Spectrum Repack – Issues and challenges encountered in the early installations

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Abstract - Nearly 1000 Television broadcasters in the United States have embarked on a massive undertaking of transition to new frequencies as part of the FCC spectrum repack. This transition has caused stations to make significant changes to their transmission infrastructure, many of which have not had modification since the turn on of digital over a decade ago. Implementing new systems to support a "flash cutover" to a new channel requires careful planning and adaptability to ensure a timely and quality turn on of new transmission equipment. There will be a review of several of the installations GatesAir has completed to date, highlight of key requirements to a successful installation, and identification of challenges to avoid. We will examine trends we have seen in the real-world implementation, and the steps taken to deliver a quality transmission facility in time to meet a stations transition phase and have a smooth path to an ATSC 3.0 future.

Background

In 2017 the FCC Spectrum auction became reality and 175 television stations sold their spectrum and elected to exit operating an over the air transmission facility. To take advantage of this vacated spectrum to auction to non-broadcast operators, an addition 987 full power and class A television stations had to relocate to a new channel. This relocation process has a relevantly short time frame of 39 months and is divided in to 10 phases. While broadcasters did not know the outcome of the auction and their channel assignments until well into 2017, many were working hard to determine what steps they might need to take if they were to be relocated. To that end many undertook early steps including site evaluations and a systematic review of their current facilities to benchmark what systems were in place, and what capabilities or obstacles might be in the way of relocated to a new channel.

First Things First

For most broadcasters it has been well over ten years since any major work was done at their transmitter sites, and for some their DTV installations were even earlier than that. Over the ensuing years many of the details of the transmission system may have changed, or the original details became less clear. As the early installations have been completed, the tried and true premise that no two transmitter sites are identical remains in force. Each individual site includes a significant number of unique characteristics that impact the installation plan and process to complete the transition to a new channel.

Before any new work can be done, or any specific planning started it is critical to understand what exactly is in place at the transmitter facility today. The best way to accomplish this is by undertaking a site survey that includes a complete catalog of the facility, equipment in place and a detailed electrical RF and mechanical analysis of the facility. The major broadcast transmitter suppliers like GatesAir and many qualified engineering consultants can complete this scope of work.

Run Don't Walk to The Tower

In addition to the evaluation of the infrastructure at the transmitter site, stations will need to have a detailed analysis of the tower structure completed to determine what if any upgrades will need to be complete prior to the installation of any new antennas systems. Your first call should be to your preferred tower company to conduct a detailed review of the tower structure. Such a review should include a mapping of all the antennas and lines on the tower and their status (See Figure 1).

Table 1 - Existing Antenna and Cable Information

Mounting Level (ft)	Center Line Elevation (ft)	Number of Antennas	Antenna Manufacturer	Antenna Model	Number of Feed Lines	Feed Line Size (in)	Note
758.0	780.5	1	-	TUA-04-10	1	7-3/16	1
	758.0	-	-	-	2	3-1/8	2
699.0	699.0	1	microwave dishes	8' std w/radome	1	EW63	
695.0	695.0	1	miscl	CRS2	1 1	1-5/8 7/8	
651.3	661.3	1	generic	20 ft x 2.5" omni whip	1	1-5/8	
	651.3	1	tower mounts	Generic 1' x 2' sidearm			
649.3	649.3	1	-	WSCN-10 Bay FM	1	3-1/8	
537.9	537.9	1	-	KKCB-8 Bay FM	1	3	
489.5	489.5	1	-	KDNI-2 Bay FM	1	1-5/8	
408.3	408.3	1	-	KUWS-7 Bay FM	1	3-1/8	
329.3	329.3	1	miscl	12" x 9" Camera	1	1.92	
		1	miscl	Ice Shield 1.5' x 2.0'	1	1/4	
291.0	295.0	1	generic	8 ft x 4.5" omni whip	1 1	EW20 7/8	1
	293.5	2	generic	5 ft x 3.5" Omni Whip			
	291.0	2	generic	TMA (10" x 8" x 4")			
		3	tower mounts	Generic 3' x 4' sidearm			
192.0	195.5	1	antennae	7' Whip	1	7/8	
	192.0	1	tower mounts	Generic 2' x 3' sidearm			
138.3	138.3	1	generic	18" x 18" x 1" Panel	1	1/4	
109.7	109.7	1	microwave dishes	6 ft x 3 ft Grid	1	1/2	
83.0	83.0	1	microwave dishes	4 ft Grid	1	1/2	
40.3	40.3	1	microwave dishes	4 ft Grid	1	7/8	
35.0	35.0	1	microwave dishes	NSI Dish	2	EW63	
27.3	27.3	1	microwave dishes	6 ft x 3 ft Grid	1	7/8	

Figure #1

Over the years services may have been added or removed, but a surprising number of out of service antennas and lines have been left in place. These unused antennas and lines impact the tower loading, and potentially the needed aperture for transition related antennas for the TV station.

With the completion of the structural analysis of the tower by the appropriate experts, review of the needed upgrades to ensure the tower will meet both the current requirements which may have changed during the years since it was installed, and the proposed changed needed to support the new antennas for broadcasting on a new channel. The report (See Figure 2) may include areas of the tower that need to be reinforced prior to any additional antennas being added to the structure

Table 3 - Section Capacity (Summary)

Section No.	Elevation (ft)	Component Type	Size	Critical Element	P (K)	SF*P_allow (K)	% Capacity	Pass / Fail
L1	757.667 - 741.167	Latticed Pole Leg	4 3/4" solid	3	-112.06	736.95	15.2	Pass
L2	741.167 - 737.667	Latticed Pole Leg	4 3/4" solid	41	-123.47	736.95	16.8	Pass
T27	220 - 190	Diagonal	L 2.5 x 2.5 x 5/16	800	-25.63	23.54	108.9	Fail
T28	190 - 175	Diagonal	L 2.5 x 2.5 x 5/16	838	-27.84	23.54	118.3	Fail
T29	175 - 160	Diagonal	2L 3 x 3 x 1/4 (1/2)	856	-46.79	76.69	61.0	Pass
T30	160 - 130	Diagonal	L 2.5 x 2.5 x 3/8	895	-31.20	27.96	111.6	Fail
T31	130 - 100	Diagonal	L 2.5 x 2.5 x 3/8	943	-27.91	27.96	99.8	Pass
T32	100 - 70	Diagonal	L 2.5 x 2.5 x 3/8	982	-22.82	27.96	81.6	Pass

Figure #2

In any event, early engagement with the tower contractors is key to be able to manage the potential bottlenecks given it is likely that the tower crews will be the most in demand and capacity restricted part of the repack. Scheduling and completing the needed tower strengthening should be undertaken as soon as possible to remove that work from the critical path. In addition to the structural work, scheduling and getting written commitment from your tower contractor is highly recommended as soon as you can to nail down that important part of the project.

While scheduling the tower contractors early, it is a good idea to include accommodation for unpredictable weather delays in your schedule (see Figure 3). A good rule of thumb is to include an additional 20% of time in your schedule and the associated cost in the budget for such delays. In areas that may have winter storms an even greater safety factor may be required to account for delays.

Figure #3

Analog is Over, Right?

While the analog shut off happened in 2009, approaching 10 years ago, and surprising number of facilities are full of analog equipment including but not limited to old transmitters, STL systems, Satellite downlinks, RPU's (See Figure 4) and of course an entire tower full of related antennas.

Figure #4

Proactively removing and disposing of this unused equipment needs to be completed as soon as possible to not only free up the needed space, but to also avoid conflicts that could occur if the removal and installation of the new equipment overlaps. In addition to the unused transmission equipment that needs to be removed, it is a good idea to use this time and effort to do a deep cleaning of the transmitter site to remove accumulations of boxes, outdated office furniture, left over promotional items, two vintages of playout servers and the famous "it is still good" equipment that is somebody's well-intentioned but never executed repair project. A quick call to a firm like 1800GOT JUNK can quickly remove these items and make the needed space for an organized installation.

In addition to the cleanup, and required tower work, there is may be deferred maintenance of the transmitter building and site that should be addressed before new equipment starts to

arrive. Some of the more pressing ones include fully functional access doors, loading docks, access roads, gates and any other constraints that normally would not be a problem for technician level access, but can pose a serious delay in the delivery and installation of large transmission equipment.

Lead Times, Ordering & Permits

When planning any major project, creating a detailed schedule requires a complete understanding of not only the end date, but the needed lead times and duration of the materials and labor needed to complete the work. Understanding the time needed to secure delivery of all the needed broadcast and infrastructure equipment will go a long way to creating a usable schedule that incorporates the key milestones including when to place orders. Given that the entire repack will be placing stress on the broadcast infrastructure supply chain it is a good idea to place your orders as early as you can once you have all the needed data to do so. When it comes to having material in place the adage of "I would rather be looking at it than for it" is a good plan to work by.

While most of the constraints in a repack transition will be related to equipment and the needed labor to complete an upgrade, don't forget to secure the necessary permits and approvals. These approvals can range from local zoning or electrical inspections to state or federal environmental approvals depending on your transmitter site location. If your station requires a new tower, or significant modification including height changes of your existing towers you may need FAA approval, which can take a significant period. In any case that you require outside authorization, it is important to plan for the time in your schedule, and proactively attack securing these permissions to limit the impact to your transition.

Avoid Needless Delays

Upon completion of the transition schedule the next major task at hand is to execute to the scheduled time line and avoid delays and roadblocks. Communication with all the parties involved in the project is critical to be able to ensure the project can be completed on time and budget. Following is a list of important and useful information to gather and communicate to the execution team and your suppliers.

Required Information	Reason
Transmitter site address	*Verify correct address for deliveries*
Transmitter site phone number	*Contact information for installation work crews onsite*
Site contact person	*Contact for delivery Notifications*
Site security procedures	*Instructions for work crews to gain access to site*
Map of directions to site	*Directions for work crews, delivery trucks*
Maximum yearly temperature range	*Possible de-rating of some transmitter & cooling components in extreme climates*
Site elevation above sea level	*Possible de-rating of some transmitter & cooling components at high altitude*
Name and address of closest hotel to site	*Lodging for work crews*
Name and location of local equipment rental, electrical supply firms	*Resource for ladders, torches, welding supplies, electrical parts*
Grade, type, load restrictions of road to site	*Determine maximum delivery truck length & weight. Determine crane access to site. Possible antenna size restrictions*
Description of site loading dock, if any	*Anticipate special requirements for equipment offloading from delivery truck*
Door sizes, passageway & equipment cabinet clearances	*Adequate space to offload and move new equipment into position*
List of moving & lifting equipment on site	*Dollies, pallet jacks, and jbars for positioning equipment cabinets*
Dimensions of staging area to store equipment upon delivery	*Adequate space to store equipment cabinets and transmission line upon delivery*
Dimensions & description of cleared ground area available outdoors for tower work	*Adequate area for tower hoist, lines, and staging exists*
Indication of water availability on site	*Required for transmission line soldering*

Capacity of backup generator, UPS	*Determine suitability to power transmitter*
BTU capacity of site cooling system	*Determine suitability to cool transmitter*
Volts / Amps / schematic of site AC feed	*Determine suitability to power transmitter. Also verify correct equipment is ordered (delta vs. wye)*

Required Information	**Reason**
Schematic and condition of site ground system	*Determine suitability for lightning/surge protection. Locate interface points for new equipment*
Type, age, and condition of ceilings, walls, and floors	*Needed for possible structural review of roof and/or floor loading*
Transmitter building drawings	*Used for structural analysis and plan transmitter system layout*
Planned transmission line entrance point into building	*Used to plan transmitter system layout. Determine if obstructions exist within building or ice bridge*
Tower drawings	*Used to analyze tower and plan any modifications*
Updated inventory of existing lines and antennas on tower	*Make sure that all recent additions to tower have been taken into account during analysis*
Previous tower inspection & guy tension reports	*Used to analyze tower and plan any modifications*
Previous tower analyses	*Used to analyze tower and plan any modifications*
Previous tower modification reports	*Used to analyze tower and plan any modifications*
Name and phone number of all major contractors, equipment suppliers	*Facilitate communication among various participants in installation project*
Calendar restrictions	*Determine which weeks, months are unsuitable for work before scheduling*
Workday restrictions	*Anticipate delays due to shortened workdays, overnight work*
Required on-air date	*Understand station's expectations*

Understand and communicate site access potential issues or constraints to your suppliers so they can work with you to accommodate any limitations in your access that may cause an issue. Larger equipment will be impacted by your access roads, loading locks, doorways or freight elevators. For example, broadcast antennas are typically 40 to 70 ft in lengths and particularly narrow roads can cause a problem for deliveries and may require a redesign to the antenna.

Don't miss the small items that can bring an installation to a stop. Review all the needed materials with your suppliers before the installation crews arrives on site and get on order anything that together you identify was missed. Ensure you check all boxes and packing lists to be certain the needed materials are on site and can be located once equipment arrives. One missing RF "bullet" can stop an entire installation team.

Double check the details around your electrical service, is it Delta or wye? Many engineers, especially those with multiple sites may not recall which configuration they have in place, and much of the broadcast infrastructure such as transmitters and voltage conditioning equipment need to be configured prior to installation. Once you verify yours, document it and ensure the right configuration has been ordered and communicated to the right parties.

Make sure your heat load calculations include everything before you provide that info to the HVAC contractors. Work with your equipment suppliers to calculate the needed cooling for proper equipment operation. While the transmitter is likely the largest generator of heat, don't forget to account for heat radiated from RF systems, pump systems in a liquid cooling system if located inside the building and any test, monitoring or remote-control equipment located in supporting racks.

Spend some time educating any local contractors you may work with for electrical or HVAC for example about the details surrounding a broadcast transmitter installation. Broadcast site installations are very different from other commercial construction projects, and the trades will need to be flexible. Ideally use local crews you have worked with before, or get a referral form other stations about contractors who work well in a broadcast environment. In addition to the education ensure you have enough electricians on site to be able to complete the work promptly and around the

broadcast equipment. The number one delay of a prompt installation is related to timely completion of electrical work.

Be prepared when the shipments start to arrive for your equipment. All the building construction work should be completed, space open to receive the new equipment and stage it until installation. In addition to the areas being clear of debris, a clear path into the building and the final resting place of the transmitter is needed. Ensure that additional labor is in place to unload equipment upon arrival of the freight companies. Special off-loading equipment and pallet jacks make the move in go much smoother. Local companies can provide this service if the station does not have the moving equipment or extra labor to help with move in.

Before your installation crew arrives on site, double check your new channel TPO to avoid any last-minute surprises or needless re-calibrations. A full system loss and gain calculation starting with the licensed ERP, antenna gain, transmission line loss and RF system loses needs to be done to establish the correct TPO. It is surprising the number of times the correct power level was not known resulting in additional days' time and labor costs to the station due to delays and doing a second proof.

Final Tips

To close, here is a collection of classic transmitter site tips that have been handed down through the ages. They still apply today.

- Use mousetraps, mothballs, and fly strips at transmitter site to keep animals from taking equipment off the air.
- Carefully seal all cable ducts entering or leaving building to keep out snakes and rats.
- Seal concrete floors to keep dust levels down.
- Make sure that all painting and drywall work is done before transmitter shipment arrives.
- Floor tiling should wait until after the transmitter is already in place; otherwise, the heavy equipment cabinets will damage the tiles during installation. The tiles can also be used to hide the copper ground strap.
- Install a phone extension in a quiet, well lit room.
- Install a second extension near the transmitter & program and monitor racks.
- If not already in place install internet connectivity to the transmitter site before installation, all new transmitters and related equipment have remote IP connectivity.
- Prominently post all emergency numbers, such as police, fire, and ambulance, next to each telephone extension. Include the site telephone number, address, and directions of how to get to the site.
- Install a red "OK to leave light" above the exit that lights whenever the transmitter is on and in "remote" mode.
- Install plenty of 120V outlets, especially around the front of the transmitter and PIE racks.
- Lay out two well-lit workbench areas in a quiet room - one for heavy work with a vise, one with a static mat and soldering/desoldering station for board repairs.
- Keep at least one set of original shipping boxes on hand for "swappable" items such as solid-state PA modules, power supplies and exciters.
- When the installation is complete, establish a baseline record of antenna, transmitter, and site parameters for future reference.
- A properly designed star-point ground system is as important as ever for protection against lightning damage.
- Install surge protection on AC and data lines connected to the transmitter.
- IP based equipment for control and monitoring can be disabled by lightning surges that enter through data connections.
- Maintaining a positive building pressure relative to outdoors helps keeps out dust and contaminants.
- Make sure that all outdoor components are sufficiently shielded from falling tower ice, snow drifts, blowing sand (desert locations), and tampering by trespassers.

Conclusion

The US spectrum repack has a very aggressive time table for stations to transition to new channels to facilitate not only the transition of spectrum to those who purchased it in the auction, but other stations who may be transitioning to the soon to be vacated channel of another. With the rapid deployment and tight timeframe for transition broadcasters will need to be diligent to ensure they can meet their required deadline. One way to facilitate a smooth transition is to take advantage of the learning of others. This paper has presented a collection of lessons learned by the GatesAir service team in their installation, turn on and transition of station in the spectrum repack and presented as a reference stations and engineers can use in their transition process.

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