March 25, 2016

Via Electronic Filing

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street SW
Washington, DC 20554

Re: Notice of Ex Parte Communication: *Amendment of Parts 15, 73 and 74 of the Commission's Rules to Provide for the Preservation of One Vacant Channel in the UHF Television Band For Use By White Space Devices and Wireless Microphones*, MB Docket 15-146; *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268

Dear Ms. Dortch:

The record demonstrates widespread support for the Commission's vacant-channel proposal as an important measure to advance broadband deployment, support innovation, and spur economic growth.[1] The proposal, moreover, will have only a small effect on the availability of channels for Low Power Television ("LPTV") and TV Translator operators.[2] In particular, the vacant-channel rule will ensure that a minimally sufficient amount of spectrum remains available

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[1] *See, e.g.*, Comments of Competitive Carriers Association at 8; Comments of the Consumer Electronics Association at 1-2; Comments of Google, Inc. at 4-6; Comments of Microsoft Corp. at 6; Comments of Open Technology Institute at New America and Public Knowledge at 1; Comments of Sennheiser Electronic Corporation at 1; Comments of Shure Incorporated at i, 2-3; Comments of T-Mobile USA, Inc. at 1-2; Comments of Wi-Fi Alliance at 1; Comments of the Wireless Internet Service Providers Association at 1-2. Unless otherwise noted, all comment citations herein are to comments filed on September 30, 2015 in MB Docket No. 15-146 and GN Docket No. 12-268.

[2] *See Amendment of Parts 15, 73 and 74 of the Commission's Rules to Provide for the Preservation of One Vacant Channel in the UHF Television Band For Use By White Space Devices and Wireless Microphones*, Notice of Proposed Rulemaking, FCC 15-68, 30 FCC Rcd. 6711, 6716 ¶ 11 (2015) ("Vacant Channel NPRM") (observing that the proposal's "impact on broadcast applicants, including LPTV and TV translator stations, in terms of the availability of channels for future use, will be limited because multiple vacant channels will still exist in all or most markets…").

for consumers using unlicensed devices in the most spectrum-constrained areas, such as urban cores. The rules will have little effect in rural areas where spectrum will be more plentiful—and LPTV and translators are most prevalent. Notwithstanding broadcasters' assertions to the contrary,[3] therefore, the Commission's vacant-channel proposal will have significant benefits for wireless users with little effect on the nation's LPTV and translator stations.

Consistent with all these points, this letter describes an additional study further documenting the minimal impact of the vacant-channel rule on LPTV and translator operations, and responds to the January 15, 2016 letter from the National Association of Broadcasters ("NAB") on this topic.[4]

1. Repacking Simulations Confirm the Minimal Impact of the Vacant-Channel Proposal on LPTV and Translators.

Using the Commission's own software[5] for predicting interference between broadcast stations and repacking the broadcast band, Google has conducted Monte Carlo simulations of likely Incentive Auction outcomes, evaluating tens of thousands of possible auction results and

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[3] *See, e.g.*, Letter from Rick Kaplan, General Counsel and Executive Vice President, National Association of Broadcasters, to Marlene H. Dortch, Secretary, FCC, MB Docket No. 15-146, GN Docket No. 12-268 (filed Jan. 15, 2016) ("NAB Letter"); Reply Comments of the National Association of Broadcasters at 2-8, MB Docket No. 15-146, GN Docket No. 12-268 (filed Oct. 30, 2015) ("NAB Reply Comments"); Comments of the National Association of Broadcasters at 10-17 ("NAB Comments").

[4] *See* NAB Letter.

[5] *See* Federal Communications Commission, *TVStudy Software – OET Bulletin No. 69*, http://data.fcc.gov/download/incentive-auctions/OET-69/; GitHub, *FCC / Constraint-Generator*, https://github.com/FCC/Constraint-Generator; GitHub, *FCC / SATFC*, https://github.com/fcc/SATFC/.

their corresponding effects on LPTV and translator stations, assuming that the Commission adopts its vacant-channel proposal. The analysis examined five markets:

- Metropolitan Trading Area ("MTA")-6 (including most of North and South Carolina);
- MTA-16 (including the Cleveland, Ohio market);
- MTA-36 (including much of Utah and Idaho as well as parts of Oregon and Wyoming);
- MTA-39 (including most of New Mexico as well as parts of Arizona, Utah, and Colorado); and
- Partial Economic Area ("PEA")-48 (including the Harrisburg, Pennsylvania market).

MTAs 6, 36, and 39 were selected due to their large number of LPTV and translator stations, mountainous terrain, and large rural areas. These characteristics are associated with worst-case impacts on LPTV and translator stations. MTA-16 was selected for a more representative look at the proposal's likely effects in a less mountainous, more urban market. Finally, PEA-48, which includes Harrisburg, Pennsylvania, was selected in order to model the possible effects of preserving a second vacant channel in a market where it may be necessary for a broadcaster to be relocated to the duplex gap.

Each market analysis consisted of 15,000 separate simulations covering three spectrum recovery scenarios: 84 MHz, 114 MHz, and 126 MHz. Each simulation evaluated a randomly selected combination of broadcasters selling their licenses in the reverse auction and the spectrum recovery scenario that would likely result given that level of broadcaster participation.

Google then analyzed each of these scenarios in detail to identify which translator and LPTV stations, if any, would be unable to continue operations as a result of the Commission's proposed vacant-channel rules. A total of 75,000 simulations were conducted across all markets.

Consistent with the Commission's proposed methodology for preserving the last vacant channel, Google evaluated every 2km-by-2km cell within each low-power station's contour, under each of the 75,000 simulations, to determine whether a vacant channel would remain available for unlicensed operations in each cell under the applicable separation distances in the Commission's newly revised Part 15 rules.[6] In the Harrisburg, Pennsylvania market, Google also evaluated a scenario in which the FCC places a broadcaster in the duplex gap and protects a second vacant channel. Google's simulations accounted for complex dynamics of the auction, including adjacent-channel restrictions between broadcasters (both full and low power), possible geographic variability in broadcasters' participation in the reverse auction, and interdependencies between 'daisy-chained' translator stations and their associated full-power stations.[7]

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[6] *See* Vacant Channel NPRM at 6729 ¶ 48 fig. 1; *Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37*, Report and Order, FCC 15-99, 30 FCC Rcd. 9551 (2015).

[7] Indeed, in the few instances where Google made assumptions to facilitate running the simulations, Google made conservative choices that tended to overstate the potential impact on LPTV and translators. For example, the simulations did not take into account the possibility that low-power broadcasters might choose to share a channel. *See Amendment of Parts 73 and 74 of the Commission's Rules to Establish Rules for Digital Low Power Television and Television Translator Stations*, Third Report and Order and Fourth Notice of Proposed Rulemaking, FCC 15-175, 30 FCC Rcd. 14927 ¶¶ 20-43 (2015). The simulations also assumed that every LPTV and translator in a given market would be required to make the vacant-channel showing. In reality, the Commission has proposed only to require this showing of stations that must relocate after the repack. Vacant Channel NPRM at 6717 ¶ 13.

The results of the 75,000 simulations demonstrate that the vacant-channel proposal will have little effect on LPTV and translator stations.[8] Across the four MTAs analyzed, an average of only 0.01% of LPTV stations and 0.51% of translators were affected. Weighted by population, these results indicate that the typical viewer would see an impact on only 0.04% of LPTV stations and only 1.61% of translators. This means that, for the typical viewer, in the vast majority of scenarios, no station will be affected at all. In the large majority of the nearly 400 counties included in these simulations (72%), not a single station was affected in any of the 75,000 scenarios. Indeed, even in the specific counties likely to be most affected, the vacant-channel rule will have only a small impact.

The following tables provide additional detail for each market included in this analysis:

MTA-6 - CHARLOTTE-GREENSBORO-GREENVILLE-RALEIGH

		Recovery Scenario (min. 5000 simulations per scenario)		
		84 MHz	114 MHz	126 MHz
Stations displaced by the vacant-channel proposal:	LPTV:	**0.00%**	**0.03%**	**0.09%**
	Translators:	**0.06%**	**0.43%**	**0.55%**
Most affected counties:	LPTV:	Graham County, NC Haywood County, NC Jackson County, NC Cocke County, TN	**1.64%**	
	Translators:	Jackson County, NC: **0.78%**		

[8] In analyzing the simulation results, stations were classified as translators when they are licensed in an appropriate radiocommunications service and FCC data identifies a second station whose signal is retransmitted by the station in question.

MTA-16 – CLEVELAND

		Recovery Scenario (min. 5000 simulations per scenario)		
		84 MHz	114 MHz	126 MHz
Stations displaced by the vacant-channel proposal:	LPTV:	**0.00%**	**0.00%**	**0.00%**
	Translators:	**0.00%**	**0.00%**	**0.00%**
Most affected counties:	LPTV:	NA (all **0.00%**)		
	Translators:	NA (all 0**.00%**)		

MTA-36 – SALT LAKE CITY

		Recovery Scenario (min. 5000 simulations per scenario)		
		84 MHz	114 MHz	126 MHz
Stations displaced by the vacant-channel proposal:	LPTV:	**0.00%**	**0.00%**	**0.01%**
	Translators:	**0.86%**	**1.93%**	**2.18%**
Most affected counties:	LPTV:	Power County, ID Caribou County, ID	**0.06%**	
	Translators:	Summit County, UT: **8.80%**		

MTA-39 – EL PASO-ALBUQUERQUE

		Recovery Scenario (min. 5000 simulations per scenario)		
		84 MHz	114 MHz	126 MHz
Stations displaced by the vacant-channel proposal:	LPTV:	**0.01%**	**0.02%**	**0.01%**
	Translators:	**0.00%**	**0.04%**	**0.08%**
Most affected counties:	LPTV:	La Plata County, CO Montezuma County, CO	**0.10%**	
	Translators:	San Juan County, CO: **2.18%**		

PEA-48 – HARRISBURG, PA
(Broadcaster in the duplex gap, two vacant channels preserved)

		Recovery Scenario (min. 5000 simulations per scenario)		
		84 MHz	114 MHz	126 MHz
Stations displaced by the vacant-channel proposal:	LPTV:	**0.00%**	**0.00%**	**0.00%**
	Translators:	**0.00%**	**0.00%**	**0.00%**
Most affected counties:	LPTV:	NA (all **0.00%**)		
	Translators:	NA (all **0.00%**)		

Further analysis of the simulation results—including county-by-county results in each market, as well as a detailed description of the methodology used in this analysis—is provided with this letter.

2. NAB's Claims that LPTV and Translators Will Be Severely Affected are Incorrect.

This new data differs dramatically from NAB's predictions about impacts on LPTV and translators.[9] While NAB has prevented a meaningful comparison by failing to disclose its methodology, NAB's predictions are manifestly implausible.

NAB predicts that the vacant-channel proposal will have a significant adverse effect on translator stations in Utah.[10] But even in the Salt Lake City market, which is by far the most affected of the five markets Google studied and probably a true outlier, the impact was minimal. Simulation results for MTA-36 indicate that preserving a vacant channel would likely affect only 0.86% of translators, and not a single LPTV station, if the Commission recovers 84 MHz in the reverse auction. In this scenario, even in the *most* affected county in MTA-36, Google's simulations showed that preserving a vacant channel is likely to affect only 5.65% of translators and no LPTV stations. In the much less likely scenario where the Commission is able to recover 126 MHz of spectrum in the reverse auction, only 2.18% of translators are likely to be affected market-wide.

NAB also maintains that the Commission's vacant-channel proposal will have a severe impact in the mountainous areas near the North Carolina / Tennessee border. But Google's analysis of Incentive Auction outcomes in this region indicates that no county in North Carolina or Tennessee is likely to see more than 0.78% of translators or 1.64% of LPTV stations affected.

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[9] *See supra* note 2.

[10] NAB Reply Comments at 3-4.

And, as in Utah, the vast majority of counties will see no affect at all.[11] Again, because NAB has not explained how they reached their conclusions, it is difficult to determine why its predictions so greatly overstate the impact of the vacant-channel rule in these markets. But the detailed simulations described above indicate that the impact will be minimal.

Across all five tested markets, 72% of counties saw no impact on translators, and 96% of counties saw zero impact on LPTV. This is hardly the "devastating impact"[12] decried by NAB. Moreover, because LPTV stations are overwhelmingly rural rather than urban, the percentage of an MTA's broadcast viewing population that might be affected by the vacant-channel rule is even lower than these already low numbers suggest. Conversely, because unlicensed wireless services will be deployed especially in more densely populated areas, a comparatively large number of MTA residents will benefit from the proposed vacant-channel policy.

NAB has argued that the Commission is attempting to "have it both ways" by proposing to protect a vacant channel in each market to ensure the viability of unlicensed in spectrum constrained areas, while emphasizing that this rule will have little effect on LPTV and translators.[13] But there is no contradiction here—the places where the vacant-channel rule will

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[11] Importantly, NAB's "preliminary" analysis "assumed that the input channel will always be one of the full-power television stations in the area, so that no additional channels are required for intermediate relays" and "assumed that all translator service areas are completely isolated." NAB Reply Comments at 6. In contrast, Google's detailed simulations relied on no such assumptions. Google fully modelled the interrelations between full-power stations and translators, including the possibility of intermediate "daisy-chained" translators based on publically available FCC data.

[12] NAB Comments at 10.

[13] NAB Letter at 4.

enable expanded access to wireless connectivity are not the places where most LPTV and translator stations operate. The vacant-channel rule will ensure consumer access to unlicensed spectrum in urban cores where wireless frequencies will be scarce. Preserving a vacant channel will have little impact in rural areas where more vacant channels are available and low-power broadcast transmitters and translators tend to operate.

NAB maintains that Google's Reply Comments painted an inaccurate picture of spectrum availability in rural New Mexico because Google (expressly) cited the number of currently available channels in each of those markets, instead of the number of channels likely to be available after the Incentive Auction.[14] Contrary to NAB's implication, current availability of spectrum offers important information about availability after the auction: In markets where many more channels are vacant than the Commission anticipates selling in the forward auction, it is unlikely that any LPTV or translators stations will be displaced.

In Newcomb, New Mexico, for example, NAB identifies 25 of the 30 channels between 21 and 51 as currently vacant. This is significantly more than the 14 channels the Commission would recover in the 84 MHz spectrum recovery scenario.[15] This means that even if—contrary

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[14] NAB Letter at 1; *see* Reply Comments of Google Inc. at 7-9, MB Docket No. 15-146, GN Docket No. 12-268 (filed Oct. 30, 2015).

[15] The Commission will recover 84 MHz of spectrum in the reverse auction only if, after the reverse auction, 84 MHz are available to either be re-auctioned to mobile wireless licensees, or repurposed for guard bands. Because each broadcast channel is 6 MHz, recovery of 84 MHz requires that 14 channels' worth of spectrum be available for reuse, either because the licensee chooses to vacate that channel in the reverse auction, or because that channel was already vacant before the auction. *See Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Report and Order, FCC 14-50, 29 FCC Rcd. 6567, 6586 ¶ 47 (2014).

to the Commission's predictions[16]—*no* full-power broadcasters serving Newcomb choose to sell their licenses in the reverse auction, and the Commission therefore is able to sell only currently vacant channels in the forward auction, 11 channels still will remain vacant after the forward auction and repack. This is *after* counting channels currently occupied by LPTV and translator stations. The vacant-channel rule would have no impact on broadcasters.

The analysis is similar for the 126 MHz spectrum recovery scenario where 21 channels will be repurposed. This scenario should typically result in four vacant channels in Newcomb after the forward auction even in the highly unlikely event that no full-power stations serving Newcomb participate in the reverse auction, *after* counting channels currently occupied by LPTV and translators. And this is to say nothing of the fact that the very premise of the Incentive Auction is that large numbers of full-power and Class A broadcasters will sell their licenses in the reverse auction. Substantial participation in the reverse auction could mean that even more channels would remain vacant in rural areas than the example above may suggest. This is precisely what the Monte Carlo analysis presented above suggests.

NAB also claims that Google miscounted the number of LPTV and translator stations operating in a few towns. Google's numbers and NAB's differ only slightly, if at all. Furthermore, Google's numbers are correct—it appears that NAB simply took its counts at different geographic points within the relevant towns and used a different propagation methodology. To ensure an objective analysis free from bias, Google used the FCC's own

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[16] *See Incentive Auction Task Force Releases Initial Clearing Target Optimization Simulations*, Public Notice, DA 15-606, 30 FCC Rcd. 4854 (2015).

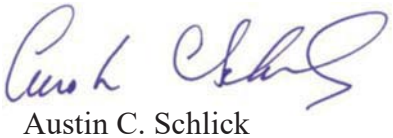
coverage data and points of measurement that approximated town centers. NAB, by contrast, appears to have hand-picked its propagation methodology and points of measurement to achieve exaggerated results.

In any event, the differences cited by NAB do not change the fact that there are enough channels currently vacant to ensure that the Commission's vacant-channel rule will have minimal, if any, effect on LPTV and translator stations where these operators are most prevalent.

* * * * *

The Monte Carlo analysis described above demonstrates that the FCC's vacant-channel proposal can advance the Commission's goal of expanding wireless broadband with only small effects on LPTV and translator operations. These results confirm that NAB's claims of major displacement are incorrect. The Commission should move ahead to adopt its proposal.

Respectfully submitted,



Austin C. Schlick
Director, Communications Law

ADDITIONAL SIMULATION RESULTS

LPTV and TV Translators: Implementing the Vacant-Channel Rule

Wi-Fi, Bluetooth, the Internet of Things, and other technologies that rely on **unlicensed spectrum** contribute **over $200 billion** to the U.S. economy every year.

To provide needed room for growth of unlicensed uses, the FCC has proposed to ensure that, after the upcoming 600 MHz Incentive Auction, at least one channel in the shared wireless/broadcast TV frequencies will be free for unlicensed uses.

Broadcasters claim this "vacant-channel rule" will require a dramatic reduction in the number of low-power TV and TV translator stations. In fact, **supporting unlicensed consumer devices will have almost no impact on LPTV or translators.** These broadcast stations overwhelmingly operate in rural areas where spectrum is plentiful and not needed for the Incentive Auction.

Analysis of 75,000 potential auction scenarios, spanning 400 U.S. counties and assuming that between 40% and 70% of broadcasters participate in the reverse auction, shows that

only 0.01% of LPTV stations and 0.51% of translator stations may have to make adjustments, such as channel sharing, to continue to reach their viewers.

What we did

- Use the FCC's own software to analyze possible channel assignments for each station in **five distinct markets**.
- For each market, conduct an analysis including 15,000 simulated reverse auctions.
- Repack the resulting TV band using the most likely spectrum recovery scenario.
- Perform a detailed vacant-channel analysis, using the exact approach proposed by the FCC.

Markets were chosen to reflect a range of population densities, concentrations of LPTV stations and translators, and terrain types. There are 51 major market areas in the United States.

What we observed

- In most counties, the rule had no impact on even a single LPTV or translator station in *any* simulation. In over 95% of counties, less than 1% of stations could be displaced in any simulation.
- The FCC has also proposed to protect a second vacant channel in a limited number of markets where a broadcaster would be placed in the duplex gap, eliminating an otherwise available unlicensed channel. We modeled this proposal for Harrisburg, PA, and no LPTV or translator stations were affected in any simulation.
- The small number of LPTV stations that could be displaced will have other means to reach their target audiences. For instance, neighboring stations can coordinate to reduce separation distances, and the FCC has recently established a framework for channel sharing by LPTV broadcasters.

Simulation Results by Market

Major Trading Area (MTA) 6 Charlotte[1]

Selected as a worst-case scenario due to high concentrations of LPTV and translator stations in a mountainous region.

- Market-wide, only 0.04% of LPTV stations and 0.35% of translators were affected in 15,000 simulations.
- Even in local areas where preserving the vacant channel has some effect, the impact is minimal—the most affected counties saw only 1.64% of LPTV stations (in Jackson County, NC, Haywood County, NC, Graham County, NC, and Cocke County, TN) and 0.78% of translators (in Jackson County, NC) affected.

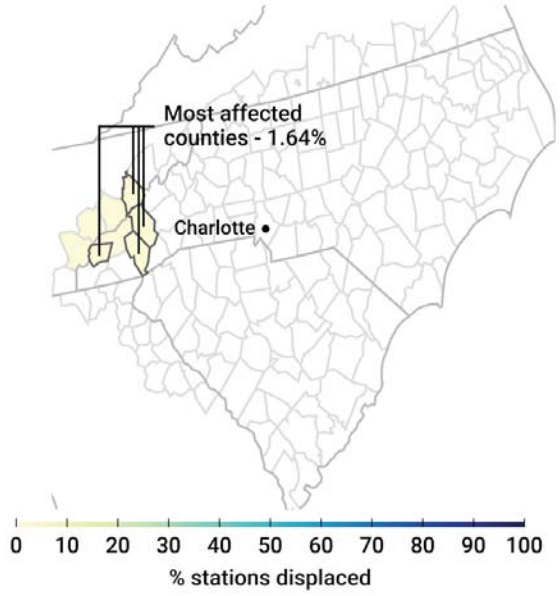
Average LPTV Stations Displaced Market-Wide

0.04%

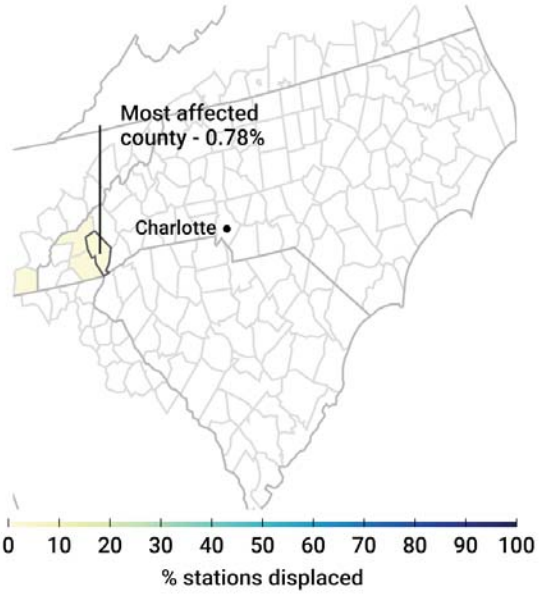
Average Translators Displaced Market-Wide

0.35%

Average LPTV Stations Displaced Per County



Average Translators Displaced Per County



[1] There are 51 MTAs in the United States.

MTA16 Cleveland

Less mountainous and more populated than the other worst-case markets, Cleveland is more representative of the United States as a whole.

- No LPTV or translator stations were affected in any of the 15,000 simulations conducted for this MTA.

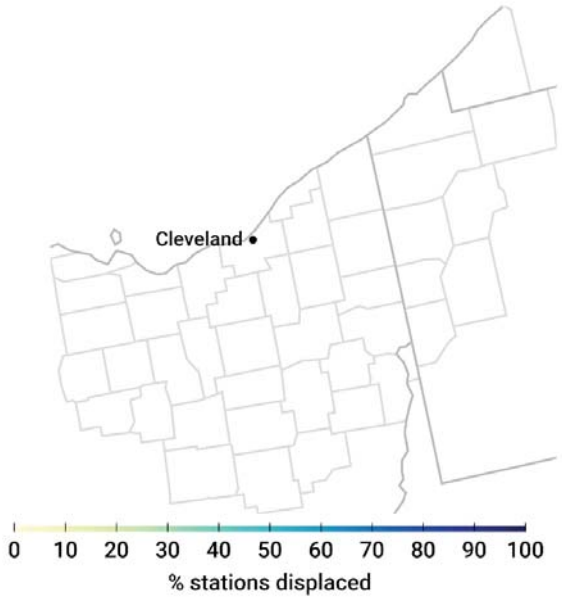
Average LPTV Stations Displaced Market-Wide

0.00%

Average Translators Displaced Market-Wide

0.00%

Average LPTV Stations Displaced Per County



Average Translators Displaced Per County

MTA36 Salt Lake City

Selected for worst-case analysis due to an atypically large number of LPTV and translator deployments in mountainous and rural areas.

- Preserving a vacant channel will have very little effect—only 0.005% of LPTV stations and 1.66% of translators were affected MTA-wide.
- The most affected county saw only 0.06% of LPTV stations (in Power County, ID and Caribou County, ID) and 8.80% of translators (in Summit County, UT) affected.

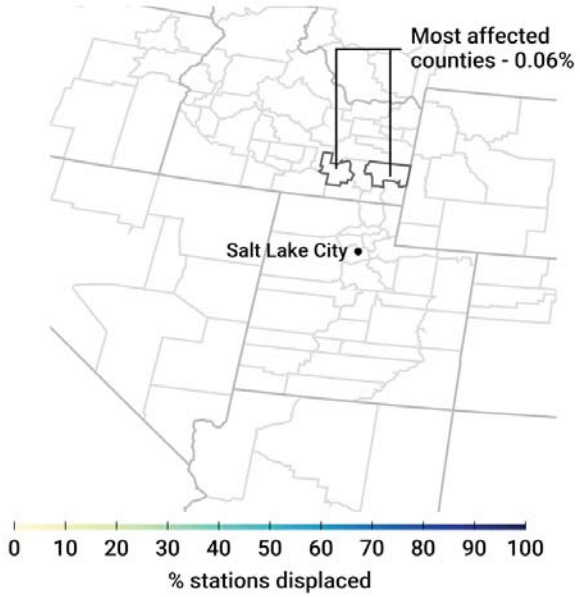
Average LPTV Stations Displaced Market-Wide

0.005%

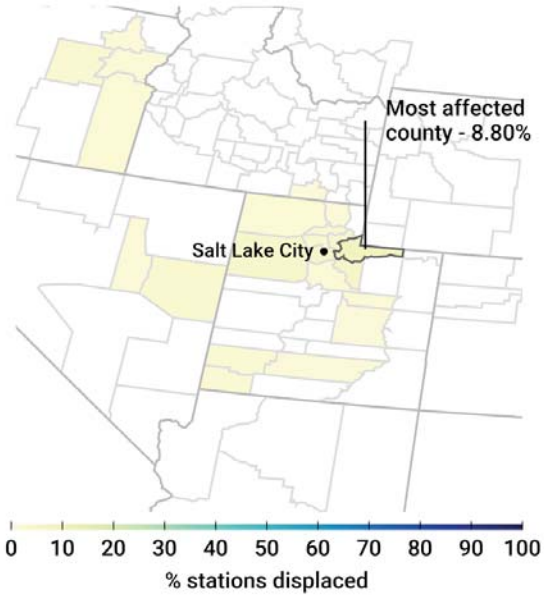
Average Translators Displaced Market-Wide

1.66%

Average LPTV Stations Displaced Per County



Average Translators Displaced Per County



MTA39 Albuquerque

Selected for worst-case analysis due to an atypically large number of LPTV and translator deployments in mountainous and rural areas.

- In 15,000 simulations, only 0.01% of LPTV stations and 0.04% of translators and were affected.
- Even in local areas where preserving the vacant channel had some effect, the impact remained minimal—the most affected county saw only 0.10% of LPTV stations (in La Plata County, CO and Montezuma County, CO) and 2.18% of translators (in San Juan County, CO) affected.

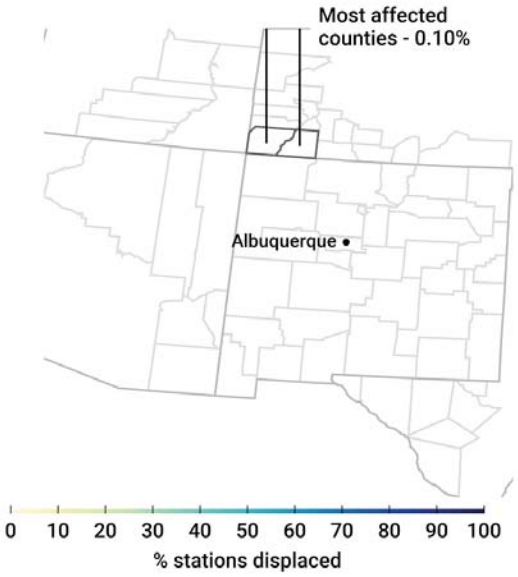
Average LPTV Stations Displaced Market-Wide

0.01%

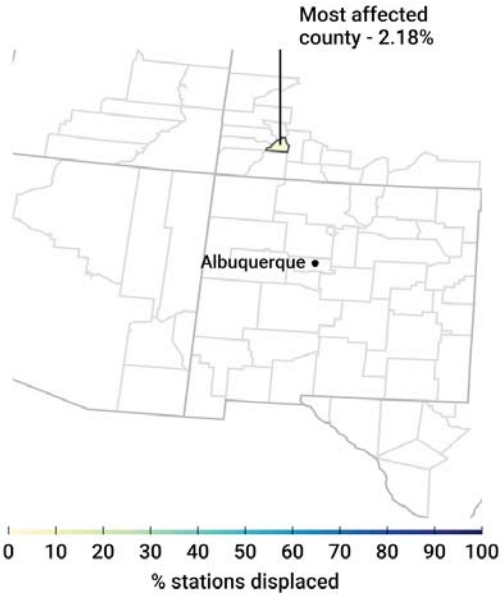
Average Translators Displaced Market-Wide

0.04%

Average LPTV Stations Displaced Per County



Average Translators Displaced Per County



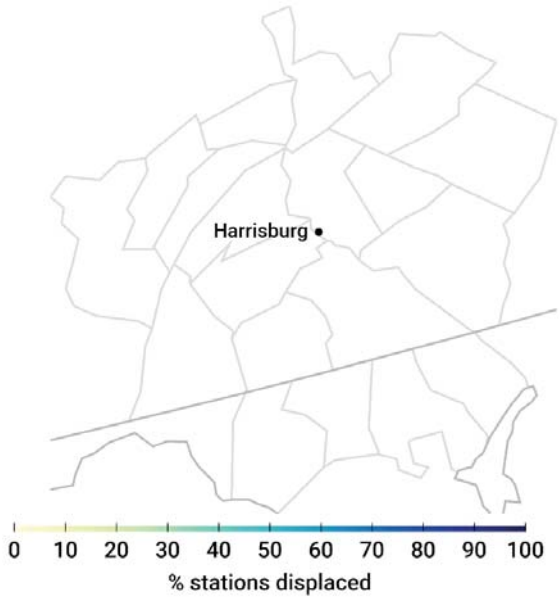
Partial Economic Area 48 Harrisburg[2]

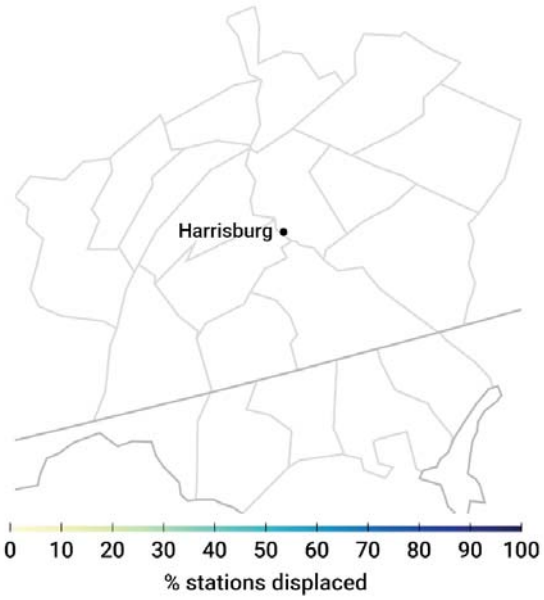
Selected, per FCC guidance, to evaluate scenarios where a broadcaster is placed in the duplex gap and the Commission protects a second vacant channel.

- Even with two vacant channels protected, no LPTV or translator stations are affected in 15,000 scenarios.

Average LPTV Stations Displaced Market-Wide	Average Translators Displaced Market-Wide
0.00%	0.00%

Average LPTV Stations Displaced Per County	Average Translators Displaced Per County





[2] There are 416 Partial Economic Areas in the United States.

SIMULATION METHODOLOGY

METHODOLOGY

To predict the likely impact of the Commission's vacant-channel proposals on LPTV ("LPTV") stations and television translators, Google used the Commission's own tools for identifying possible post-auction channel assignment based on likely intra-broadcaster interference.[1] Although the Commission has used these tools primarily to model interference between full-power stations, the same methods can be applied to model interference between LPTV stations, translators, and full-power stations. Using these tools to identify thousands of possible post-auction channel assignments, with additional analysis to determine the implications of the Commission's proposed vacant-channel rules in these scenarios, it is possible to draw concrete conclusions about the likely impact of the Commission's vacant-channel proposal on LPTV and translator stations.

To accomplish this goal, possible full-power broadcaster participation scenarios were identified, spanning a range of participation levels and associated spectrum recovery targets. Then, for each participation scenario, LPTV and translator stations were reintroduced into the band one-by-one, in a random order, to determine first whether a channel would exist in the repacked band where the station could operate consistent with the pre-calculated interference constraints and, if so, whether operation on that channel would be consistent with the Commission's vacant-channel rules. These simulations use the Commission's actual interservice interference methodology described in OET-69,[2] the rules adopted in the recent Part 15 Report and Order (e.g., white-space separation distances),[3] and the rules proposed in the Commission's Vacant-Channel NPRM.[4]

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1 *See* Federal Communications Commission, *TVStudy Software – OET Bulletin No. 69*, http://data.fcc.gov/download/incentive-auctions/OET-69/; GitHub, *FCC / Constraint-Generator*, https://github.com/FCC/Constraint-Generator; GitHub, *FCC / SATFC*, https://github.com/fcc/SATFC/.

2 Federal Communications Commission, *OET Bulletin No. 69*, *Longley-Rice Methodology for Evaluating TV Coverage and Interference* (Feb. 6, 2004), https://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet69/oet69.pdf.

3 *Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37, and Amendment of Part 74 of the Commission's Rules for Low Power Auxiliary Stations in the Repurposed 600 MHz Band and 600 MHz Duplex Gap*, Report and Order, FCC 15-99, 30 FCC Rcd. 9551, 9662 ¶ 273 (2015).

4 *Amendment of Parts 15, 73 and 74 of the Commission's Rules to Provide for the Preservation of One Vacant Channel in the UHF Television Band for Use by White Space Devices and Wireless Microphones*, Notice of Proposed Rulemaking, FCC 15-68, 30 FCC Rcd. 6711, 6716 ¶ 11 (2015).

We describe this methodology in greater detail below.

Initial Configuration

The following steps are performed once to determine market characteristics and pre-calculate interference-based constraints between stations. This information will be reused in each subsequent simulation.

1. Simulation Parameters

Each simulation depends on a number of assumptions about outcomes in the reverse auction, such as the achieved spectrum recovery target and actual broadcaster participation. To best capture interactions and constraints between geographically diverse stations, simulations were conducted at the Major Trading Area ("MTA") level and, in one instance, at the Partial Economic Area ("PEA") level. Google also conducted simulations at the PEA level to assess the impact in a market where the Commission predicted that it might place a broadcaster in the duplex gap and, accordingly, require the preservation of an additional vacant channel.[5] Impacts were simulated in the following markets:

- MTA-6 - Charlotte/Greensboro/Greenville/Raleigh;
- MTA-16 - Cleveland;
- MTA-36 - Salt Lake City;
- MTA-39 - El Paso/Albuquerque; and
- PEA-48 (includes Harrisburg, PA).

For each of these markets, the simulations reflected a range of spectrum recovery scenarios and broadcaster participation levels. The 15,000 simulations performed for each market were evenly divided between spectrum recovery scenarios of 84 MHz, 114 MHz, and 126 MHz.

2. Constraint Generation

For each market, a set of constraint files was generated using the process and tools described in the appendix to the Commission's Analysis of Potential Aggregate Interference[6] and the final Longley-Rice parameters contained in the Commission's final Incentive Auction parameters file.[7] This process analyzed each broadcast station to determine, for each channel to which that

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[5] *See, e.g.*, Federal Communications Commission, *Data PN Runs* (rel. July 10, 2015), http://apps.fcc.gov/ecfs/document/view?id=60001114816.

[6] *Incentive Auction Task Force Releases Updated Constraint File Data Using Actual Channels and Staff Analysis Regarding Pairwise Approach to Preserving Population Served*, Public Notice, DA 14-677, 29 FCC Rcd. 5687, 5691 at Appendix (rel. June 2, 2014).

[7] *See* Federal Communications Commission, *Constraint Files for Repacking*, http://data.fcc.gov/download/incentive-auctions/Constraint_Files/.

broadcaster may be relocated, the other stations that could not be assigned to that same channel or an adjacent channel. The end-result of this process was a set of files for each market: (1) a "domain" file listing the channels on which each station could operate, and (2) an "interference_paired" file listing the restrictions on channel assignments due to the fact that certain station pairs cannot operate co-channel or adjacent channel to one another.[8] This process matches the process used by the Commission to generate its own constraint files, except that LPTV and translator stations were included in the analysis along with full-power and Class A stations.

Simulation

The following steps were performed for each simulation. To generate the results described here, each of these steps was completed at least 5,000 times for each spectrum recovery scenario in each market, for a total of at least 75,000 simulations.[9]

1. Simulation Initialization

For each simulation, a number of steps were taken to supply needed details of the hypothetical post-auction environment. First, a market and spectrum recovery target were selected. The post-repack channelization plan was then selected based on the chosen spectrum recovery scenario and the band plans set forth in the Commission's June 2, 2014 Incentive Auction Report and Order.[10] For markets where the Commission has indicated that a broadcaster may be placed in the duplex gap, an additional channel was added, corresponding with the spectral location of the duplex gap in the repacked band under the applicable spectrum recovery scenario. Each of the three possible band plans analyzed is set forth below.

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[8] For additional details, *see Incentive Auction Task Force Releases Information Related to Incentive Auction Repacking*, Public Notice, DA 13-1613, 28 FCC Rcd. 10,370, 10,375 at Technical Appendix (rel. July 22, 2013).

[9] The FCC's repacking methodology requires that every full-power or Class A broadcaster be assigned a channel in the repacked television band. Therefore, as described below, a simulation was discarded if not all of the full-power broadcasters in the market were able to be repacked in the new broadcast band, taking into account the possibility, in appropriate markets, that a broadcaster could be placed in the duplex gap. Accordingly, these discarded simulations are not included in the total number of simulations conducted. No simulation results were discarded for any reason other than inability to repack full-power broadcasters.

[10] *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Report and Order, FCC 14-50, 29 FCC Rcd. 6567, 6572-3 ¶ 10 (2014).

Recovery	Channels																								
84 MHz	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
114 MHz	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
126 MHz	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45

Available channel

Available channel when broadcaster is relocated to the duplex gap

For each recovery scenario, a broadcaster participation level was then selected at random from the range of possible corresponding participation levels the Commission itself assumed in its Initial Clearing Target Optimization Simulations.[11]

Recovery Scenario	FCC's Assumed Broadcaster Participation
84 MHz	40-50%
114 MHz	50-60%
126 MHz	60-70%

A corresponding number of full-power and Class A broadcasters were then randomly designated as having sold their licenses in the reverse auction and, accordingly, to be removed from the post-auction band.

A list was also created of LPTV and translator stations serving the selected market. This list is randomized except that, in the case of "daisy-chained" translator stations, translators closer to the original station being translated were placed earlier in the list than translators farther down the chain. This ensured that, later in the simulation, it would be possible to identify translators that participate in a daisy chain and are, in effect, taken off the air by the displacement of a station earlier in the chain.

2. Full-Power Repack

With the simulation parameters specified as described above, a repack was attempted of the full-power stations that were not designated as having sold their licenses in the reverse auction, using the Commission's publically available satisfiability SAT-Based Feasibility Checker ("SATFC"). SATFC was used to analyze the previously generated constraint files, and the channels available

[11] *Incentive Auction Task Force Releases Initial Clearing Target Optimization Simulations,* Public Notice, DA 15-606, 30 FCC Rcd. 4854, 4856 ¶ 6 (rel. May, 20 2015).

for broadcasters under the selected recovery scenario and channelization plan to determine whether it was possible for the remaining broadcasters to be assigned into the remaining channels and, if so, produce a viable set of channel assignments.

If it was not possible to assign all remaining full-power broadcasters to a channel in the repacked band, the simulation was aborted and restarted with a new set of parameters, randomly selected using the procedure described above. Otherwise, each full-power broadcaster was designated as assigned to the channel identified for it by SATFC.

3. Low-Power/Translator Repack and Vacant-Channel Showing

Once full-power stations were assigned to channels consistent with the relevant interference constraints, LPTV and translator stations were added one at a time back into the band. The following was performed for each of these stations in the relevant market.

a. Screening

The station was checked to determine whether it was a translator that retransmits a station previously displaced from the band. If so, then the current station was also recorded as having been displaced for the same reason as the retransmitted station and not assigned a channel in the repacked band. Thus, for example, if a translator retransmits a station that was displaced from the band due to its inability to make the vacant-channel showing, then *both* translators are recorded as having been displaced for this reason.[12]

Under this approach, a low-power station might be displaced because 1) the translated full-power station participated in the reverse auction and would no longer be on the air after the Incentive Auction, 2) a translator earlier in a translator daisy chain was displaced by the repacking process, or 3) a translator earlier in a translator daisy chain was displaced because it was unable to make the vacant-channel showing.

b. Repack

If the station was not excluded from the band in the 'screening' phase, the simulation attempted to add it to the band. Specifically, the simulation determined, using SATFC, whether a permissible channel assignment existed where each full-power station was assigned the channel selected for it earlier by SATFC and whether the LPTV or translator station was eligible to be assigned to any remaining channel in the post-auction band under the relevant spectrum recovery scenario. If other LPTV or translator stations were already repacked, then those stations remained assigned to the channels already identified for them and those channels were not considered available for the low-power station seeking an assignment.

[12] A similar result would obtain for a translator that retransmits a translator that itself, in turn, retransmits another translator that was displaced.

If SATFC determined that the station could be assigned a channel, consistent with relevant interference constraints, then it was designated as having been provisionally assigned to that channel. If not, then the station was designated as having been displaced by the repack process, and is not assigned a channel.

c. Vacant-Channel Showing

If a station was provisionally assigned a channel, then a vacant-channel analysis was performed for that provisional channel assignment. For this process, the station's coverage area was divided into a collection of 2km-by-2km cells, forming a grid. For each cell, the repacked band was analyzed to determine whether, given the stations already assigned channels, there was at least one channel (or two channels where a broadcaster is assigned to the duplex gap) where the center point of that cell was not within the separation contour of any station given the applicable spectrum recovery scenario.

If one or more cells would not have the necessary number of channels available, then the station is designated as having been unable to make the vacant-channel showing, and is not assigned a channel. Otherwise, the station is assigned the provisionally assigned channel for the remainder of the simulation.

d. Logging

The result for this station—its channel assignment, if it was permanently assigned, or the reason no channel was assigned—was recorded in a database.