Television Spectrum Repack – A radio perspective

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Abstract - United States Television broadcasters are about to embark on a significant cycle of change in their transmission infrastructure as part of the upcoming FCC administered spectrum repack – auction plan. While much focus has been placed on what that means to TV broadcasters and what they should be doing to prepare, there has been little discussion about the potential impact to the operations of potentially thousands of FM radio broadcasters who will also be affected. Radio stations need to quickly engage in planning alongside TV broadcasters to ensure they have plans in place to avoid lost air time and revenue disruption. The author will discuss FCC proposed timelines, scope of potential changes, approaches to mitigate off-air interruption, what to start doing today and what type of relief may be available as part of the auction proceeds to offset TV relocation costs.

Background

For the second time in as many decades the U.S. over-the-air television industry is about to go through massive change and reorganization of the television spectrum. The first transition for full power televisions stations that had been underway for most of the decade, ended in 2009 with the shut off of analog transmission and the return of the spectrum used for those signals. During this conversion, television stations operated simultaneously analog and new digital television transmission facilities and began to offer both free over the air HD broadcasts, as well as new services using the multicast capability of the ATSC 1.0 digital television transmission standard.

Over the past ten years new applications of rich media content delivery on mobile wireless networks have emerged and gained traction with consumers. These applications deliver video in both short and long form over ubiquitous IP networks including mobile wireless carriers. Industry analysists have projected increases in data consumption, primarily driven by video content ten times by 2019.

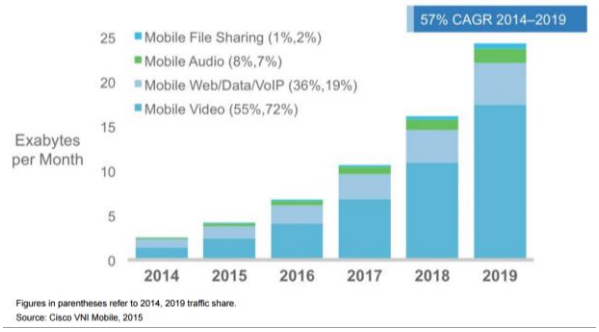

Fig 1 Projected mobile data usage

Wireless operators have been working on multiple fronts to address the need to increase network capacity in order to meet the increasing demand for data capacity. The attack on the capacity challenge on one front requires improvements in the efficiency of the delivery system with many operators using LTE today to offer increased bandwidth. On the other front, additional spectrum is being deployed to meet demand. In the most recent spectrum auction – AWS-3, significant spectrum in the 700MHz band was auctioned off for a total of $45 billion dollars.

With projected demand continuing to grow, reallocation of the television broadcast spectrum is the next prime target to create spectrum capacity to meet the growing demand.

Repack - Spectrum Auction

In order to meet the increased demand for optimal spectrum for use in mobile wireless networks for the distribution of voice and data services, Congress authorized the FCC to conduct voluntary spectrum auctions of a portion of the current UHF television spectrum. This process is often referred to as "Repack" or "Repacking". As defined by the FCC, "Repacking involves, reorganizing television stations in the broadcast television bands so that stations that remain on the air after the incentive auction occupy a smaller portion of the UHF band, thereby freeing up a portion of that band for new wireless services uses."

The FCC has established a target of between 84MHz and 126MHz of spectrum currently used by broadcast television stations to be reclaimed for auction to wireless operators in the upcoming spectrum auction. To achieve these targets the new top end of the UHF television spectrum channels would stop at channel 30 if the maximum of 126MHx of spectrum is recovered or channel 38 if the lower target of 84MHz of spectrum is recovered. The following chart outlines four potential scenarios of the remaining upper UHF television channels after differing levels of spectrum are recovered as shown in figure 2

Fig 2 Remaining UHF television channels post spectrum recovery

The FCC and communications consultants have run numerous different simulations totaling over 100 scenarios to determine the likely number of television stations that would remain on the air but have to be relocated as part of the process. The estimate ranges from 800 stations, assuming 84MHz of spectrum recovered, to 1200 full power

television stations, assuming 126MHz of spectrum recovered, that will need to relocate to different frequencies than they currently operate on.

Proceeds from the auction up to $1.75 billion have been allocated to reimburse television stations who did not participate in the auction but have to be relocated to a new channel. In addition, there is proposed legislation to add an addition $1B for broadcaster transition costs. While these numbers certainly sound like large values, industry experts have estimated that transition costs could range from $2 billion with 800 stations being displaced to almost $3 billion if 1200 stations need to repack.

Various factors impact the costs at each station, including but not limited to, age of transmission equipment, how far the new frequency is from the existing, bandwidth of existing systems, availability of back-up antennas, structural status of tower, density of other tenants on the tower structure and location. One of the less obvious technical factors impacting television stations is the fact that the vast majority have frequency specific equipment. This ranges from the transmitter through the RF system to the transmission line and finally the antenna. While this may seem overly restrictive to an FM broadcaster who has long enjoyed solid state broadband transmitters, that capability is relatively new to High Power UHF digital television broadcasters. Television broadcasters will need to pull together a total budget for their channel relocation, which will include structural and temporary solutions, including other work that may need to be done to accommodate there relocation. For radio broadcasters it is this area of "other impacts" related to the channel relocation that may make their supporting changes part of the TV stations budget and reimbursable.

The proposed timeline for the repack calls for both the reverse and the forward auction of spectrum to take place in mid-2016, with the results and awards happening the end of 2016. Stations who will be impacted and need to relocate will find out their new channel assignment and need to file for a new construction permit starting in December of 2015. The current legislated time period starts at December 2015 and continues for a period of 39 months. At the end of the 39-month period, broadcasters need to have moved to their new channel and vacated their old frequency. The FCC has indicated that they will quickly turn around these applications within 90 days so that broadcasters will have ample time to transition.

Most industry experts agree that the currently legislated 39-month period is not sufficient to transition all of the stations. Best estimates range from 40% to 60% of the total stations needing to move may have moved by that time. Other estimates suggest the entire process swill take five to nine years to complete. As we learned in the analog to digital conversion, there are a great number of complexities when transitioning a large number of stations over a rather short period of time, not the least of which is a generally limited number of skilled consultants, engineers and installers capable of completing high power digital television transmission systems.

What part of the TV facility is impacted?

The task of changing operating frequencies for a high power television broadcast facility ranges in levels of difficulties and complexities. On the simple end of the equation, broadcasters have broadband transmission equipment including a transmitter, antenna and transmission line and may only need to tune or replace the channel filter. While this scenario is possible, the vast majority of U.S. television broadcasters have systems implemented during the conversion to digital that have limited frequency agility. Most systems are limited in the ability to move in frequency, and a significant number of systems in the field may be from suppliers who are no longer in business, making replacement parts impossible to obtain. In addition, even with products still supported by leading suppliers, electronic components on many have been discontinued such that crafting new parts on a different channel is not practical.

When taking a view of what part of the facility would be impacted by a frequency relocation, viewing a simple block diagram of the typical broadcast chain for a television station allows us to focus on the specific areas impacted as shown in figure 3.

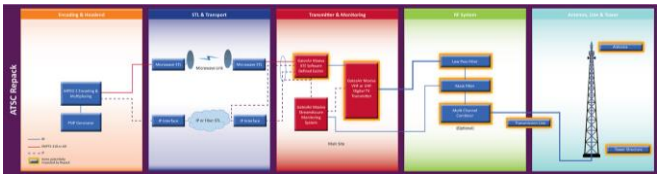

Fig 3 Simplified block diagram of television transmission system

The major area of impact will be from the transmitter through the antenna system. Some stations may have to adjust their encoding solution should they opt to channel share with another broadcaster which is an activity that is typically adding some addition cards to an encoder at the studio, and not a major undertaking.

The majority of transmitters will need to be replaced with a suitable new unit to accommodate the needed power of the new channel of operation. Most of the high power transmitters will likely be liquid cooled, and also have cooling system components both inside and outside of the transmitter building. Many of the station RF systems which provide sharp tuned filters to eliminate unwanted side band energy, will also need to be modified or replaced. If a station is in a combined operation, similarly the combining system will need modification or replacement.

On the tower, most antennas some transmission lines and potentially even the tower itself will need to be modified or replaced to support the new channel. All of this work will need to be done such that the station can remain on the air and have an orderly transition, likely focusing stations to install back-up or temporary systems to support reduced coverage operation during the transition.

How does this impact FM radio

The biggest question any FM station must consider is what the impact to their operation might be. The first place to start is the number of sites one has that are shared with a television station. Based on our research of the FCC documentation, we have identified 1,153 tower sites that have both FM radio and television stations on them that may be impacted. These sites have a total of 2,368 FM radio stations including translators and low power stations. Out of these 2,368 stations, over 1,300 are full power FM stations. Figure 4 outlines common stations per state.

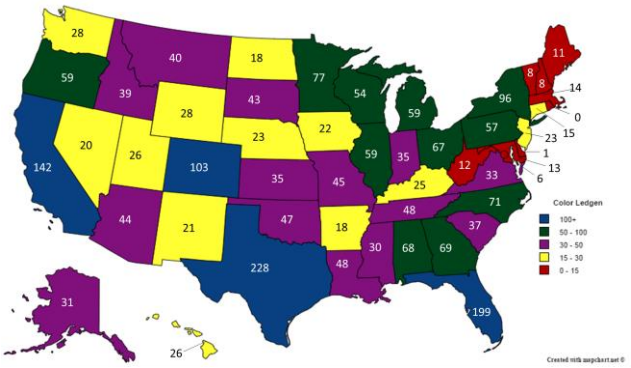

Fig 4 Number of potentially impacted FM stations by state

FM stations that share common infrastructure with a television station will need to engage their television counterparts to identify potential construction and be prepared for the potential of off-air time, and facility reorganization. Based on the severity of off-air time, FM stations may look to establish back-up sites or alternative antennas to allow for reduced coverage operation during these interruptions. As anyone who lived through the first conversion to digital for television stations can attest, setting up a TV transmitter and new antenna system is not a single overnight project, but rather months of time and coordination.

Transmitter building impacts

The configuration of co-sited broadcast facilities vary in how they allocate space for each station. In some cases the site may be broken up into separate rooms by tenant, providing physical isolation between the various radio and television stations. In other cases, the site is a large open room with clusters of transmitters for each station and the required supporting racks of gear located around the facility.

The biggest issue radio stations that share space need to be aware of is the additional room, either permanently or on a temporary basis that is needed for the television station to make their facility changes. The basic placement of the new transmitter is rather obvious, and in some cases it could be in space vacated by the former analog transmitter. What is not so clear is the impact of changes to electrical systems, transmission line paths, filters which may be mounted to the ceiling or placed on the floor, and routing of cooling systems. In addition, some sites may have to remove old equipment to make room for the new television transmitter, especially if this old equipment is the non-operating analog gear that was installed long ago. New tenants such as an FM station may have been installed around the analog television transmitter. These radio transmitters may have to be relocated to allow the old television equipment to be removed and new equipment brought in. It is interesting to note that many analog transmitters are still in the same place they were at shut off. We anticipate this repack effort will require the remaining ones to be removed from facilities.

In all cases, early engagement by radio operators with their landlord and the co-located television station, however preliminary, is necessary to understand what their plans might be and to actively participate to ensure the needs of the radio station operations are considered and costs captured and budgeted for in the transition process.

Tower Structure Impacts

Any time broadcasters embark on additional antennas on a tower, a certain amount of structural analysis must be completed. The impact of this will show up in a few ways for radio operators. There may need to be a full on tower inspection and inventory of all antennas, requiring off-air situations to allow for safe climbing. This inspection is likely to take place as part of a greater tower analysis by properly certified structural engineers. While this is a potential interruption of operations, the impact should not be major.

The largest impact will likely come from the potential structural reinforcement that may come as a result of the study. While changing out or adding an additional antenna may not seem like a major undertaking that would impact the structural integrity of a broadcast tower, it is likely that most tower structures holding a current digital television antenna with the collocated radio stations had the majority of the installation done before the implementation of the new TIA-222-G structural standard for antenna supporting structures and antenna, which was first published in 2006 with the latest addendum in December of 2014. TIA-222-G outlines structural requirements taking into consideration ice, wind speed, topography and shape factors of the

structure and antennas mounted on them. In general, these new requirements are more stringent than the prior ones that most of the high power U.S. television stations were built under and may force tower structure reinforcement to support new antennas. This effort to improve the structure will likely impact operations of most tenants on the tower, not just the television station.

Antenna & Line Impacts

For most television stations, the use of relatively narrow band antennas is fairly wide spread with many made for the specific channel in use. Given the frequency specific nature of the antenna systems, most will need to be replaced. One of the factors that will impact the transition is that we estimate only about 10% of the television stations in the U.S. have back up antennas that could be used to assist in the transition to a new antenna on the repacked frequency.

Industry experts agree that many stations will need to add a side-mount television antenna to broadcast from in order to get on the new channel, and over time transitioning the current main antenna location to the new frequency. This new side-mount antenna has the largest potential to impact vertical aperture used by an FM station on the same tower. It is expected that this antenna may be in use for several months to a few years depending the tower structural study and any reinforcement that may be needed.

With the reclamation of the upper portion of the UHF television spectrum, many of the stations will need to operate at a lower frequency than they operate on today. One impact on the use of tower space this will have is the relative size and gain of broadcast television antennas based on frequency of operation. For example, an antenna on channel 51 might have a vertical length of 45.2 ft with a gain of 27. If that station moved to channel 24 they would need an antenna with a vertical length of 58.3 ft to maintain the same gain. In addition to the growth in vertical space needed, the weight is almost double the existing antenna. For the television station, maintaining the gain is an important factor to using a similar sized transmitter. However, the additional space on the tower may impact FM radio stations operating on the same structure. The impacted FM station may need to relocate on the tower or possibly have to reduce the size of their antenna to accommodate the television antenna change.

An additional factor that may impact the sizing of a television broadcast antenna is the fact that current antennas are almost exclusively horizontally polarized and optimized for fixed reception. As broadcasters look forward to the future, the use of advanced standards such as ATSC 3.0 would target users on the move with an efficient one to many wireless IP service. In order to effectively reach mobile users, a certain amount of vertical polarization is required. While not a 50-50 split as in radio, this additional amount of power in the vertical plan will also drive up the requirement for more power to reach a certain ERP, additionally focusing on the balance of antenna gain and transmitter power.

Television stations using ridged transmission line on the towers have the additional detail of the transmitting frequency versus the length of the transmission line. Many stations had to optimize lines in 20', 19-3/4' and 19-1/2' lengths to avoid hot spots due to VSWR effects. Moving to a new channel may require the station to change the transmission line, not for power handling requirements, but for the unacceptable VSWR that the line length would cause. Again, this significant installation requirement for a television station changing channels, may impact the co-located FM in off-air time, and potential relocation of antennas depending on transmission line run.

While we have discussed the potential impact of these changes to the radio station in terms of relocation or off-air time, the long-term impact of a potential relocation on the tower could be a significant impact to the radio station's coverage. The figures below show the impact on the FM pattern due to moving from a 24" face potentially higher on the tower to a 48" face lower on the tower.

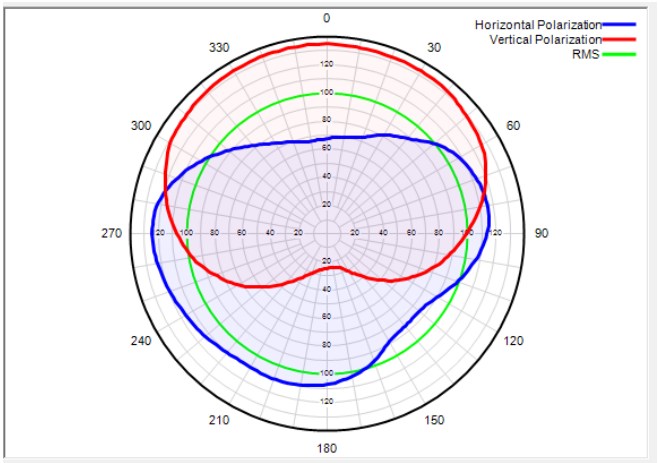

Fig 5 Dielectric DCRC leg mounted on 24" face

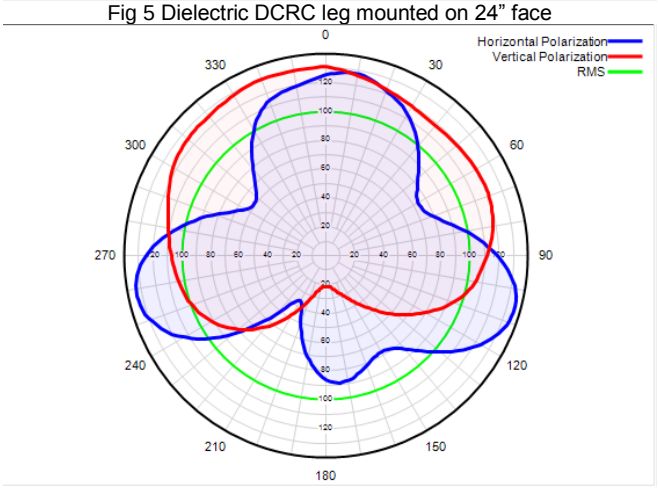

Fig 6 Dielectric DCRC leg mounted on 48" face

Careful attention will need to be paid in cases such as this to ensure radio stations do not suffer significant coverage loss or shift in their critical market areas due to changes required to support television transmission infrastructure conversion.

Potential Interference – CH 6

Educational FM stations have long been keenly aware of the impact of a CH 6 television station in their market. With the conversion to digital, many stations vacated low band VHF (CH 2-6) for higher frequencies such as UHF. With the advent of repack it is unclear how many stations may return to low band VHF, including CH 6. Should television stations relocate to CH 6 in a market, a detailed study needs to take place to evaluate any potential interference projected to radio stations operating in the market, not simply those who are co-located, to predict what impact this change will have in terms of usable coverage for the radio station. For those FM stations who may be co-located with new CH 6 television station, care should be taken to ensure the CH 6 signal does not enter the FM transmitter via the antenna and mix with the FM signal in the output of the FM transmitter. In some cases such intermixing can be prevented by more aggressive filters on the television transmitter, such as using an eight pole filter to reduce the amount of power from the television transmitter that is emitted on FM channels at the lower end of the band.

Technical Resource Impacts

The first discussion most broadcasters start to address is the availability of technical products such as transmitters and RF systems. While these will certainly need proper planning and adequate lead times to produce the appropriate amount for the market, the industry agrees that with proper planning, these products will not be the items that are in short supply to be able to meet the market and conversion timelines. The focus however, quickly turns to the availability of qualified technical professionals to be able to plan and implement this significant amount of station frequency changes. The capacity limits will be stretched in several areas.

Consulting and structural engineers will have a significant amount of work to complete in a short period of time to engineer and create the proper documentation needed to file for a construction permit, tower analysis and structural studies. This capacity limit will impact not only the television broadcasters who need to move, but also has the potential to consume many of the professionals who serve radio stations with projects not associated with television repack. It is wise to get planned projects under way quickly for your FM station before these professionals turn to television projects which will require significant effort in a short span of time.

In a similar manner to proper structural and consulting engineers, the installation of both transmitters and antennas and line on the tower, along with any tower construction will tax the crews available to work on typical high tower high power television facilities. While many have discussed the capacity that may exist from the mobile wireless industry, the skills needed to work on a 200ft self-supporting tower and working on a 1000' guyed tower are different. The broadcast high tower type crews are a specialty subset of the overall tower and antenna service industry. This is one of the major areas of concern television broadcasters have about being able to complete the projects within the 39-month time frame. FM broadcasters with pending projects that would use similar tower crews should plan early to get the work scheduled and started. It is anticipated that during the repack, these crews will be fully consumed with television projects and many radio projects may need to be postponed pending resources.

The typical high power television antenna requires significant time for planning and budgeting based on structural specifics of the tower and the antenna pattern, in many cases taking up to 13 to 20 months. Broadcast antennas are an area many are concerned will be a bottle neck of capacity impacting the overall repack program timeline. Despite the increasingly global economy, high power television antenna systems are a specialized smaller segment of the overall industry and somewhat specific to the U.S. Not only will this limited capacity have impact on the procurement of television antennas, but some suppliers that provide both television and radio products may have capacity limits on radio products during the repack. Proper planning on the part of a radio station is critical during this time frame.

What should a Radio Station Do?

As the Boy Scout motto goes "Be Prepared"! Radio broadcasters should start engaging their television counterparts quickly to learn what they can about potential repack changes to the television facility. Start planning and budgeting for back-up sites if it appears you will have significant interruption of your main site during repack construction. Not only will you cover potential lost air time during repack, but you will have a valuable back-up resource for a long time to come. Understand what changes may need to take place in your main facility due to repack activities. Prepare a budget for these costs, and work with the TV station to include these costs in their overall budget for reimbursement. The funding is intended to cover the cost of moving to a new channel. Work that needs to be done to a co-located radio facility may very well be covered if it is included in the television reimbursement request.

If you have planned projects that require structural engineering or consulting engineering, it may be wise to engage those services now before the rush that may consume

the industry's capacity. Most of all, communicate, make a plan and execute against it to ensure your station has minimal interruptions due to the television conversion.

Conclusion

With over 2,300 radio stations sharing facilities with television stations, the potential for a radio station that is co-located to be impacted is very real. Clear, early communication with your neighbors will help ensure you know the potential impact and can start planning together to avoid the risk of off-air time, lost revenue, and service to your community. By working closely with the broadcast technical supply industry, including transmitter suppliers, antenna companies and engineering professionals, you will be able to navigate the challenges.

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