Repacking the Broadcasters in 39 Months or Less

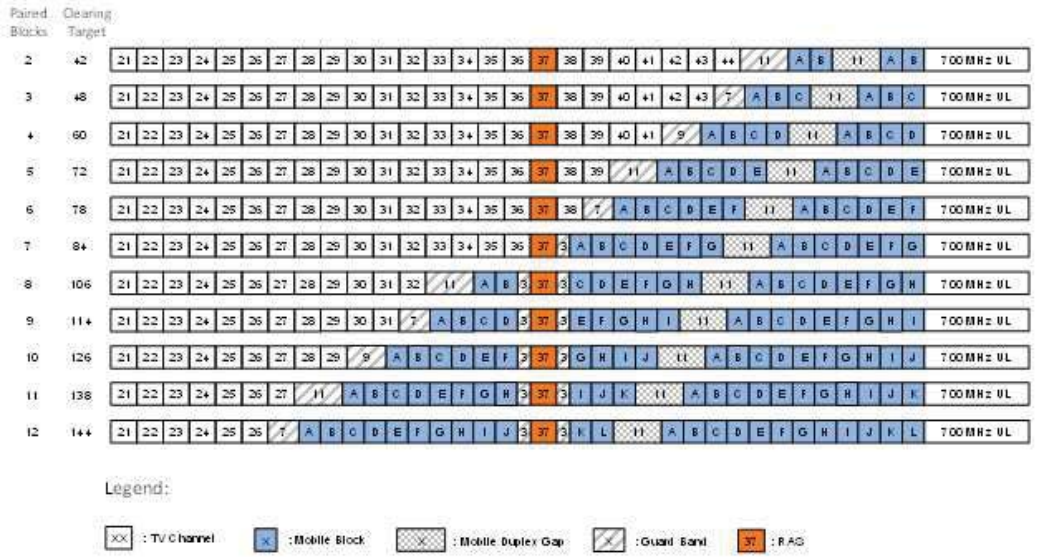
February 12, 2016

Topics

1. Overview of the Repacking process
2. Ample Repacking Resources Exist
   - ✓ Fewer Antennas Needed; Manufacturers Preparing
   - ✓ More Tower, Transmission, and Antenna Installers and Fitters
   - ✓ More RF Consulting & Structural Engineers
3. Updated and More Realistic Simulations Show Even Fewer Repacked Stations
4. The FCC Can Take Steps to Minimize Relocation Time

Overview of the Repacking Process

- Following completion of the reverse and forward auctions, the Media and Wireless Bureaus will announce the results of the auction and repacking process in the *Channel Reassignment Public Notice*



- The *Public Notice* will establish a 39-month transition period, and identify new channel assignments for full power and class A television stations that the FCC has reassigned to different channels
- These stations will have three months to file their initial construction applications relating to their channel reassignments
- Following the three-month application window, stations will be repacked over a 36-month period

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Ample Repacking Resources Exist

- ✓ Fewer antennas are needed than DTC estimated and manufacturing is ramping up
- ✓ There are more tower, transmission, and antenna installers and fitters than DTC identified
- ✓ RF & structural engineers can handle the workload

Takeaway – A clear, organized relocation plan will repack in 39 months or less

Significant Number of Antennas Do Not Need Replacement

Key Findings:

1. Approximately 25% of UHF broadcasters report using antennas capable of operating over multiple UHF channels
2. Approximately 13% of UHF broadcasters use antennas that cover 30 or more TV channels
3. Approximately 56% of UHF broadcasters use antennas that are side mounted, which makes removing and installing new antennas much easier than more costly and complex top-mount installations

Takeaway – Stations with broadband antennas and those with side-mounted installations should need fewer resources and repack more quickly than other stations.

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Antennas: Broadband Antenna Examples

Slot Antenna

Panel Antenna

Takeaway – Panel antennas with the ability to tune across multiple channels are already deployed and can facilitate a timely repacking

Antennas: Broadband Example in LA

- In the Los Angeles DMA, seven stations use antennas capable of supporting the entire UHF band, and two of these seven share an antenna

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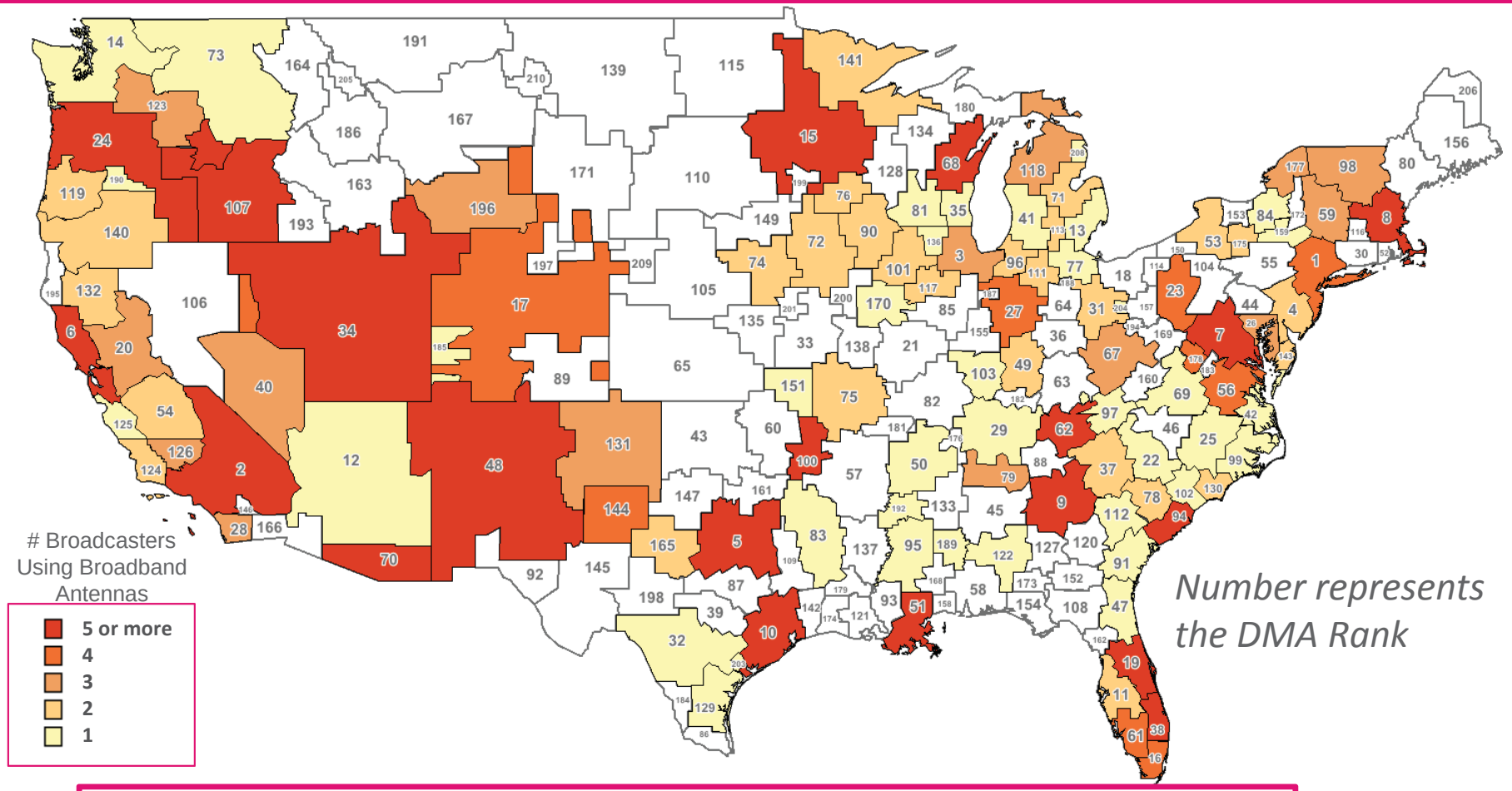
Antennas: Count by DMA of Broadcasters Using Broadband Antennas (6 or More UHF Channels)



Takeaway – Broadband antennas are used extensively around the country, especially in areas that are most difficult to pack (e.g., northeast, Pacific Northwest, California, Florida, Chicago, etc.)

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Antennas: Supply Chain Expanding, Innovating

- BTTi contacted almost every US broadcast antenna manufacturer
  - All of them are aware of the repack and the potential business opportunity
  - Some have started to build a supply chain, order equipment, and take other steps to prepare for the transition
  - The base of manufacturers includes many different companies eager to gain market share
- Tower companies are deploying community antennas, which reduces the need for individual antennas
- General trend in the industry is to share antennas when possible
- Sharing reduces future OpEx costs (rent) for broadcasters

Antenna Make	Percent Used
Dielectric/RCA	50%
ERI/Andrew	20%
Kathrein/Scala	7%
PSI	4%
SWR	4%
Jampro/Alan Dick	3%
RFS	2%
Other	10%

Takeaway – The supply of new antennas is expanding and antenna sharing will continue to transform broadcasting technology

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Availability of Tall Tower and Antenna Installers

Company	DTC Identified	Location	Current Crews	Potential Crews
Advance Tower Service	No	Albequerque	1	2
Beckman Tower	No	Fresno, CA	1	2
Coast To Coast	Yes	Waxahachie, TX	3	5
Cycle Tower	No	Bristal, VA	1	2
Deep South Comm	No	Baton Rouge, LA	2	3
Electronic Research, Inc.	Yes	Evansville, IN	1	2
FDH Velocitel	Yes	Cedar Hill, TX	3	4
Great Lakes Towers	No	Flat Rock, MI	3	5
Great Plains Towers	No	Fargo, ND	1	2
Grundy Telcom	No	Ontario, CN	2	3
H.C. Jeffries Tower Co.	Yes	Porter, TX	2	3
Kelley RF Services	No	Titusville, FL	1	1
LIT Systems	No	Chattanooga, TN	1	1
Northeast Tower, Inc.	Yes	Farmington, CT	1	2
P and R Tower Co	No	Sacramento, CA	2	3
Precision Tower	Yes	Grove, OK	3	5
Quality Tower	No	Largo, FL	2	3
Seacom Erectors	Yes	Seattle, WA	1	4
Sioux Falls Towers	Yes	Sioux Falls, SD	2	3
Tower Communications	Yes	*Incorrectly identified by DTC - not a tower company*		
Tower King II	Yes	Cedar Hills, TX	2	5
Tower Systems, Inc.	Yes	Watertown, SD	1	1
Tower Systems South	Yes	Winter Park, FL	1	1
Vertical Technology	Yes	Hagerstown, MD	2	4
WallaceTower Service	No	Franklin, AR	1	1
Wallen Tower	Yes	Tuscon, AZ	1	1
		Totals ==>	**41**	**68**

- BTTi has concluded that there are more qualified companies and personnel available for tall tower broadcast work than claimed by DTC
- The companies on the list are qualified to work on towers over 1000 feet and were found not to have had any material OSHA violations in the last 10 years
- The authors personally contacted persons of responsibility within each company to obtain the information shown in the table

Takeaway – there are more than sufficient qualified tower companies and crews available for repacking within 39 months

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Weather Constraints on Broadcast Antenna Swaps

- Well trained and equipment tower crews can work safely year round despite often challenging environmental conditions
- BTTi and many of the other tall tower companies identified have changed antennas and transmission equipment in northern states during the winter months

← Many tower firms advertise their ability to work safely in suboptimal conditions

Discovery Channel's *Dirty Jobs* featured a tower company in North Dakota and explained that tower crews work in suboptimal conditions

Buffalo, New York

Ample Supply of RF Consulting Engineers

- The DTC report estimated 35 RF engineers at 13 firms
- H&E's research revealed another 18 consultants at nine additional firms
- In addition, larger broadcast networks typically have in-house engineers
- DTC understated the loading capacity of individual engineers

DTC Identified RF Consulting Engineering Firms/Individuals	Engineers
Carl T. Jones Corporation	
Cavell, Mertz & Associates	
Chesapeake RF Consultants, LLP	
Cohen, Dippell & Everist, P.C.	
Communications Technologies Inc.	
duTreil, Lundin & Rackley, Inc.	
Greg Best Consulting, Inc.	
Hammett & Edison, Inc.	
Hatfield & Dawson	
Kessler & Gehman Associates	
Meintel Sgrignoli & Wallace	
Merrill Weiss Group, LLC	
Vir James PC	
Total Number of Engineers Identified by DTC	**35**
Additional H&E Identified RF Consulting Engineering Firms/Individuals	**Estimated Engineers**
D.L. Markey & Associates, Inc.	2
Graham Brock, Inc.	1
KGI Broadcast Engineering Consultants	2
Marsand, Inc.	2
Mullaney Engineering, Inc.	3
Munn-Reese, Inc.	4
Smith and Fisher	2
V-Soft Communications	1
Wind River Group, Inc.	1
Total Number of Additional Engineers Identified by H&E	**18**
Total Engineers	**53**

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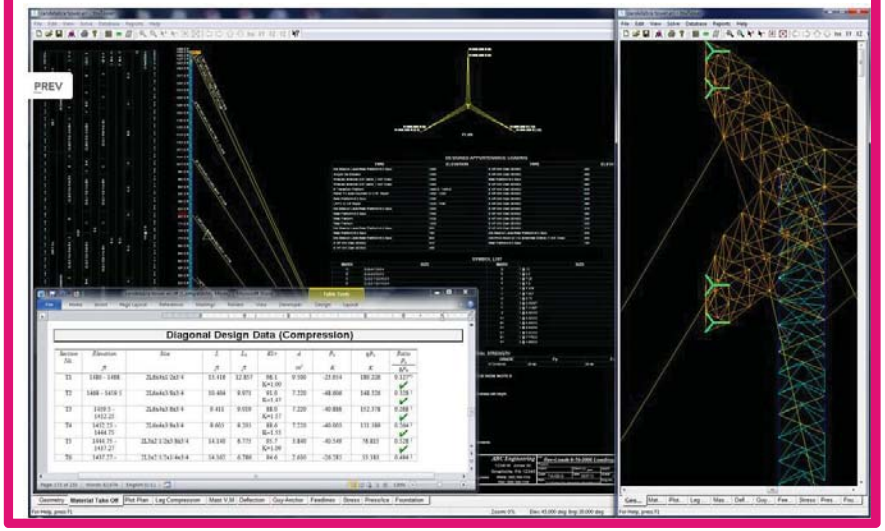
Availability of Structural Engineers

- The DTC report identified seven firms capable of tall-tower analysis, modification design and rigging plans
- BTTi identified at least a dozen additional firms, for a total of 19 firms, capable of performing this work

Company	DTC Identified	Location	P.E.
4SE	Yes	Charleston, SC	John Moore
Anderson-Foreman	Yes	Columbia, SC	Lewis Foreman
Consolidated Engineering	Yes	Evanville, IN	Pending
Davidson Engineering	No	Rouge River, OR	D. Wayne Davidson
EET, LLC	No	Granger, IN	John Erichson
FHD Velocitel	No	Norbrook, IL	various
Hodge Structural Eng	No	Evanville, IN	Gray Hodge
IETS	No	Charlotte, NC	William Griswold
Malouf Engineering	Yes	Dallas, TX	Mark Malouf
Morrison Hershfield	Yes	Canada	Various
Pate Engineering	No	Tampa, FL	Ricardo Raudales
Paul J. Ford & Co.	No	Columbus, OH	John Wilson
Tashjian Towers	No	Sanger, CA	Karl Tashjian
Tower Consultants	Yes	Columbia, SC	Jean Lecordier
Tower Engineering Co	No	Mount Lake, WA	Madison Batt
Turris Engineering	Yes	Toronto, CN	John Wabba
Walker Engineering	No	Atlanta, GA	Jim Walker
Westbrook & Assoc.	No	Johns Creek, GA	James Westbrook
Weisman Consultants	No	Toronto, CN	Simon Weisman

In addition, the proliferation of modeling, analysis and design software specifically for communications towers (e.g., tnxTower) has simplified and shortened structural analysis and design tasks



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DTC Does Not Consider Broadband Antennas

- DTC's methodology does not consider antenna bandwidth capability, only "Stations Remaining on Channel"
- Using DTC's methodology and actual stations needing to be repacked per the simulations - combined with actual antenna bandwidth capability for those stations - increases the number of stations that can reuse their current antenna
- This additional analysis reduces the number of facilities requiring substantial structural modification

Takeaway – Using actual data from the FCC's 2014 simulations* and DTC's methodology, but taking agile antennas into account, results in nearly **200 fewer** stations requiring new antennas in a worst-case estimation of repacking

DTC Analysis - 84 MHz Clearing Targets

Data from FCC 84 MHz Repacking Simulations		
Eligible UHF Stations	1,675	
Stations Eliminated	222	249
Stations Remaining on Channel (No Optimization)	92	132
Stations Required to Repack (No Optimization)	1,361	1,294
DTC Estimated Stations Remaining on Channel (After Optimization)	433	262
DTC Estimated Stations Required to Repack (After Optimization)	1,020	1,164

Sources: FCC DMA Simulations and DTC Analysis

T-Mobile Analysis - 84 MHz Target		
Eligible UHF Stations	1675	
Stations Eliminated (min/max)	186	244
Stations That Can Reuse Antenna (min/max) (not optimized)	290	**356**
Stations Required to Repack (max/min) (not optimized)	1199	1075
Estimated Stations That Can Keep Antenna (+25%/+10% - optimized)	590	464
Stations Requiring a New Antenna (min/max) (optimized)	899	**967**

** The study relies directly on the FCC data, which differs from information DTC provided. For example, the number of Stations Eliminated in the two tables are not identical, which is attributable to a mismatch between the values in the DTC report and the figures the FCC's simulations actually produce. The numbers in the lower table represent the actual minimum and maximum number of stations eliminated in the 50 simulations the FCC conducted at 84 MHz.*

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Updated and More Realistic Simulations Show Even Fewer Repacked Stations

- DTC based their estimates on 2014 simulations which are no longer relevant
  - The assumed participation was based on three methods of artificial repacking prioritization
  - The effects of an optimized repack had to be estimated
- Professor Peter Cramton recently performed updated simulations using the FCC's current band plans, repacking optimization objectives, and realistic participation for three clearing targets
- Professor Cramton's results demonstrate that a more optimized repacking algorithm can allow many more stations to be assigned their pre-auction channel than estimated by DTC
- Further enhancements are possible since Professor Cramton's repacking algorithm did not attain optimality

Takeaway – More current and realistic simulations predict that only 650 to 760 stations will need to be repacked, with about 450 to 550 requiring tall tower crews

	Clearing Target		
	84	114	126
Total UHF Stations Post-Auction	1,482	1,298	1,188
Repacked on Same Channel	716	411	315
Remaining station count with in-range broadband antennas	110	127	117
Remaining station count with antennas <= 350'	182	220	217
Total stations requiring tall-tower crews for repacking work	474	541	539

Source: Repacking of Broadcasters Can Be Completed in 39 Months or Less, Peter Cramton, Darrell Hoy, and David Malec, 10 Feb 2016

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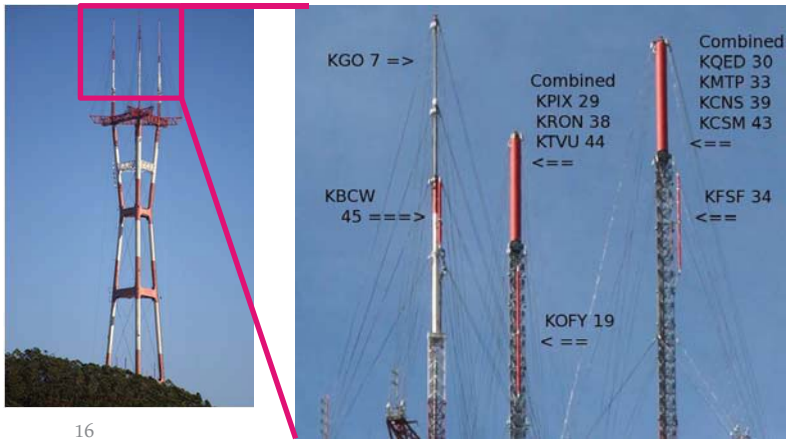
Fewer Antennas and Fewer Structures

Key Findings:

- Nearly 20% of all broadcast structures host multiple transmitters
- For example, the maximum 967 antennas requiring replacement calculated on Slide 14 represents only 870 distinct structures.



Total Number of Broadcast Structures and Number of Transmitters Per Structure		
Structure Info	**Structure Count**	**Transmitter Count**
Structure with 12 Transmitters	2	24
Structure with 11 Transmitters	0	0
Structure with 10 Transmitters	3	30
Structure with 9 Transmitters	1	9
Structure with 8 Transmitters	2	16
Structure with 7 Transmitters	6	42
Structure with 6 Transmitters	5	30
Structure with 5 Transmitters	11	55
Structure with 4 Transmitters	25	100
Structure with 3 Transmitters	59	177
Structure with 2 Transmitters	190	380
Structure with a single Transmitter	1094	1094
Structures without ASRNs	265	265
Totals:	**1663**	**2222**

Takeaway – The number of structures to be "touched" is fewer than the number of antennas.

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Summary of Resources Available

Resources	DTC/NAB	H&E + BTTi / T-Mobile
Antennas:	Every station needs a new antenna	Broadband antennas and existing and future antenna sharing will reduce antenna needs significantly
Tower Crews:	13 current qualified crews, 3 additional crews	41 existing qualified crews, 27 additional crews
RF Engineers:	170 applications per month	370-475 applications a month
Structure Engineers:	40 project a month	108 projects a month

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Final Channel Assignment Optimization Objectives

- In the *Auction 1000 Procedures PN*, the Commission established the following sequence of optimization objectives:

1. Maximize the number of stations that remain on their pre-auction channel
2. Among solutions that keep at least 95 percent of the maximum number of stations found in Objective (1) on their pre-auction channel, minimize the maximum amount of aggregate new interference that any station receives
3. Among solutions that satisfy Objectives (1) and (2), minimize the costs of relocating stations to new channels in the U.S. and Canada
4. Among solutions that satisfy Objectives (1), (2), and (3), the optimization will choose an assignment that prioritizes assignments of U.S. and Canadian stations to channel 5 in the Low-VHF band and avoids assignments of U.S. and Canadian stations to channel 14

Takeaway – Among other things, the H&E/BTTi analysis provides critical information about antenna bandwidth capabilities (i.e., frequency agility) that are relevant to Objective (3) and will help optimize the repacking costs and timeline

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Steps to Minimize Relocation Time

1. The FCC's repacking optimization Objective (3) should include antenna agility as a factor to minimize costs
2. Broadcasters with licenses not in the Incentive Auction should start repacking preparatory work
3. Tower owners should conduct structural analysis of their towers in preparation for antenna change outs
4. The FCC should clarify that preplanning expenses are reimbursable
5. The FCC should provide an updated listing of tower companies and equipment manufacturers for broadcasters
6. The FCC should include project management in the list of reimbursable expenses, and broadcast licensees should provide timely repacking status information to the FCC and public

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