381 filings. This increases the stations that are likely to be repacked by 31.

In addition, when examining the number of stations that reside above DTC's assumed clearing targets (84 MHz and 126 MHz), two-thirds of the eligible Full Power stations rest above these clearing targets. For an 84 MHz clearing target, 593 of the 1,320 are above the target, and for a 126 MHz clearing target, there are 922 stations above the target. This, however, only accounts for Full Power stations.

When considering the Class A stations for an 84 MHz clearing target, 144 of the 386 total Class A stations are above the target. For a 126 MHz clearing target, 211 of the 386 Class A stations are above the target.

As stated above, it is not possible to know what percentage of these stations will meaningfully participate in the auction, but it is obvious that a majority of stations could be impacted by repack. The number, of course, could be less than our estimates, but it seems unlikely that it would be significantly less.

Also seemingly absent from the CCA estimates is the recognition that, even though most stations below the cutoff on channels aren't likely to have to relocate to a new channel, there will be some of the larger markets in densely packed regions where these stations will have to change channels to accommodate new stations that had to be moved into the lower UHF portion of the bands.

The report also ignores the fact that some stations participating in the auction will elect to move from UHF to VHF channels. While these stations will be funding their move from their auction proceeds, they also will be utilizing the same resources as those stations required to repack, and will be on the same timeline. This will add additional loading to the repack resources that was not factored into T-Mobile's completion statement. While we don't know for certain how many stations will fall into this category, those that do will have to be factored into the manufacturing and services work load.

Available Resources: Tower Crews

The T-Mobile report disputes DTC's estimates of available resources for TV stations to accomplish upcoming channel changes, with a special emphasis on a greater number of "tower-climbing" firms available to assist with channel changes. The T-Mobile report emphasizes the number of tower-climbing crews that can climb towers with more than 1,000 feet of height, tower-climbing crews with "rigging equipment on hand," and firms with acceptable OSHA safety records[6].

Based on these criteria, DTC is not surprised that the researchers identified additional crews in the marketplace. DTC can only assume that the T-Mobile research did not account for the exacting requirements for tower-specialty firms that are responsible for installing or removing 3,000 pound to 24,000 pound antennas and large-diameter rigid transmission lines in all types of terrain and weather conditions. DTC can also

[6] *On Time And On Budget: Completing The 600 MHz Incentive Auction Repacking Process Within The FCC's 39-Month Relocation Deadline And The Budget Established By Congress"* report, page 37

only assume that T-Mobile did not account for the current practice of renting equipment to those firms that don't own the necessary gin poles, hoists and other equipment. The TV broadcast tower rigging companies that own this equipment reported to us that they will not rent or share any of their equipment during the repack project because they will have no capacity to do so, and they do not rent gin poles to companies using crews inexperienced in installing TV antennas.

DTC presents in the Appendix on page 26 the detailed steps and equipment required for this type of TV antenna installation, as well as the standards that antenna installation crews must meet to competently and safely install these antennas on towers that range in height from more than 100 feet to 2,000 feet. It must be pointed out that this includes antennas that are on "short" towers. These antennas are big and heavy, and still require the same equipment and expert crews that are required for work on tall towers. Experienced TV tower-service owners reported to us that in some cases, the short towers present a greater degree of difficulty for antenna installation, due to variable elevations and limited space for towers in mountainous regions.

The T-Mobile and CCA reports focused on tower height for analyzing the qualifications of tower crews. The ability to climb tall towers is one of the criteria required, but the experience and skill to operate specialized gin poles, double- and triple-drum hoists, and to handle large-diameter transmission lines is of equal or greater importance. As a point of clarification, the term "tall tower work" within the TV broadcast antenna installation industry inherently includes the installation of large and heavy antennas and transmission lines to broadcast towers, it does not merely address the height of towers.

DTC interviewed owners and supervisors of the majority of the firms cited by T-Mobile and found that many of them have little experience installing the types of TV antennas that will mostly be installed and removed during the repack. Some of them did not own the required equipment, primarily did tower construction and reinforcement work, or some simply plan to exit TV broadcast work altogether.

Results of a March, 2016 survey of engineering directors of 889 high-power TV stations by the NAB showed that only seven of the additional 25 crews cited by T-Mobile had ever done any antenna work for these stations. The remaining 18 tower firms were unknown to the engineering directors. In the same survey, where the technical directors were asked to rank the most important among six criteria, 87% ranked "prior experience with the company" as the most important. It is highly unlikely that broadcasters will be willing to trust their most valuable asset to unknown firms.

DTC did, however, confirm that there are likely an additional five qualified crews (not 25 as T Mobile claimed) in addition to the 16 we estimated in our 2015 study, for a total of 21 crews. The 21 crews meet the qualification criteria to remove and install heavy antennas (up to 24,000 pounds) and attending rigid transmission lines, as well as the capacity and willingness to work outside of their geographic regions.

An additional four crews with regional footprints and lighter rigging equipment were identified. All are included in the two tables below.

Qualified Tower Crew Availability Nationwide*			
Company	**Location**	**Current Est. No. of Crews**	**Results from Survey of 889 High-Power TV Stations ^**
Beckman Tower	CA	1	High-power TV stations report to have used in past
Coast To Coast Tower Service, Inc.	TX	3	High number of high-power TV stations report to have used in past
Cycle Tower Service LLC	VA	1	No report of past use by stations
Electronics Research, Inc.	IN	1	High number of high-power TV stations report to have used in past
FDH Velocitel	IL	3	High-power TV stations report to have used in past
Grundy Telcom Integration, Inc.	Canada	2	No report of past use by stations but has worked as sub-contractor to U.S. general contractors
H.C. Jeffries Tower Co., Inc.	TX	2	High-power TV stations report to have used in past
Northeast Towers, Inc.	CT	1	High-power TV stations report to have used in past
Precision Communications, Inc.	OK	1	High number of high-power TV stations report to have used in past
Seacomm Erectors, Inc.	WA	1	High number of high-power TV stations report to have used in past
Sioux Falls Tower & Communications	SD	2	High-power TV stations report to have used in past
Tower King II, Inc.	FL	2	High number of high-power TV stations report to have used in past
Wallen Communications	AZ	1	High-power TV stations report to have used in past
Total		**21**	

* Nationwide TV antenna installation companies with required equipment and experienced tower and installation crews. See Appendix for equipment specifications and crew criteria.

^ Results of the survey question: *Identify the number of qualified companies that can install a large Full Power transmitting TV antenna on broadcast TV towers.*

Availability of Regional Tower Crews with Limitations*			
Company	**Location**	**Current Est. No. of Crews**	**Results from Survey of 889 High-Power TV Stations ^ & Additional Notes**
LIT	TN	1	No report of past use by stations. Can install lighter-weight antennas and installs heavy-weight antennas with rented equipment.
Quality Tower Erectors, Inc.	FL	1	One report of use in past. Owns gin pole that can lift light- and medium-weight antennas.
Wallace Tower	AR	1	No report of past use by stations. Owns equipment that can lift light- and medium-weight antennas.
Wireless Infrastructure Services	CA	1	One report of past use by stations
Total		**4**	

***** These companies typically work only in a specific region and are qualified to do limited TV antenna installations.
^ Results of the survey question: *Identify the number of qualified companies that can install a large Full Power transmitting TV antenna on broadcast TV towers*.

The availability of approximately 20 qualified TV antenna installation crews was repeatedly confirmed by owners and managers of companies that have years of experience within the TV broadcast tower services business. Industry veteran and leader Don Doty, Regulatory Compliance Advisor at FDH Velocitel[7], which provides tower structural engineering services as well as antenna installation services to the broadcast and wireless industries, said the following: "Today there are only about 20 properly trained, skilled and qualified crews that can meet TV broadcasters' standard for the complex work of removing and installing large TV antennas and rigid transmission lines."

The implication from the CCA study is that the FCC's and the Department of Labor's (DoL) workshops on tower climber safety, plus a technician apprenticeship program, is sufficient to fill the currently thinly populated pipeline with skilled crews who can handle the hundreds of heavy TV antennas and corresponding equipment necessary during the upcoming repack.[8]

[7] Doty is formerly the CEO of Stainless LLC, which was acquired by FDH Velocitel in 2015. He is a past Chairman of the National Association of Tower Erectors (NATE) and the current President of the National Wireless Safety Alliance (NWSA) Board of Directors and a Member of the NWSA Board of Governors. He continues to serve on NATE's OSHA Relations committee and is on the Editorial Committee for the ANSI A10.48 Criteria for Safety Practices with the Construction, Demolition and Maintenance of Telecommunication Towers

[8] "*Repacking of Broadcasters Can Be Completed in 39 Months or Less"*, pages 4- 5.

DTC was repeatedly told by experienced TV tower-rigging crews that safety training and certification is critical for tower crews, but safety certifications alone are inadequate for filling TV antenna installation crew positions. In response to the tower-climber safety courses, Doty said the following. “It’s like taking a driver’s license test. It means you passed the test. It doesn’t mean you have the skills or experience to operate specialized equipment,” he said. “There is no school to go to for gin pole training. It’s hands-on training.”

There are a handful of additional tower companies that work on a regional basis who indicated that they have no plans to work outside of their specific region. These regions included the Southeast, the Plains, the Southwest and California. These companies will be able to handle some of the installation projects, but cannot be reasonably included in a list of “Tower Crew Availability Nationwide.”[9] Furthermore, the greatest density of TV stations likely to repack is east of the Mississippi River.

There are several reasons why these companies do not work outside of their regions. First, the cost of mobilizing four-six person crews and the attending equipment is expensive and time consuming. If mobilizing to a long distance outside of their regions, firms report to DTC that is difficult to compete with firms that have smaller mobilization costs.

Buying the necessary equipment to do the TV antenna rigging jobs is estimated to cost more than $350,000. This estimate is comprised of the costs for an appropriate-sized gin pole, winch system, cabling, and other hardware. See the appendix on page 26 for more details on required equipment.

Many regional firms won’t invest in financially risky expansion to acquire work during the temporary repack time window. Firms such as FDH Velocitel, that have large national organizations behind them, are much better equipped to work all over the country. In addition, broadcast-tower specialty firms are required to have state General Contractor licenses. In some cases, there is reciprocity among states, but there are many for which there is no reciprocity. In these cases, firms must obtain state licenses or work as subcontractors for general contracting firms.

Since the high-power analog-to-digital TV transition completed in 2009, most of the national companies have been primarily doing tower maintenance work, and have ongoing contracts to take care of maintenance and emergencies for both their radio and television customers. Servicing their contractual obligations will likely take precedence over “one-off” installation jobs, especially in times when there is an emergency outage.

Available Resources: RF Consulting Engineers & Other Consultants

The T-Mobile report states that there are 18 additional RF consulting engineers available to work with high-power TV stations, in addition to the 35 originally

[9] *On Time And On Budget: Completing The 600 MHz Incentive Auction Repacking Process Within The FCC’s 39-Month Relocation Deadline And The Budget Established By Congress”* report, page 39

estimated in DTC's 2015 study. T-Mobile, therefore, estimates that there will be 53 consulting engineers available to prepare engineering studies for CP applications that must be submitted after the station receives its new channel assignment.

Upon review of our research from a year ago, we discovered our estimates were actually high, and we now identify 29 from our original list. In addition, we reviewed T-Mobile's list of 18 additional RF consulting engineers and verified that there are only 10 available (see table below), bringing the total to 39, which is four additional consultants than was estimated in DTC's report. The four additional engineering consultants will not take significant pressure off the bottleneck that will form in the 90-day CP application period, especially when considering T-Mobile's miscalculation of the number of stations that may need new or rebuilt antennas.

RF Engineering Consultants with Television Practice (Identified in DTC Report)		
Consulting Firm	**No. of TV RF Consultants**	**Comments**
Carl T. Jones Corp.	6	
Cavell, Mertz & Associates	3	Verified with Garrison Cavell
Chesapeake RF Consultants, LLP	1	
Cohen, Dippell & Everist, P.C.	3	Verified with Don Everist
Communications Technologies Inc.	2	
duTreil, Lundin & Rackley, Inc.	2	Reduced staff will only focus on existing TV customers and radio work. Verified by one of the firm's principals.
Greg Best Consulting, Inc.	1	One person firm
Hammett & Edison, Inc.	4	2 full time and 2 with shared duties
Hatfield & Dawson	1	Verified by one of the firm's principals
Kessler & Gehman	2	
Meintel Sgrignoli & Wallace	2	
Merrill Weiss Group, LLC	1	Verified with Merrill Weiss
Vir James PC	1	One person firm
Total	**29**	

RF Engineering Consultants with Television Practice (Identified in T-Mobile Report)			
Consulting Firm	**T-Mobile Estimate**	**Actual**	**Comments**
D.L. Markley & Associates	2	0	D.L. Markley is deceased; Jeremy Ruck departed the firm
Graham Brock, Inc.	1	0	Radio-only practice
KGI Broadcast Engineering Consultants	2	0	One member is retired and the other is on long term sick leave
Marsand, Inc.	2	2	Limited RF consulting clients; Marsand specializes in transmitter installation services
Mullaney Engineering, Inc.	3	2	One engineer departed firm
Munn Reese, Inc.	4	2	Data from firm's website
Smith & Fisher	2	2	Primarily focused on Empire State Building site
V-Soft Communications	1	1	Very limited TV consulting practice, primarily radio and RF coverage software
Jeremy Ruck	0	1	Formerly D.L. Markley; now in independent practice
Total	**17**	**10**	

Upon review of T-Mobile's list of structural engineering firms available, DTC found several misrepresentations of these firms. Those misrepresentations include:

- Separate listings for Consolidated Engineering and Griswold Towers. These two firms have merged.
- One of the identified firms primarily designs and sells software for structural engineers.
- One of the identified firms primarily works only on towers with a maximum of 500-700 feet of height.

Transmitter Needs and Costs

T-Mobile's assertion that DTC overestimated the number of UHF transmitters that are likely to be impacted by channel change is incorrect, because its analysis of the transmitter data reported from FCC Schedule 381 is flawed in several ways.

- There is no reporting of stations that own main and alternate (standby) transmitters. A recent NAB survey of Full Power TV stations indicates that

about 36% of these stations own and maintain alternate transmitters at a single site as a means of backup. If that factor is applied to the 1,320 Full Power UHF stations, there are about 470 additional UHF transmitters that could be impacted by a channel change, thus adding additional cost to T-Mobile's assertion that repacked stations can be fully compensated by the $1.75 billion repack compensation fund.

- The T-Mobile report assumes that 20% of the transmitters reported are likely able to move to a new channel assignment. While this is likely true if you factor in the transmitters at both Full Power and Class A stations, a closer look at the details will reveal that the transmitters most likely to be moved to a new channel are the lower-power transmitters used by Class A stations, and a very limited number at the Full Power stations.

There are essentially three categories of transmitters in use by UHF stations today:

- Tube-type transmitters operating with IOT and depressed collector IOT tubes. Of the 1,320 Full Power TV stations, 724 currently operate with this category of transmitter, and 473 of these are with stations operating in the spectrum that is targeted to be cleared in the auction. This category represents the higher power levels and the more costly transmitters in the field. The majority of these transmitters are made up of between two- and four-tube amplifiers, combined by a waveguide-combining network and phase shifter. These transmitters typically operate with output power levels (TPO) in the range of 20 to 80 Kilowatts.

  There are multiple limiting factors that make changing channels on these transmitters an unrealistic task, if it is to be accomplished in a short time period without taking the station off air for several days.

  The solid state driver sections of many of these transmitters are banded into five- or six-band segments between channels 14 and 51, and are obsolete technology that cannot be easily replaced.

  The RF combining systems are made of waveguide and are also banded by three different types, with each type having different physical dimensions. Replacing the RF system is a major task, as this equipment is mechanically complex, heavy and very large.

  The cavities that each tube operates in will also likely require changes, with new coupling loops and spacers to facilitate tuning. There were three manufacturers of this technology, but none were interchangeable. One company has exited the market, one only supports parts and tubes on special order with very long lead times, and the third has limited production capability. Further, the cavities are likely to have suffered from the effects of heat, corrosion and dirt, making them more difficult to retune and then provide reliable operation.

  It should be assumed that any of these transmitters that must be moved to a new channel will need to be replaced with new transmitters.

- Solid state transmitters that are channel banded. This category is made up of early solid state transmitters typically operating at power output levels between one and 20 Kilowatts (TPO), and used by some Full Power stations as either main or standby transmitters. A few are also used by Class A stations. The Schedule 381 data identifies 234 of these transmitters; many more are in service as standby transmitters, but not reported in Schedule 381. There could be as many as 500 of these transmitters in service.

  The technology used in the amplifier modules in these transmitters results in the UHF channels being typically divided into five- or six-band segments. A combination of the amplifier pallet designs and the RF circulators in each module are the key factors in the band limitations. This is obsolete technology, and the modules are not able to be replaced with new amplifier modules capable of operating on the new channel assignments.

  It is with high probability that transmitters of this type will have to be replaced if they are to be moved to a new channel, especially if they are currently used on channels that are targeted for spectrum clearing, since the channel clearing foundries closely line up with the band segment boundaries within these modules.

- Solid state transmitters that are frequency-agile and not limited to a small range of channels. There are two groups of transmitters that fall into this category. The first group are lower-power transmitters in the range of 50 Watts up to about five Kilowatts, and are either first or second generation solid state units. Most Class A stations and some Full Power stations operate transmitters of this type as either main or standby transmitters. This group represents the least costly type of transmitter, and they will not need to be replaced during repack.

  There is a second group of frequency agile transmitters serving primarily Full Power stations. This group is a limited number (150 or less) of second generation solid state transmitters that have the capability of power levels from five Kilowatts to 20 Kilowatts, and a few recent models up to 80 Kilowatts. They also will not need to be replaced during repack.

  Most stations operate 24/7 with only an infrequent maintenance period. Putting a station off air for more than a few hours overnight represents an unacceptable interruption of its business. Therefore, any modifications that can’t be made in this time period will result in the need of a new transmitter.

Appendix

Below is a list of necessary equipment, materials and personnel qualifications DTC compiled from its interviews with TV broadcast tower companies, antenna manufacturers, and gin pole fabricators and certifiers.

Broadcast television transmitting antennas weigh between 3,000 and 24,000 pounds, and are from 30 feet to more than 100 feet in length. The accompanying transmission lines are typically 6 1/8 inches to more than nine inches in diameter sectionalized lines, which come in about 20-foot sections that have to be assembled in the air.

The equipment and required qualifications are as follows:

- 100-foot gin pole
    - 16-, 24- or 36-inch pole face width
    - Extended rooster head in some cases
    - Custom hand-off brackets
- Gin poles should be inspected and certified on a regular basis
- Lifting is done with three-drum winches that have from 2,500 feet to 3,500 feet of steel cable that is from ½ inch to one inch in diameter on each of the drums
- Two- or three-drum hoist with 2,000 to 3,000 feet of wire rope
- Headache Balls
- Trucks
- Four-six people on crew with climbing certification and gin pole training or experience
- Included in that crew should be a winch operator, one ground man, and three men on tower
- Rescue equipment

In special cases, installations must be done with sky crane helicopters. These antennas can be mounted on towers that range from 100 feet on mountaintops to over 2,000 feet.

In most every case, a rigging plan must be developed prior to a crew beginning the process of changing out antennas or modifying a tower. Such plans are typically developed by the tower rigging firm and then reviewed by a structural engineering firm and stamped by a licensed Professional Engineer. There is a limited number of qualified engineers for reviewing and certifying theses plans. It is not a simple “rubber stamp” process.