Market Variability:
- Northeast U.S. Co-Channel Analysis
- Adjacent Channel Interference

Prepared for T-Mobile, USA

by Roberson and Associates, LLC

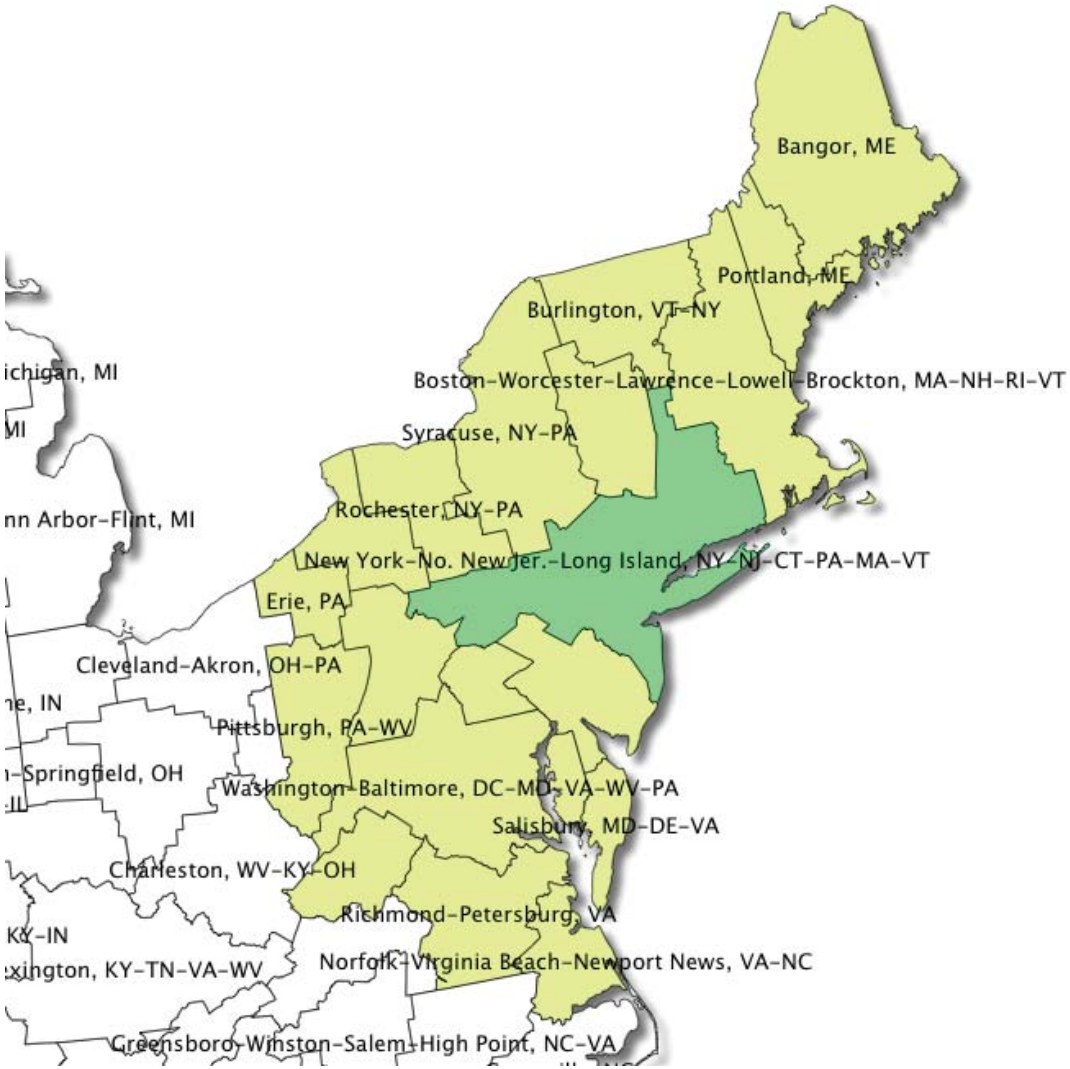
Northeast US Co-Channel Analysis

- Analysis of co-channel DTV interference at LTE base receivers (DTV in uplink)
  - Follow up to previous analysis presented to the FCC on Sept. 23, 2013
  - Same methodology as previous study: terrain-based propagation model
  - Assess the distance from DTV transmitter to co-channel LTE base required

- Current analysis: 18 TV stations in and around New York City
  - Examined all stations operating channels 38-51 inclusive, and potentially needing to be repacked based on outcome of the incentive auction
  - Examination of New York City area stations is representative of the NE region
    - Could expand future studies north or south of NYC (Boston, Philadelphia, Washington - Baltimore, etc.), but expect results to be similar due to similar geography
  - A total of 19 EAs were analyzed as shown in the map on the following slide
  - DTV signal (interference) levels at more than 10,000 T-Mobile sites studied
  - Results are presented in terms of predicted probability of interference at the cell site:
    - **No Risk** (DTV signal < -122 dBm)
    - **Low Risk** (-122 dBm < DTV signal < -100 dBm)
    - **Potential Risk** (DTV signal > -100 dBm)

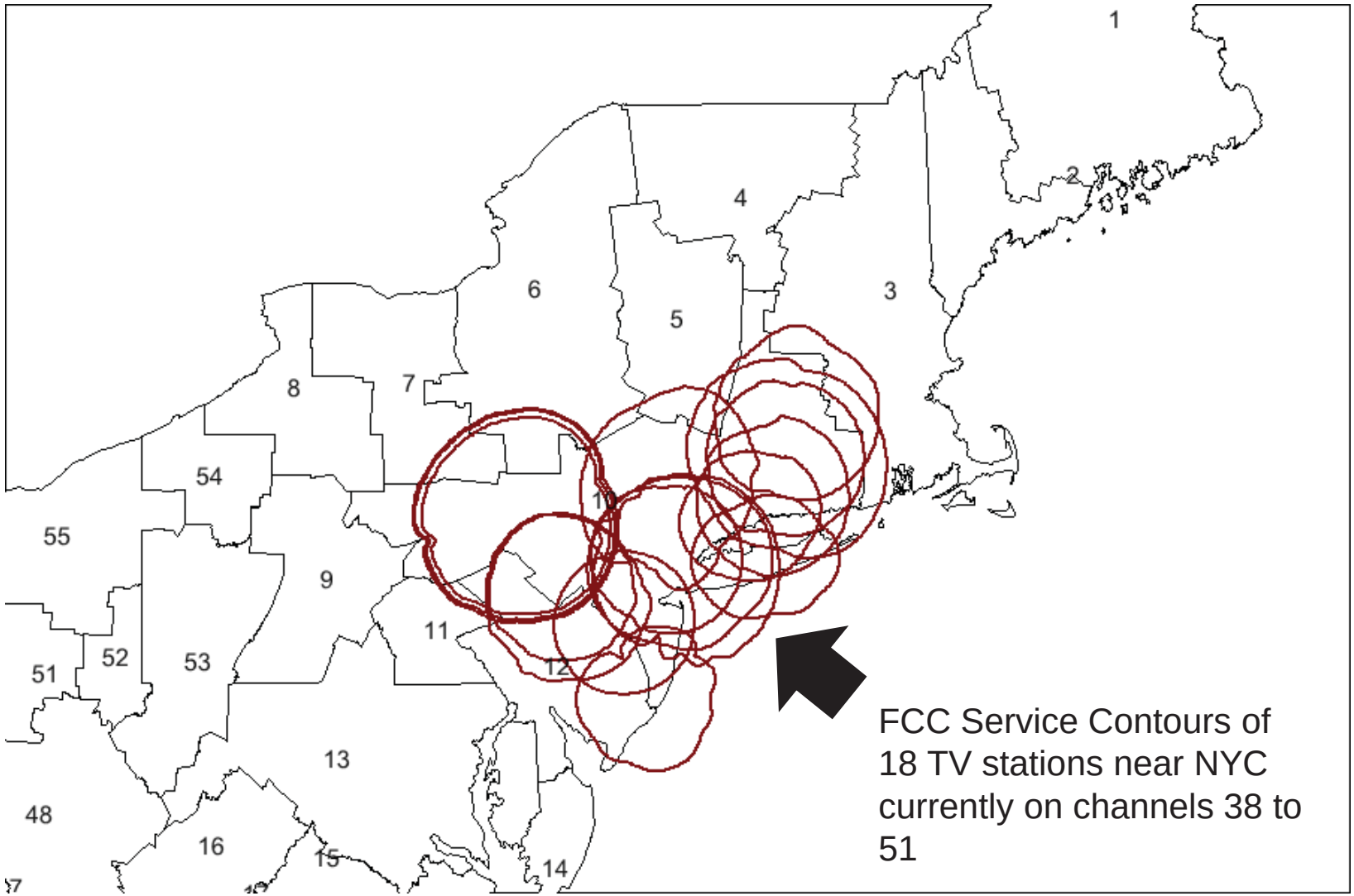
- Note – we did not analyze any Canadian TV stations

19 Economic Areas (EA) Analyzed



EA #	EA Name
1	Bangor, ME
2	Portland, ME
3	Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH-RI-VT
4	Burlington, VT-NY
5	Albany-Schenectady-Troy, NY
6	Syracuse, NY-PA
7	Rochester, NY-PA
8	Buffalo-Niagara Falls, NY-PA
9	State College, PA
10	New York-No. NJ-Long Island-CT-PA-MA-VT
11	Harrisburg-Lebanon-Carlisle, PA
12	Philadelphia-Wilmington-Atl. City, PA-NJ-DE-MD
13	Washington-Baltimore, DC-MD-VA-WV-PA
14	Salisbury, MD-DE-VA
15	Richmond-Petersburg, VA
16	Staunton, VA-WV
20	Norfolk-Virginia Beach-Newport News, VA-NC
53	Pittsburgh, PA-WV
54	Erie, PA

TV Stations Examined

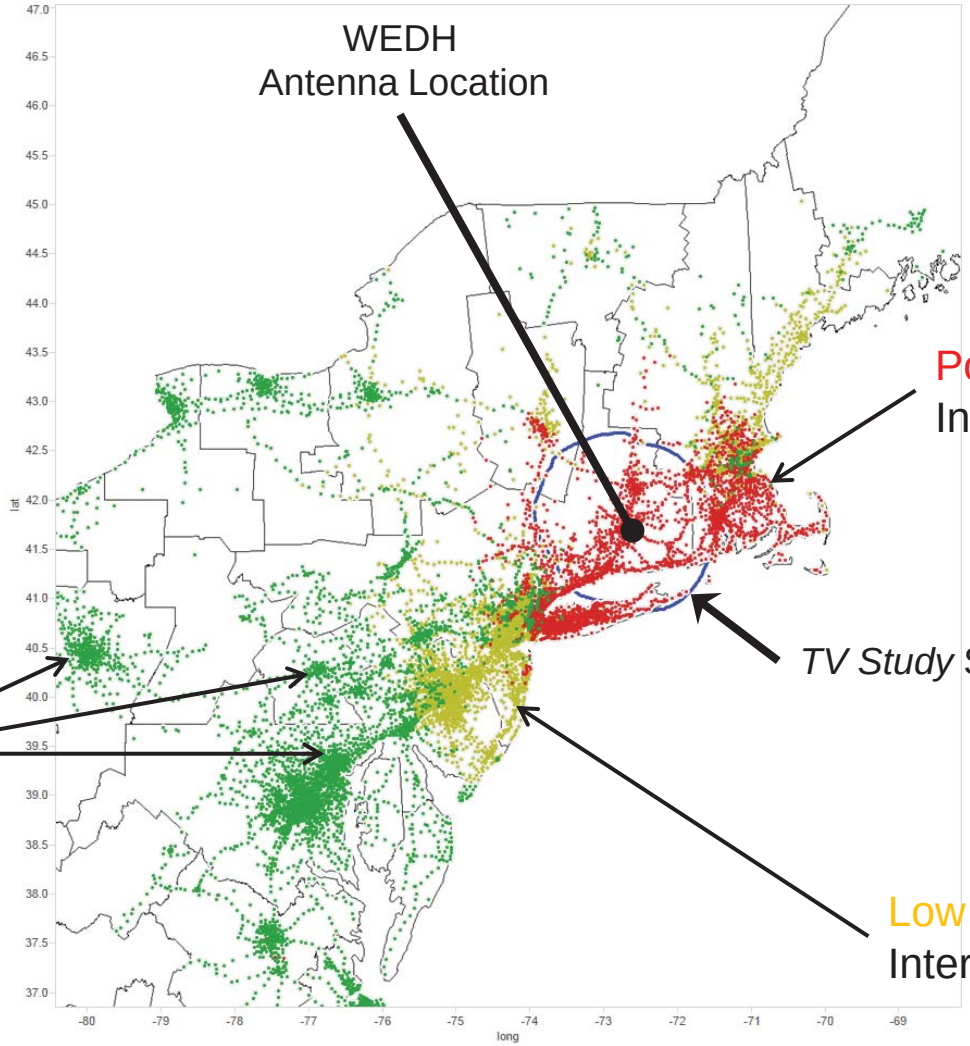


FCC Service Contours of 18 TV stations near NYC currently on channels 38 to 51

TV Stations Analyzed (cont.)

Station Reference Number	Call_Sign	Channel	Latitude	Longitude	City	State	ERP_kW_	Ant_height_ft_
1	WCTX	39	41.4228	-72.95167	NEW HAVEN	CT	170	987.53284
2	WEDH	45	41.7036	-72.8325	HARTFORD	CT	490	1656.8242
3	WEDW	49	41.2789	-73.18556	BRIDGEPORT	CT	170	721.7848
4	WFMZ-TV	46	40.5644	-75.44	ALLENTOWN	PA	800	1085.95804
5	WGGB-TV	40	42.2417	-72.64917	SPRINGFIELD	MA	460	1062.99216
6	WLNY-TV	47	40.8972	-72.91556	RIVERHEAD	NY	1000	633.20212
7	WLVT-TV	39	40.5644	-75.44	ALLENTOWN	PA	52	967.8478
8	WNEP-TV	50	41.1825	-75.87083	SCRANTON	PA	500	1696.19428
9	WNJN	51	40.8647	-74.20083	MONTCLAIR	NJ	200	764.43572
10	WNJT	43	40.2828	-74.68639	TRENTON	NJ	59.4	872.70344
11	WNYW	44	40.7483	-73.98611	NEW YORK	NY	990	1204.06828
12	WOLF-TV	45	41.1833	-75.86944	HAZLETON	PA	420	1601.04992
13	WRNN-TV	48	41.4883	-73.94889	KINGSTON	NY	950	1240.15752
14	WUVN	46	41.775	-72.80111	HARTFORD	CT	217	882.54596
15	WVIA-TV	41	41.182	-75.87119	SCRANTON	PA	365	1673.2284
16	WWSI	49	39.6314	-74.35333	ATLANTIC CITY	NJ	130	972.112892
17	WXTV-DT	40	40.7483	-73.98611	PATERSON	NJ	300	1381.23364
18	WZME	42	41.3619	-73.11333	BRIDGEPORT	CT	780	552.82154

Example Results: WEDH



Summary Results: Impaired Markets for Each TV Station

U = EA Unimpaired S = Needs Further Study I = EA Impaired

	TV Stations IDs																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
EA1	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
EA2	S	S	U	U	S	U	U	U	U	U	U	U	U	S	U	U	U	S
EA3	I	I	I	U	I	S	U	U	U	U	I	U	U	I	U	U	S	I
EA4	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
EA5	S	I	U	U	I	U	U	U	U	U	I	U	I	S	U	U	S	S
EA6	U	U	U	U	U	U	U	I	U	U	U	I	U	U	I	U	U	U
EA7	U	U	U	U	U	U	U	S	U	U	U	S	U	U	S	U	U	U
EA8	U	U	U	U	U	U	U	S	U	U	U	S	U	U	S	U	U	U
EA9	U	U	U	U	U	U	U	S	U	U	U	S	U	U	I	U	U	U
EA10	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
EA11	U	U	U	I	U	S	I	I	S	S	S	I	S	U	I	U	I	S
EA12	S	U	I	I	S	I	I	I	I	I	I	I	I	S	I	I	I	I
EA13	U	U	U	I	U	U	I	I	U	U	S	I	S	U	S	S	S	U
EA14	U	U	U	I	U	S	S	S	S	S	S	S	S	U	S	I	S	S
EA15	U	U	U	S	U	U	U	U	U	U	U	U	U	U	U	U	U	U
EA16	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
EA20	U	U	U	S	U	U	U	U	U	U	U	U	U	U	U	U	U	U
EA53	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
EA54	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U

Determination of Impaired Market

1. Where 90%+ sites are green, then classify market as unimpaired

2. Where 10%+ sites are red, then classify market as impaired

3. All other cases look at the power distribution on a market by market case

Note – we believe the power distribution values for impaired and unimpaired markets is subject to debate in the yellow shared areas (marketed as “S”)

Conclusions

- As expected, cell sites in the New York City EA experience high levels of interference from most of the TV stations in the same EA

- For cell sites located in the economic areas outside of New York City EA, many cities in those EAs can provide LTE service co-channel to DTV station in NY

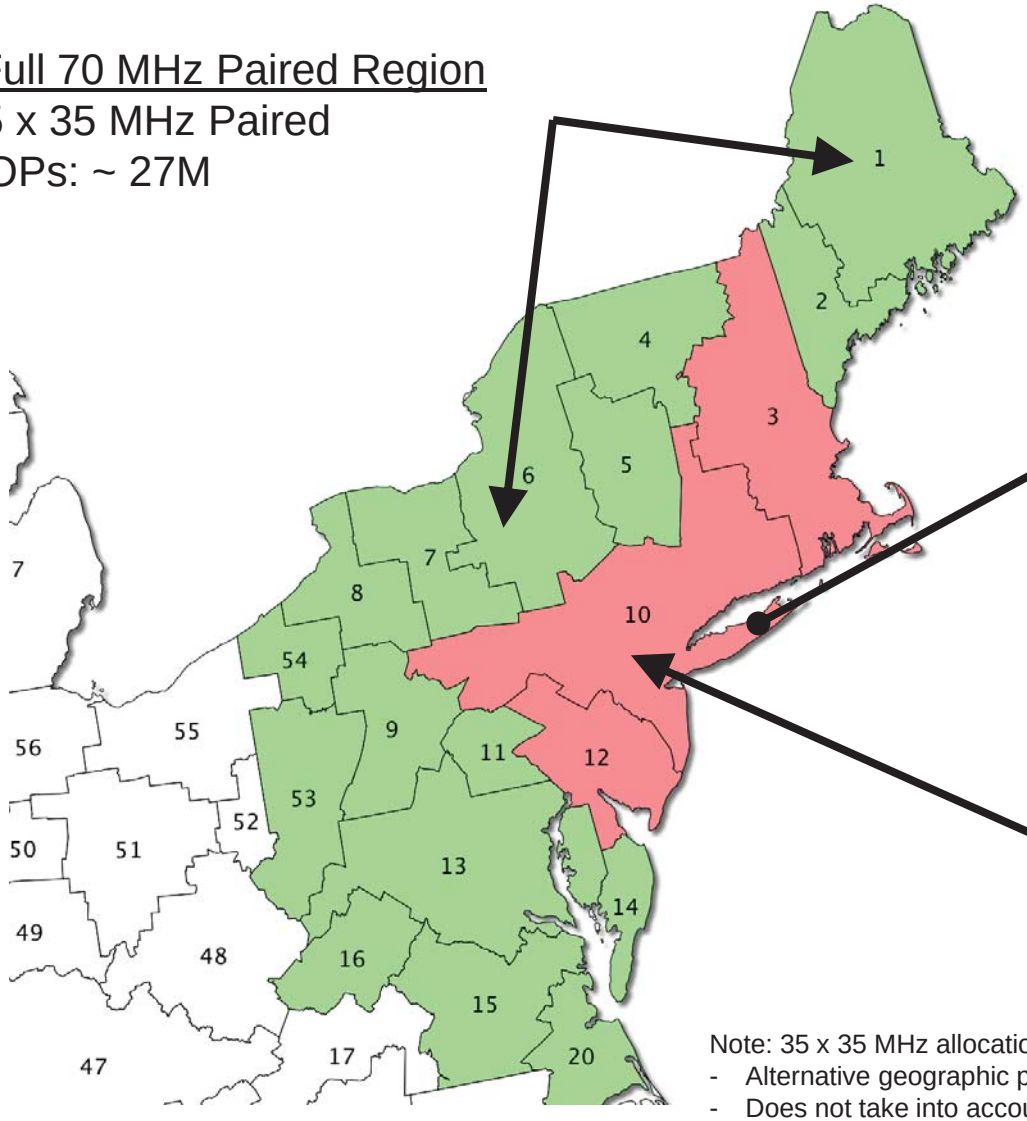
- It may be possible to accommodate a small number of different regional band plan variations, where regional EA clusters have the same bandplan
  - While not the most desirable scenario, this may be necessary if insufficient spectrum is recovered nationally in the incentive auction

- Smaller market areas may facilitate greater flexibility

Hypothetical Case Study: Northeast Region Variable Bandplan

<u>Full 70 MHz Paired Region</u>

- 35 x 35 MHz Paired
- POPs: ~ 27M



WLYN repacked on to Channel 46
1 MW ERP
Directional Antenna
HAAT is 193 m

<u>"Variable" Region</u>

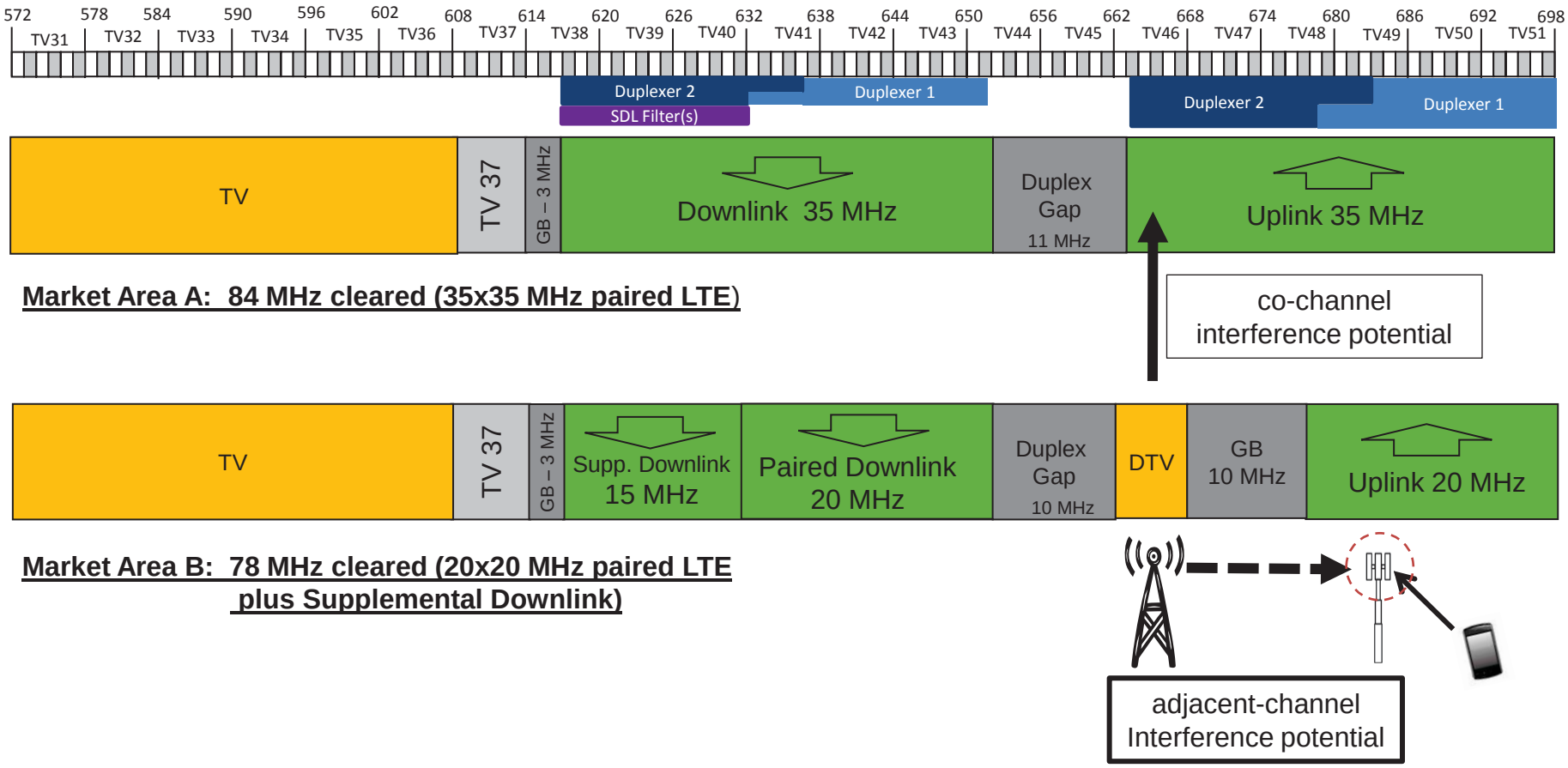
- 20 x 20 MHz Paired; 15 MHz SDL
- POPs: ~ 43M

Note: 35 x 35 MHz allocation is possible in a majority of EA3 and most of EA12.
- Alternative geographic partitions should be considered
- Does not take into account the Canadian TV stations along the border

Adjacent Channel Interference

Market Variability:
Adjacent Channel Interference Scenario

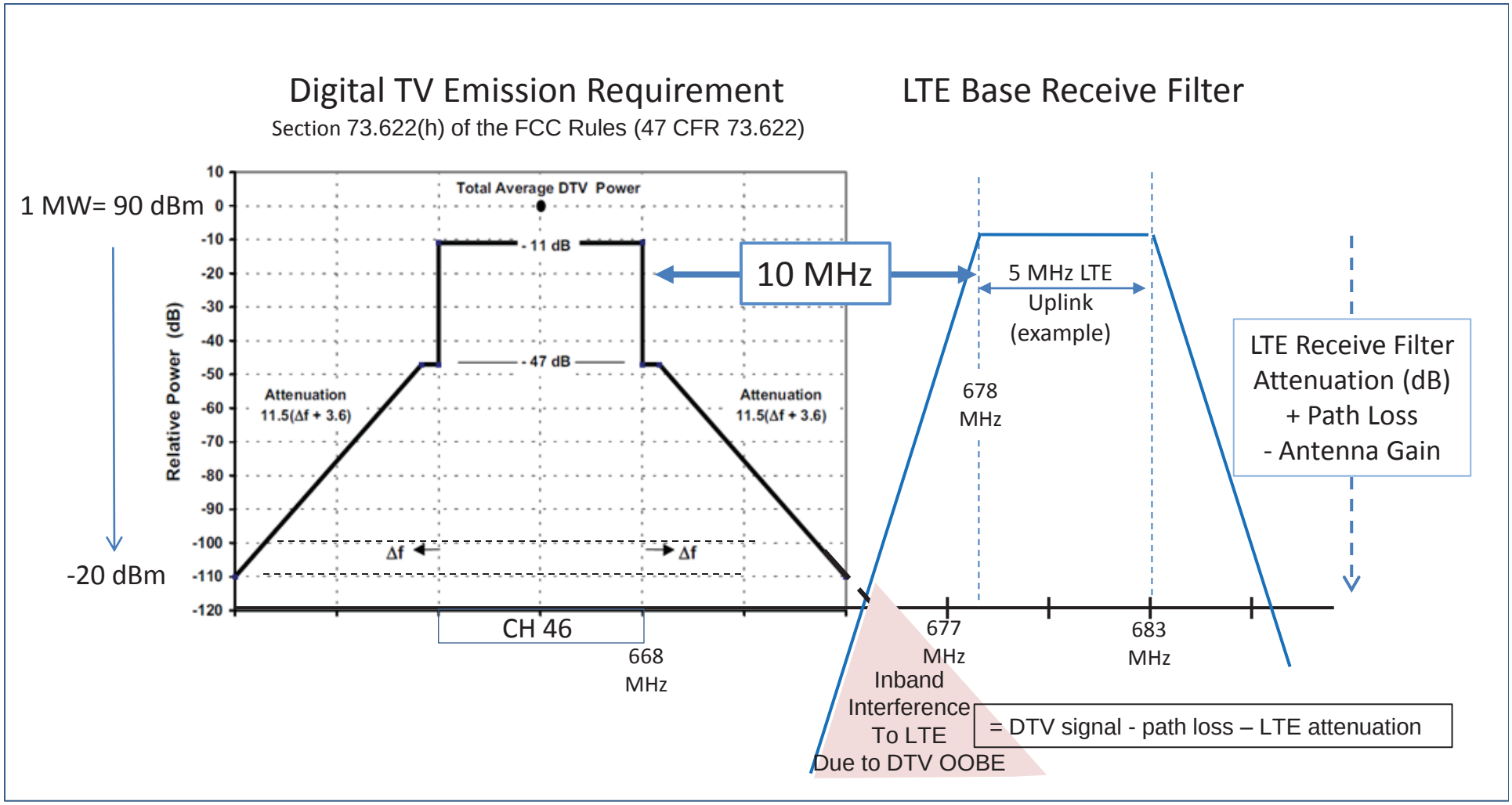
DTV to LTE Interference Scenarios: T-Mobile/Verizon Joint Band Plan



Market Area A: 84 MHz cleared (35x35 MHz paired LTE)

Market Area B: 78 MHz cleared (20x20 MHz paired LTE plus Supplemental Downlink)

Adjacent Channel Interference Analysis Approach



Criteria for LTE: Inband Interference to LTE Must Be < -122 dBm

Adjacent Channel Interference Analysis Results and Conclusion

Typical Parameters

DTV ERP (1 MW)	90 dBm
DTV OOBE atten @ 6 MHz from DTV edge	-110 dB
Path Loss @ 500 m.	-83 dB
LTE antenna gain	10 dB
LTE rcvr. attn. @ 4 MHz from LTE edge (min.)*	30 dB
Receive interference power	-123 dBm

➡ < -122 dB

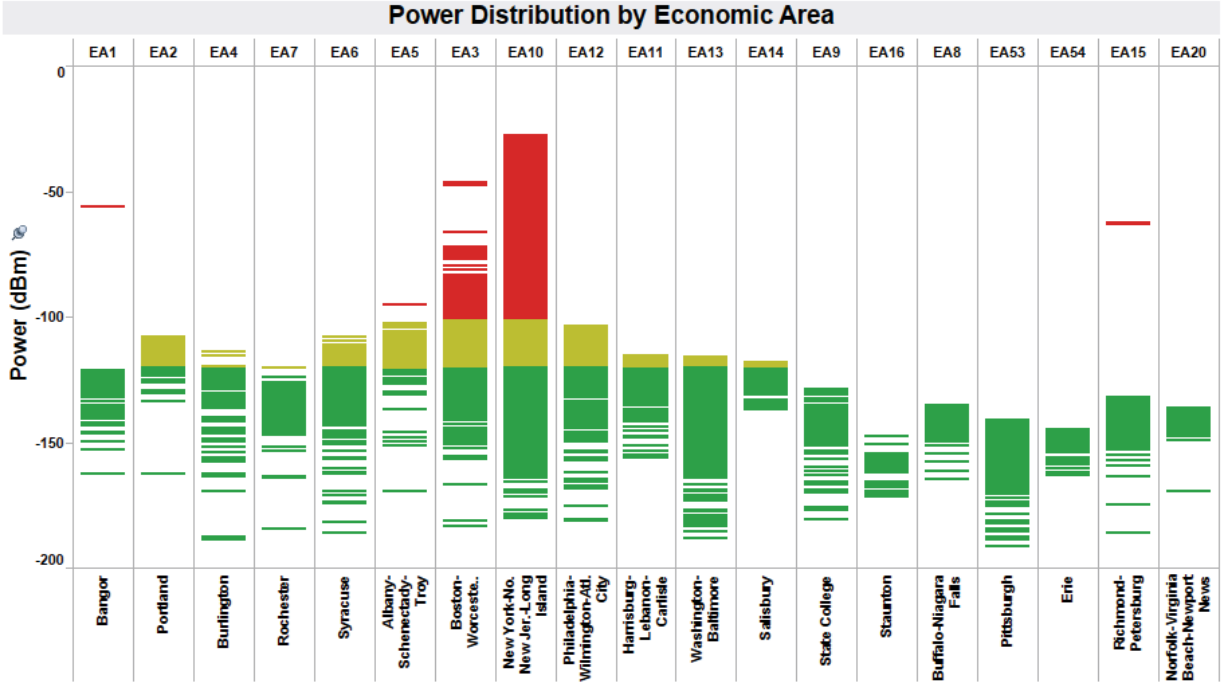
* Typical attenuation values are higher, resulting in lower interference power.

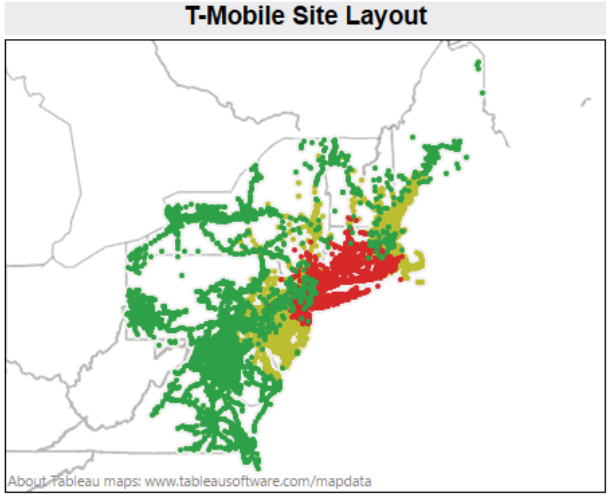
Conclusion: 10 MHz separation is sufficient to allow LTE uplink in same geographic area as DTV

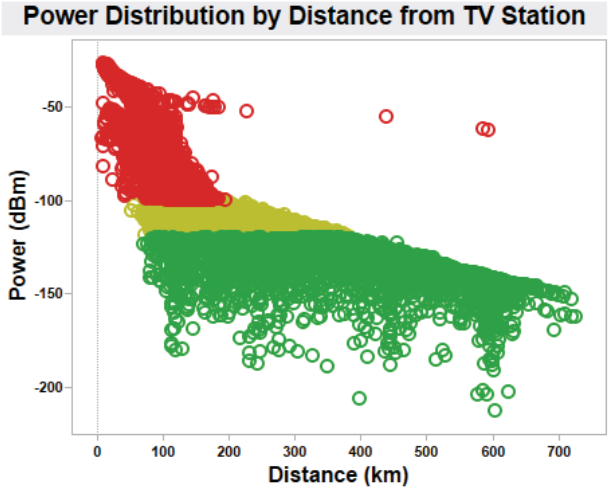
Atypical Interference Situations Can be Resolved By:
- LTE Base antenna re-alignment
- Additional LTE Base RF filtering

Appendix

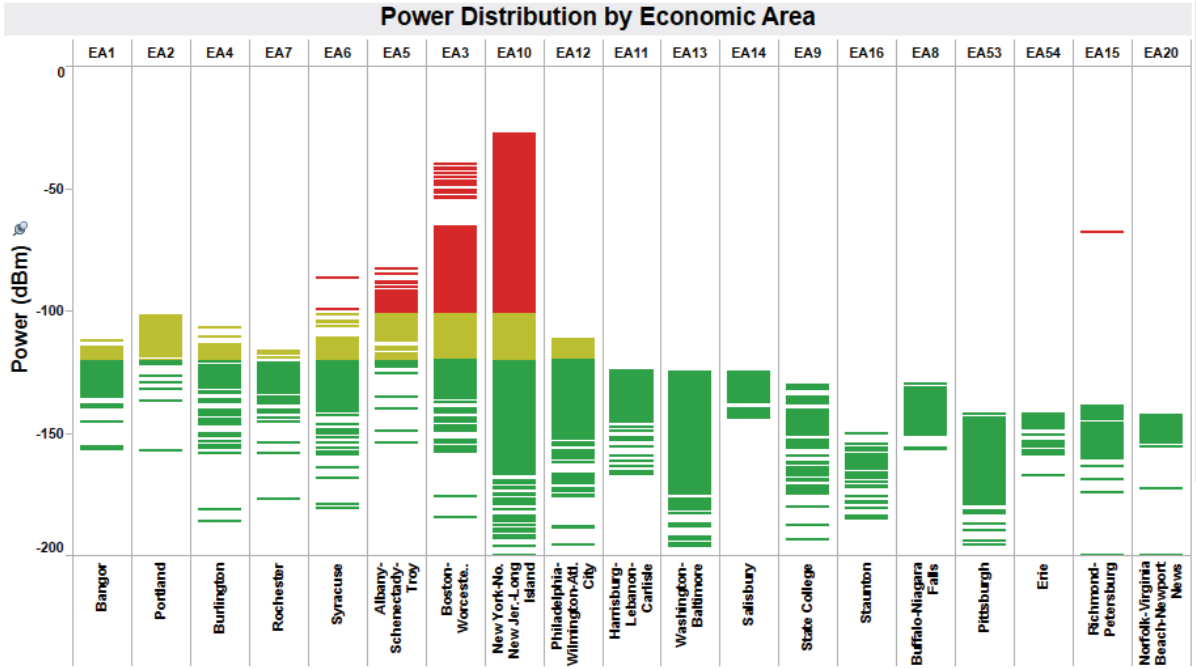
Station 1 Analysis (WCTX, New Haven, CT)

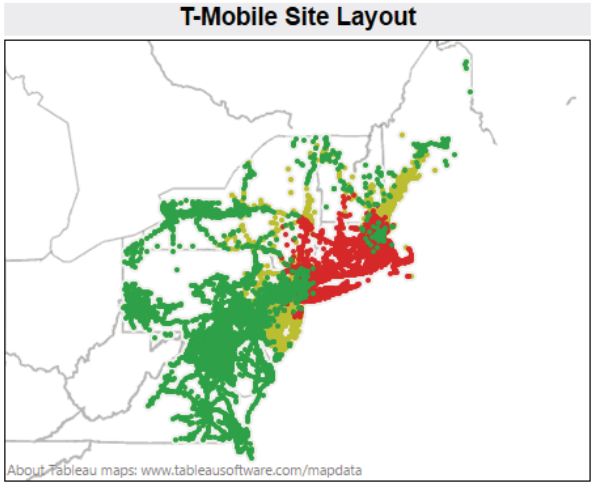


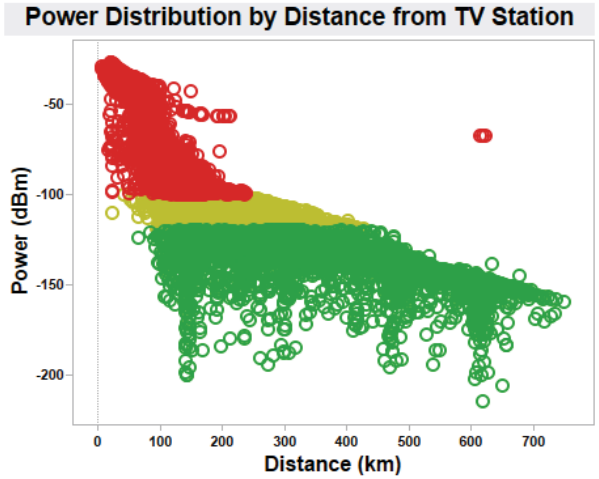




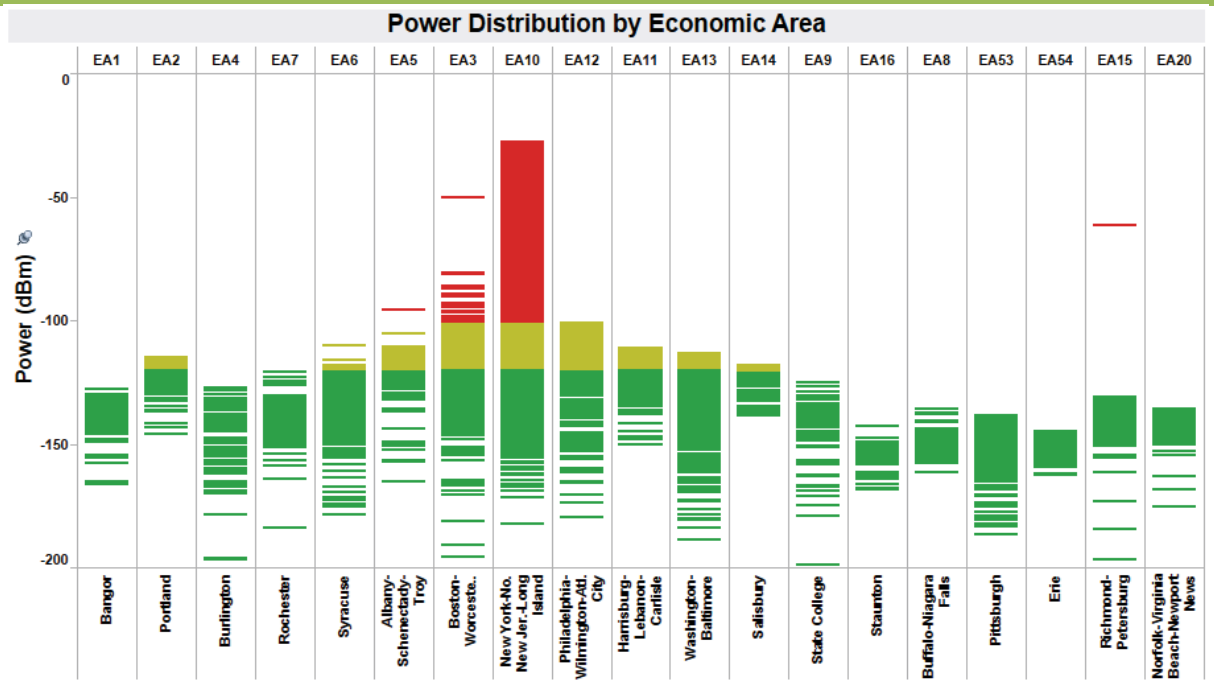
Station 2 Analysis (WEDH, Hartford, CT)

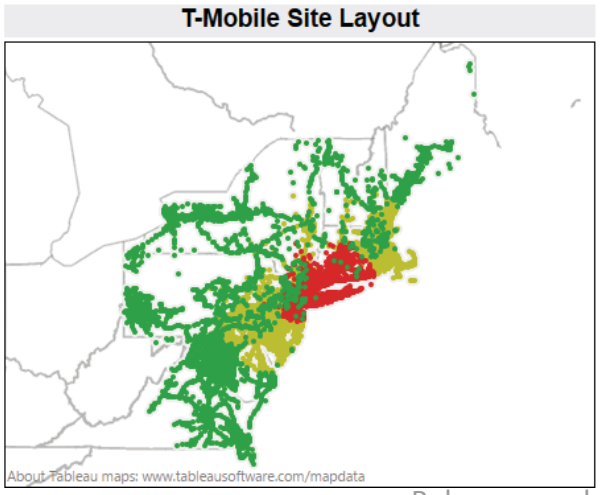


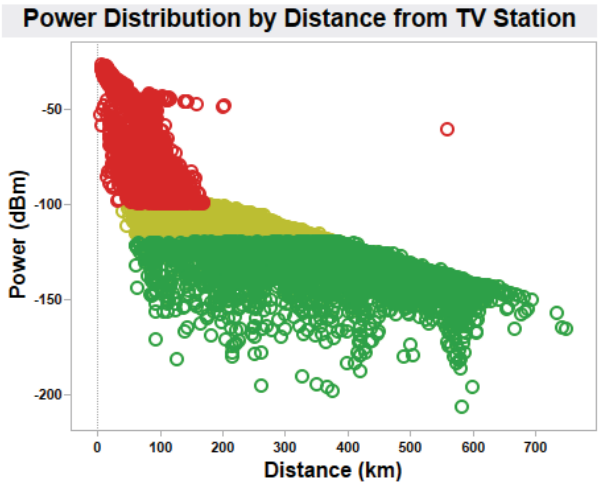




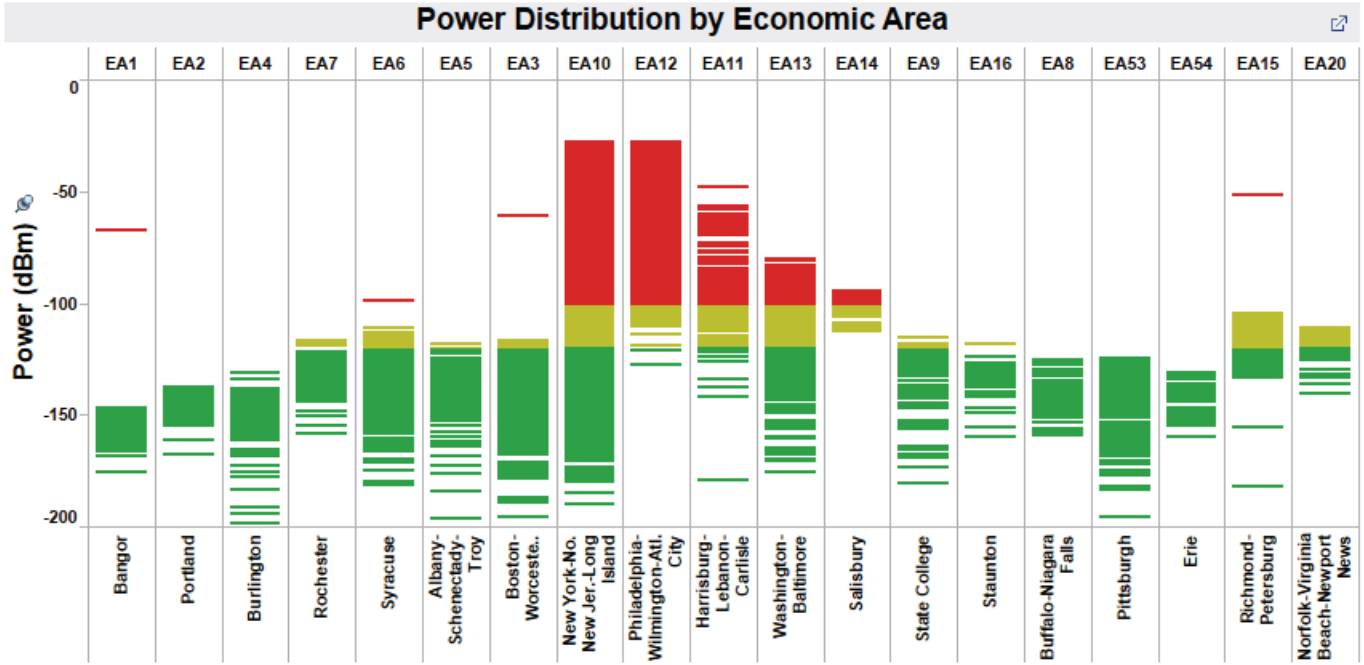
Station 3 Analysis (WEDW, Bridgeport, CT)

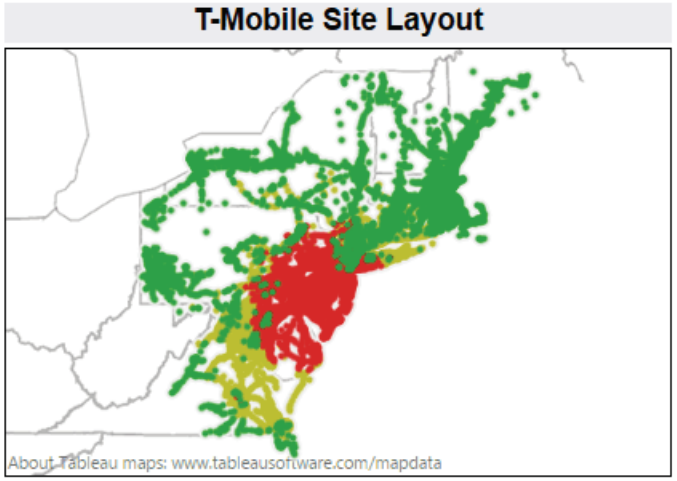


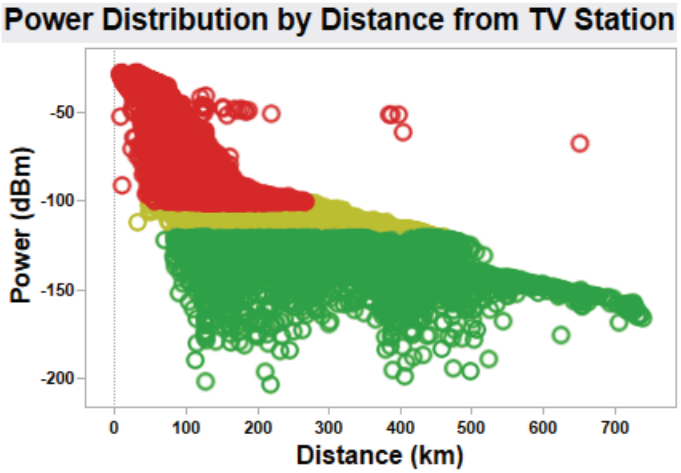




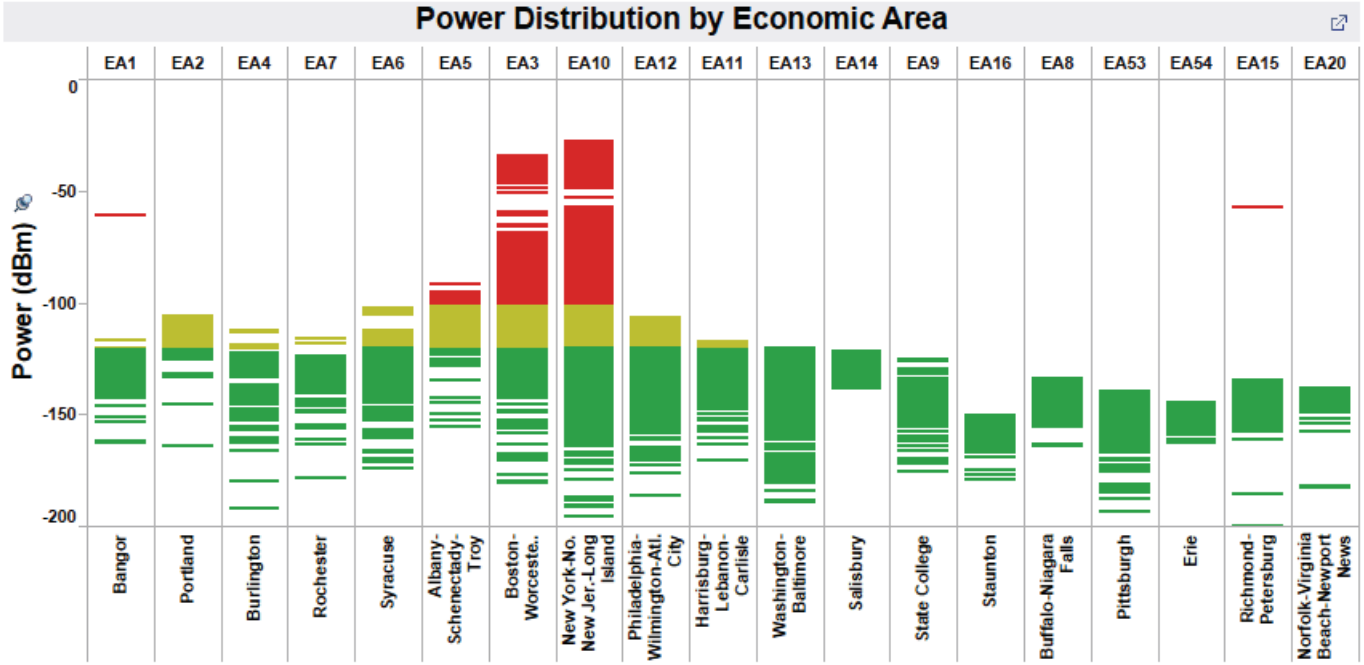
Station 4 Analysis (WFMZ-TV, Allentown, PA)

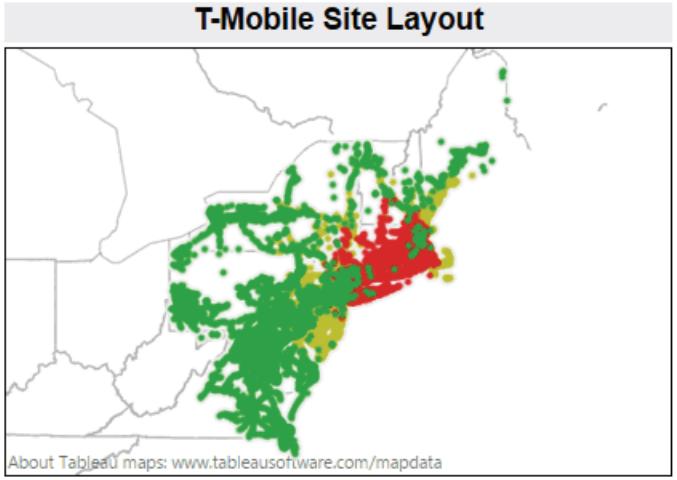


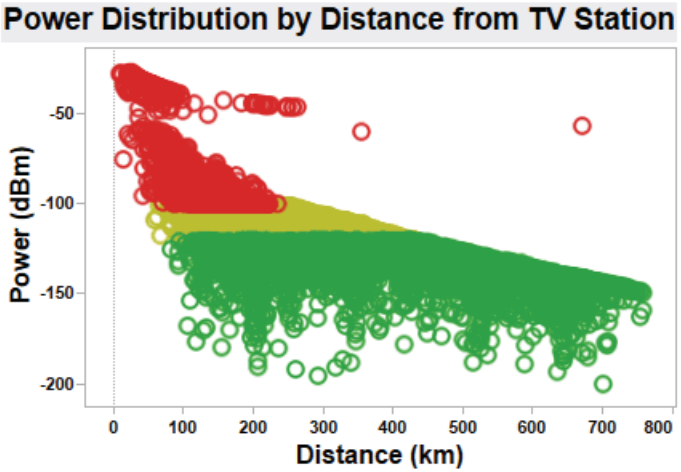




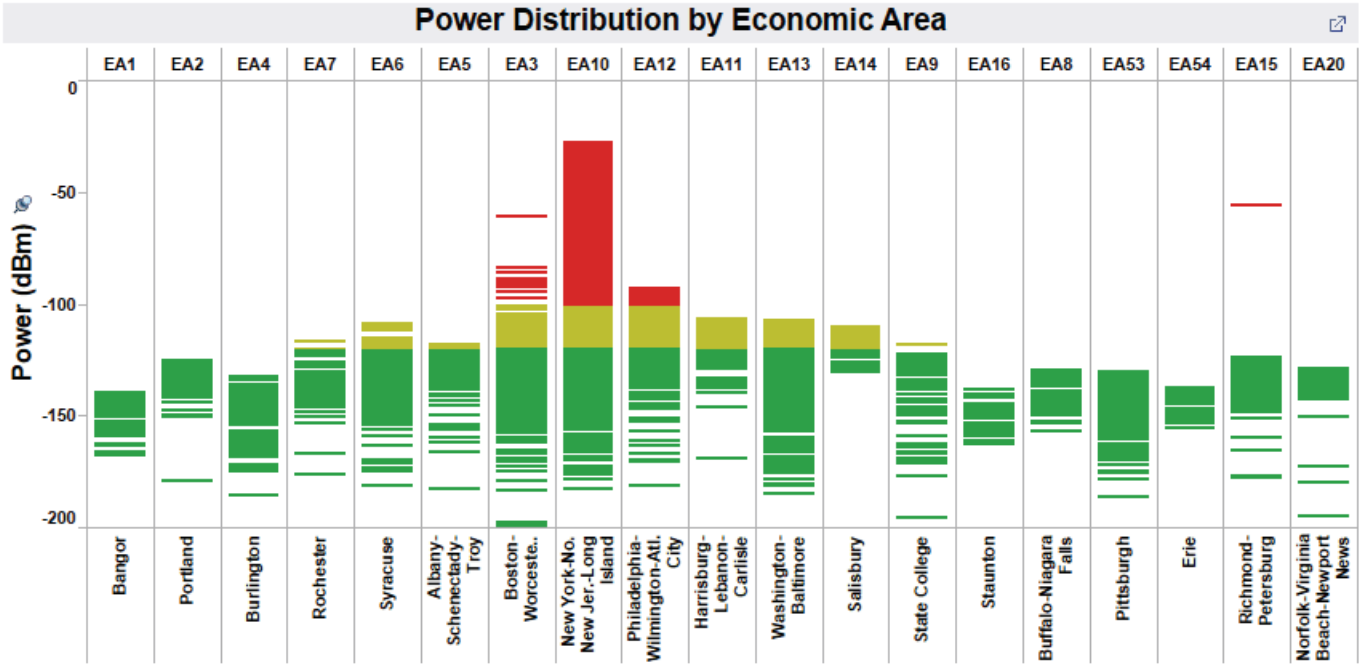
Station 5 Analysis, WGGB-TV, Springfield, MA)

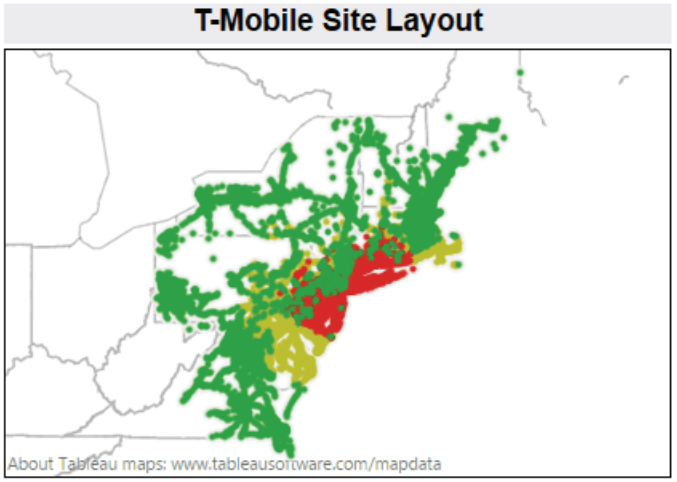


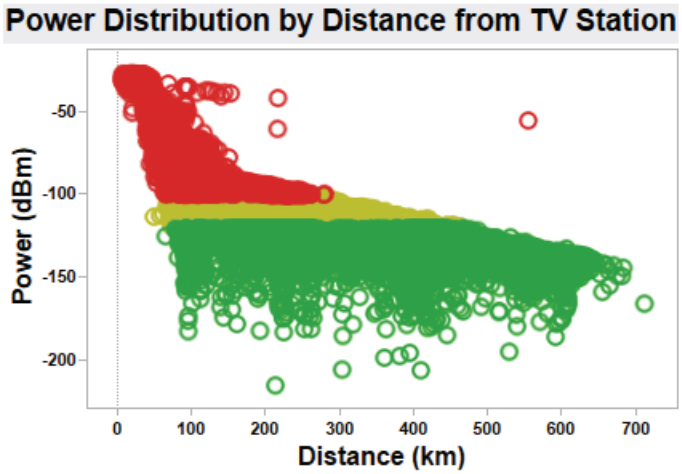




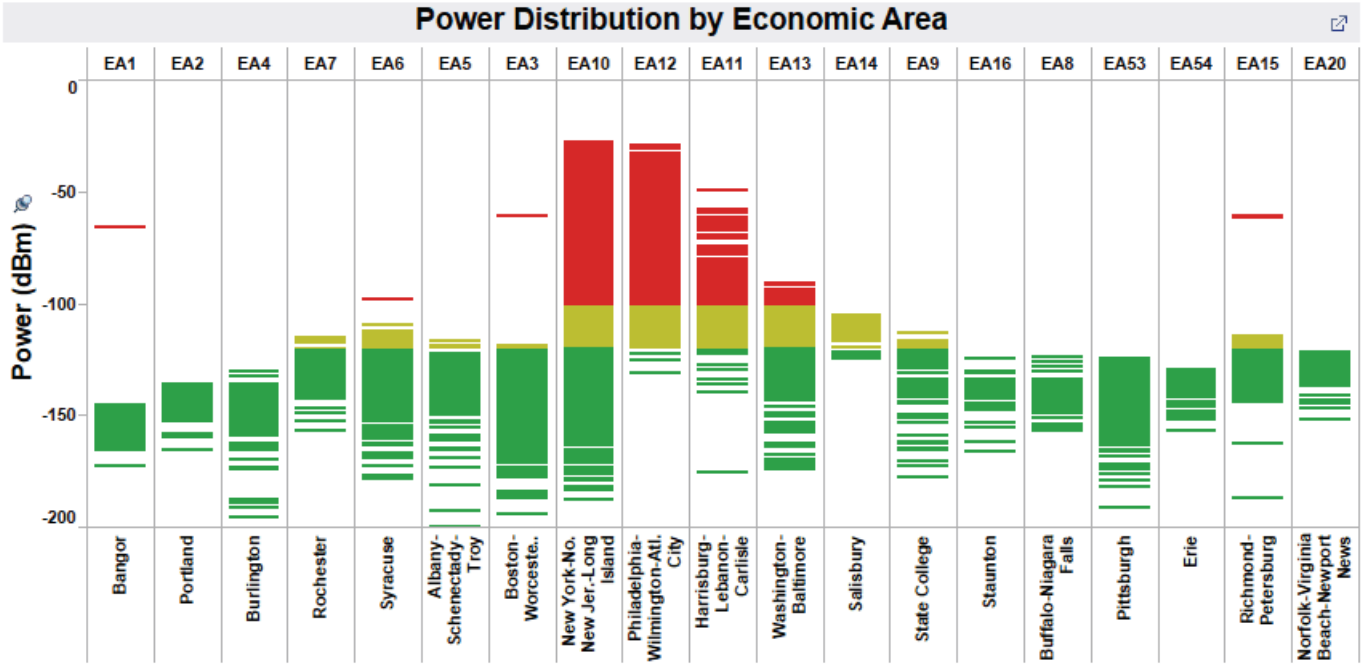
Station 6 Analysis (WLNY-TV, Riverhead, NY)

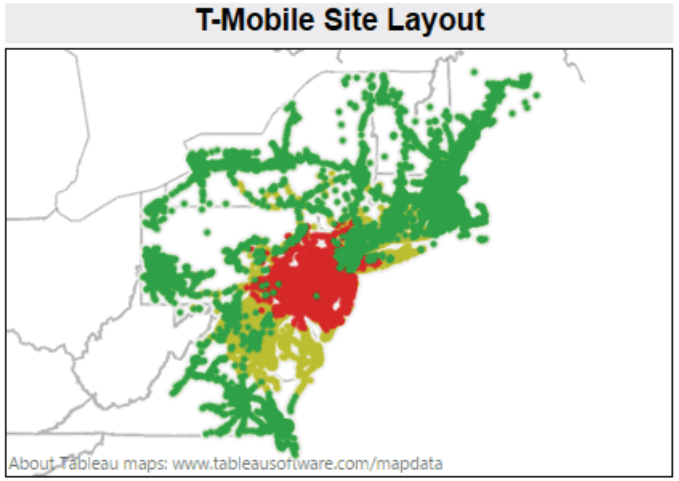


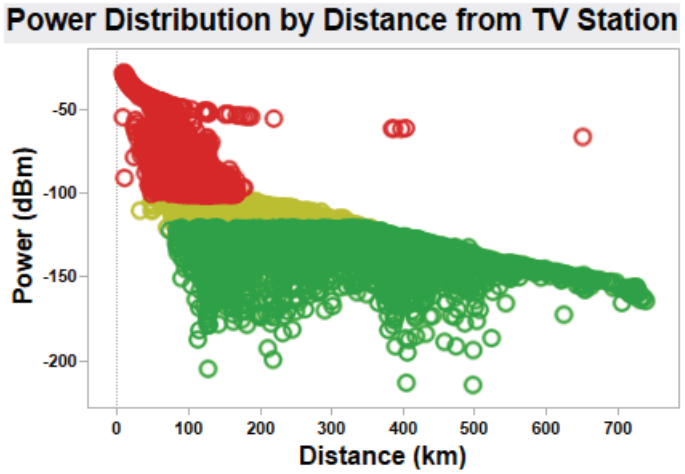




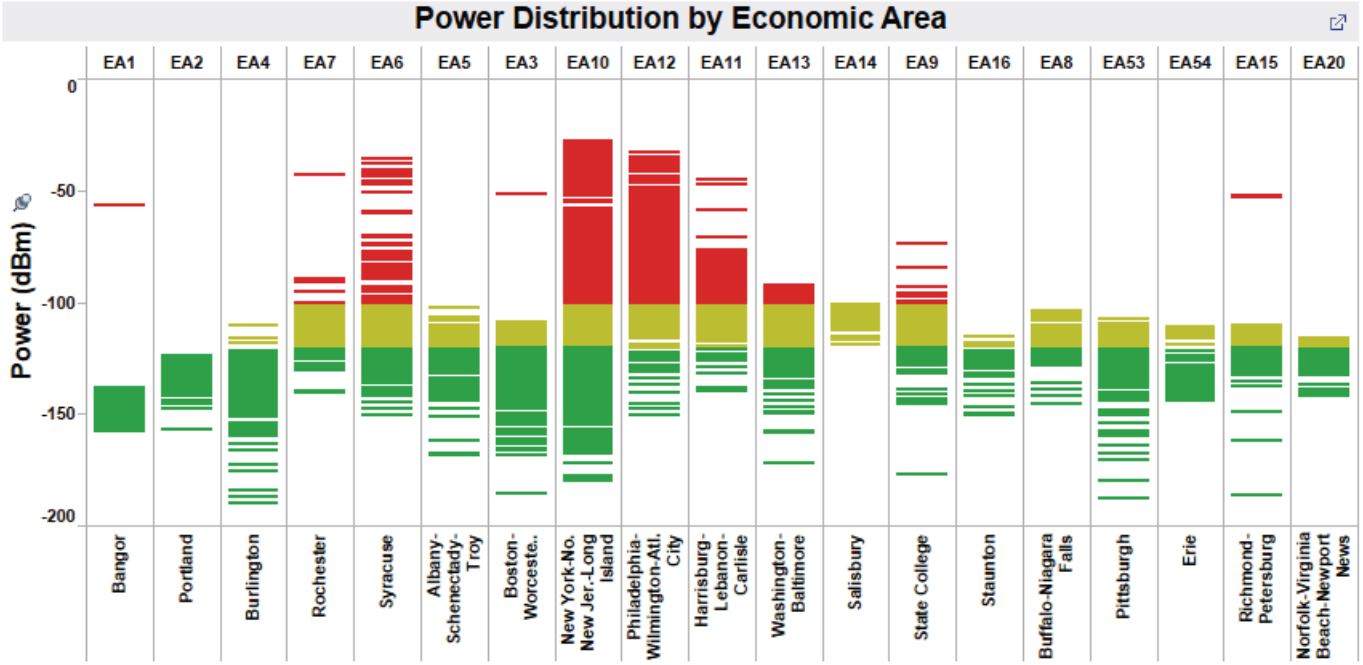
Station 7 Analysis (WLVT-TV, Allentown, PA)

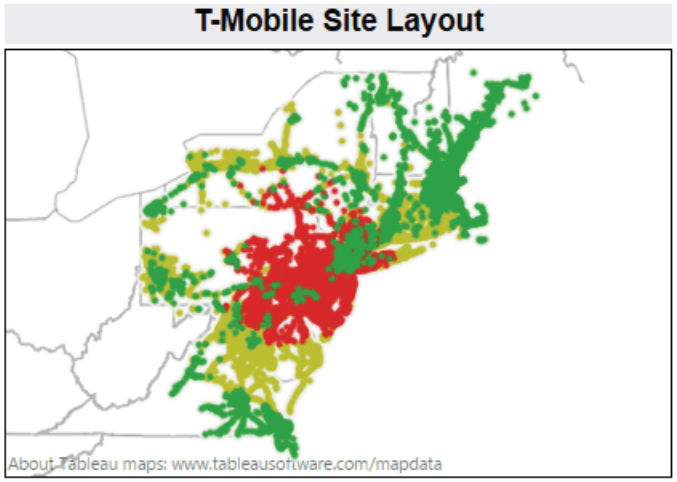


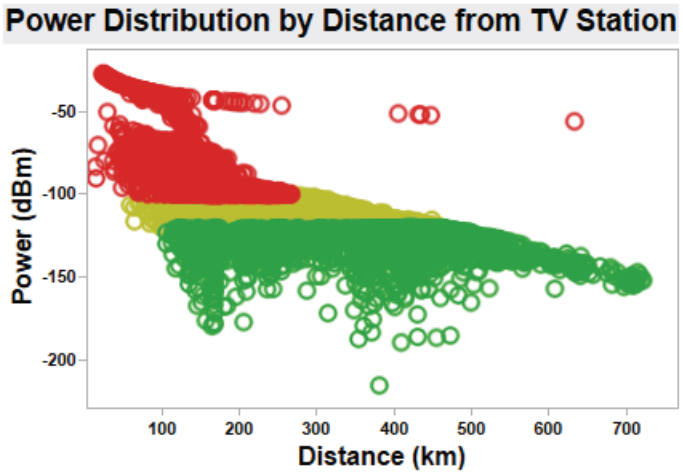




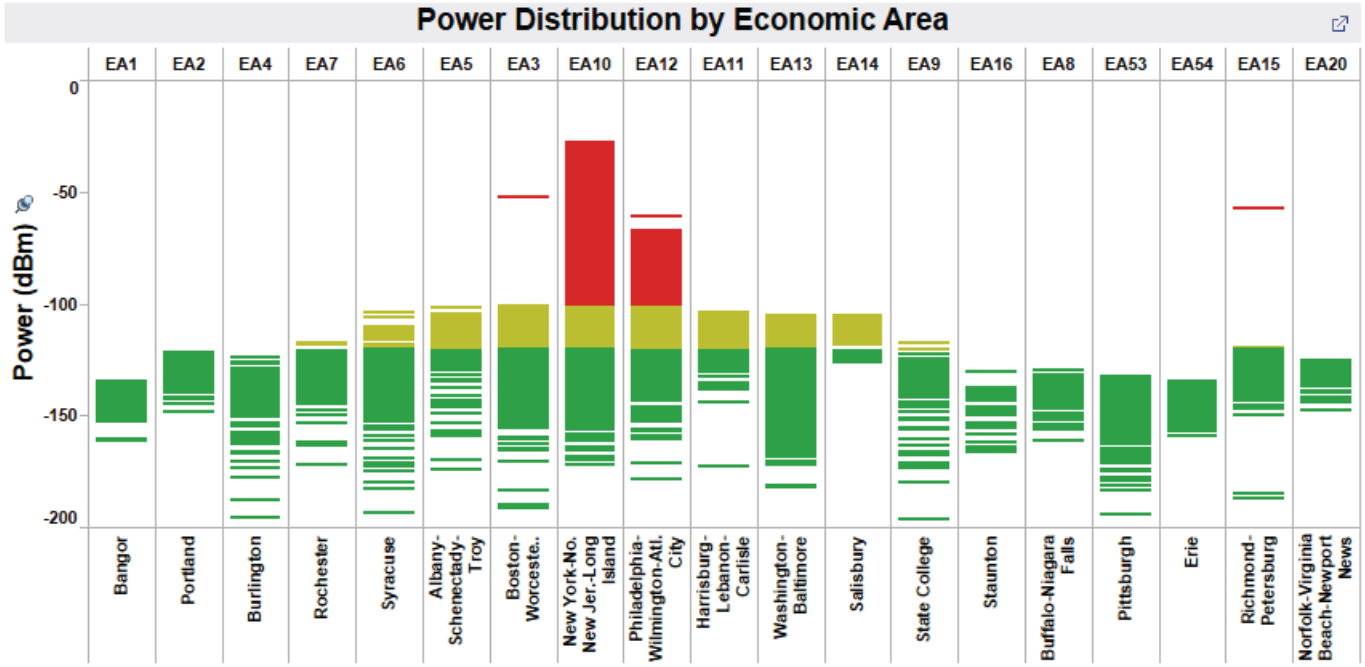
Station 8 Analysis (WNEP-TV, Scranton, PA)

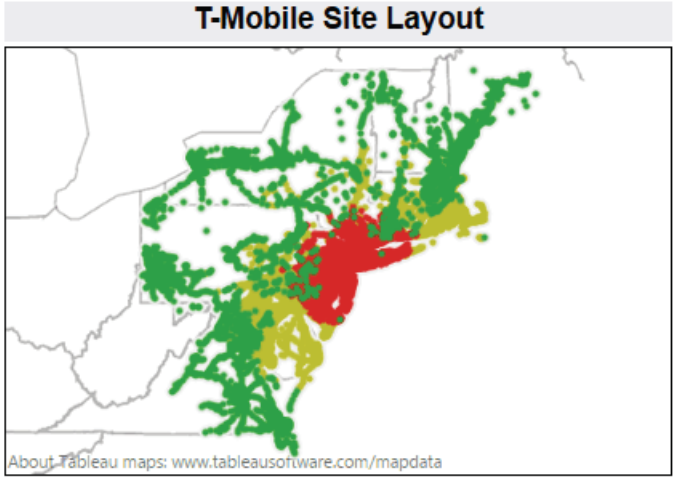


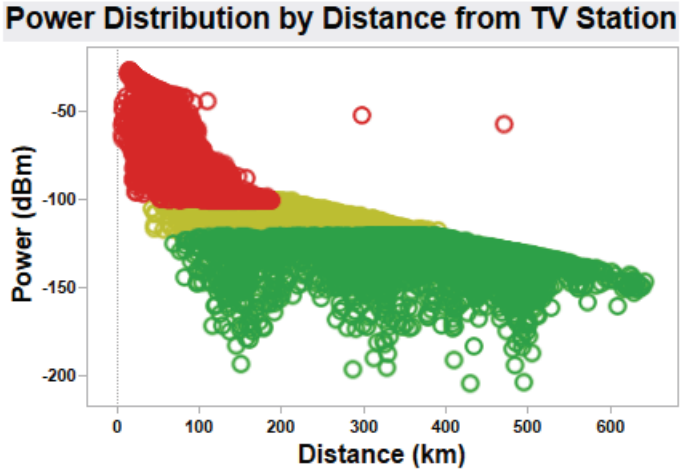




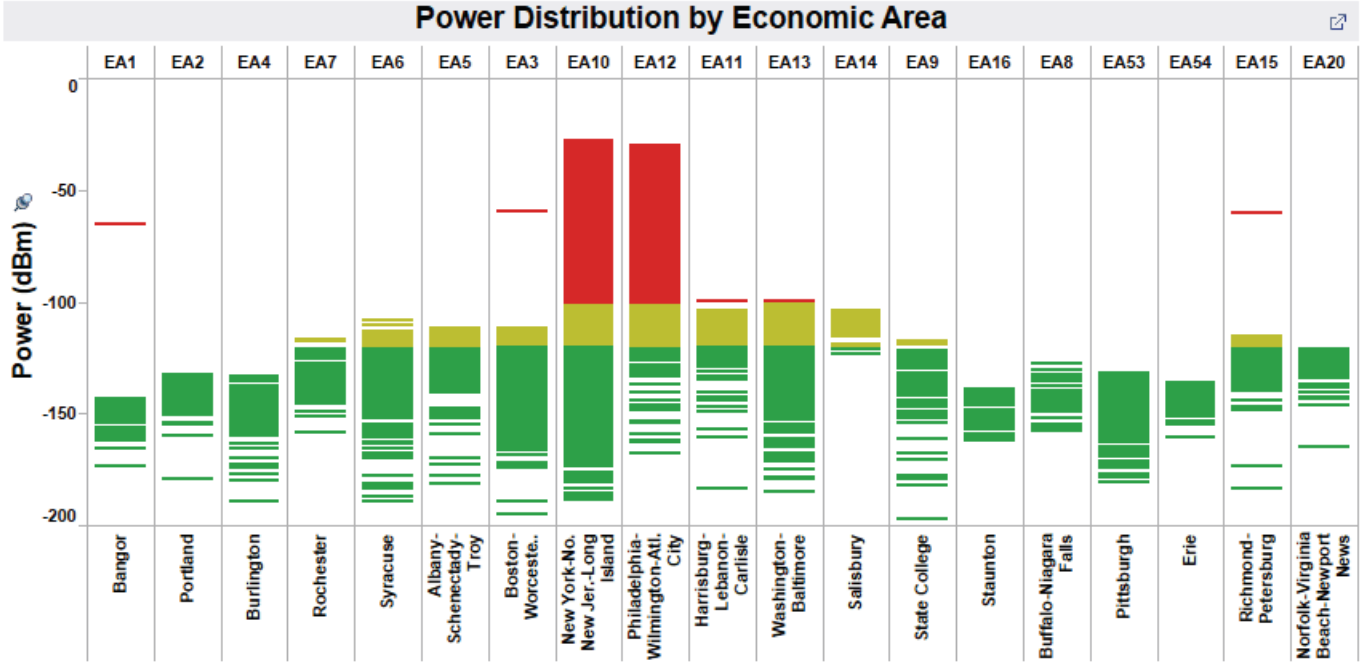
Station 9 Analysis (WNJN, Montclair, NJ)

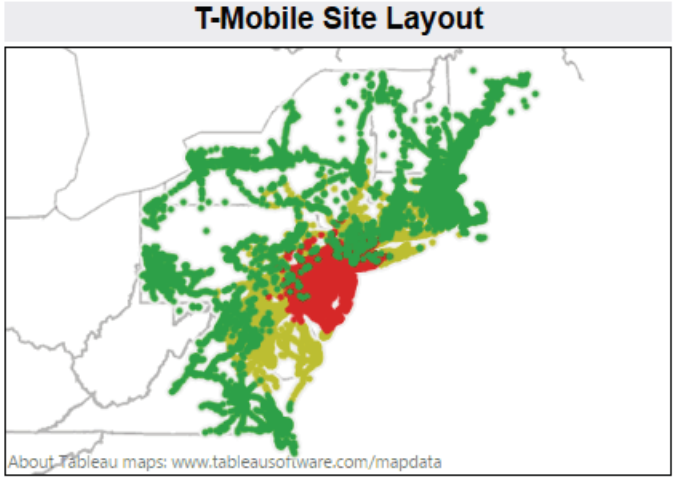


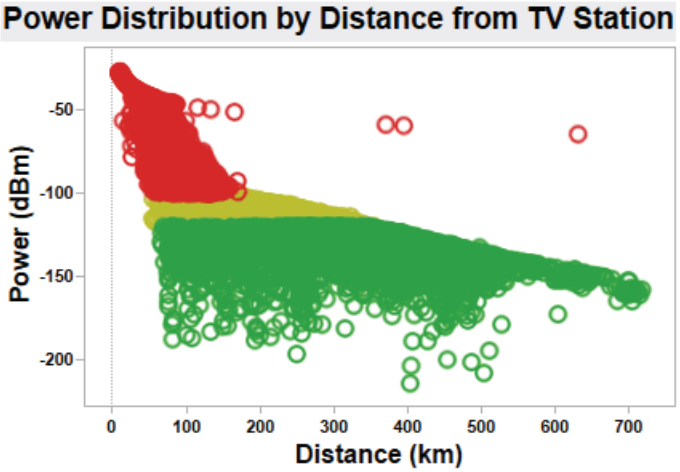




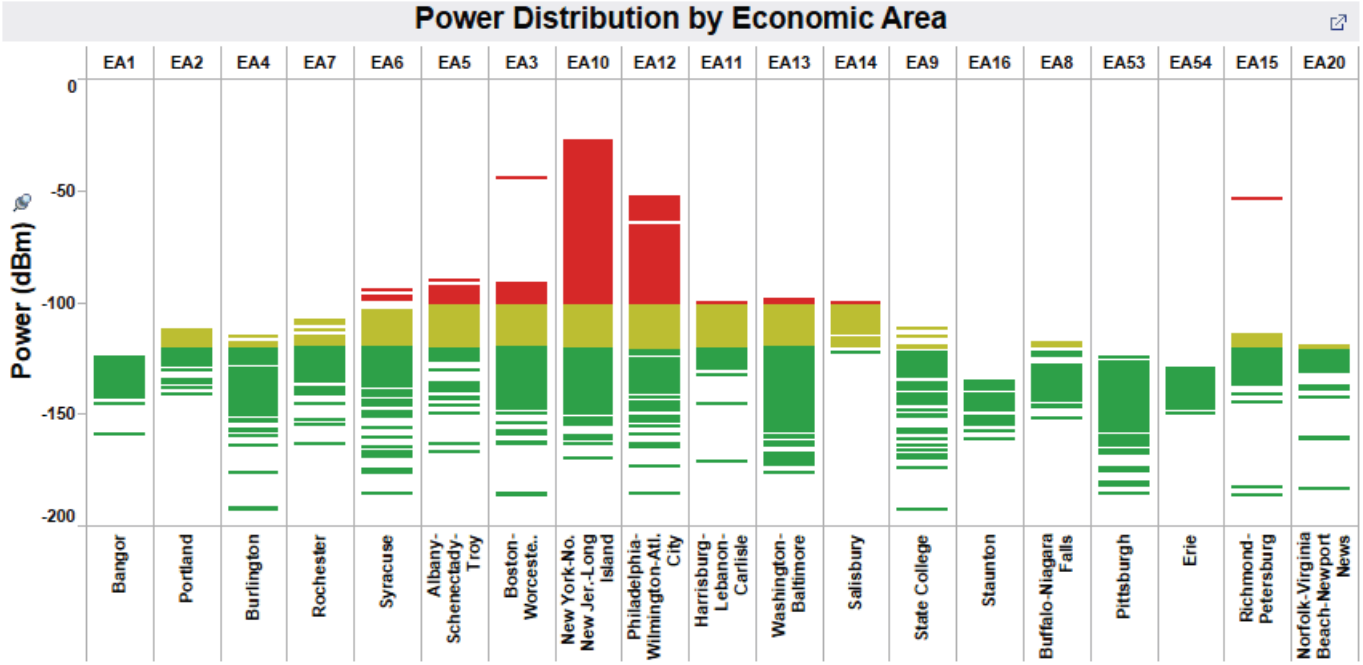
Station 10 Analysis (WNJT, Trenton, NJ)

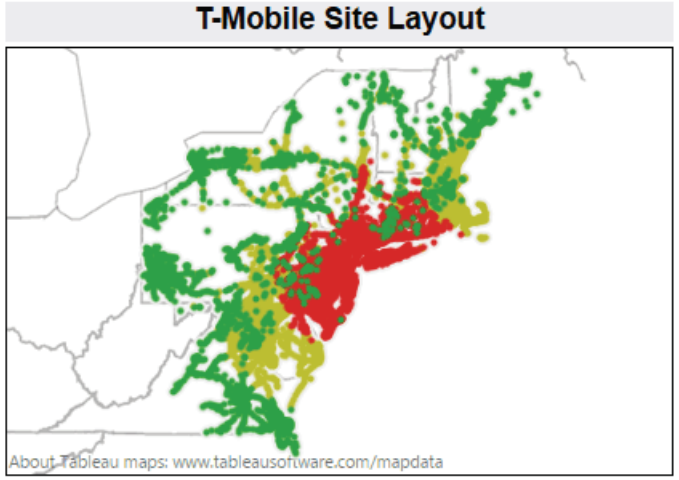


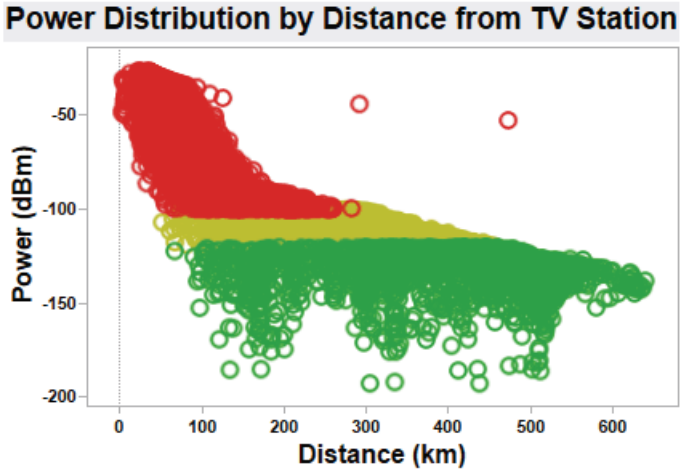




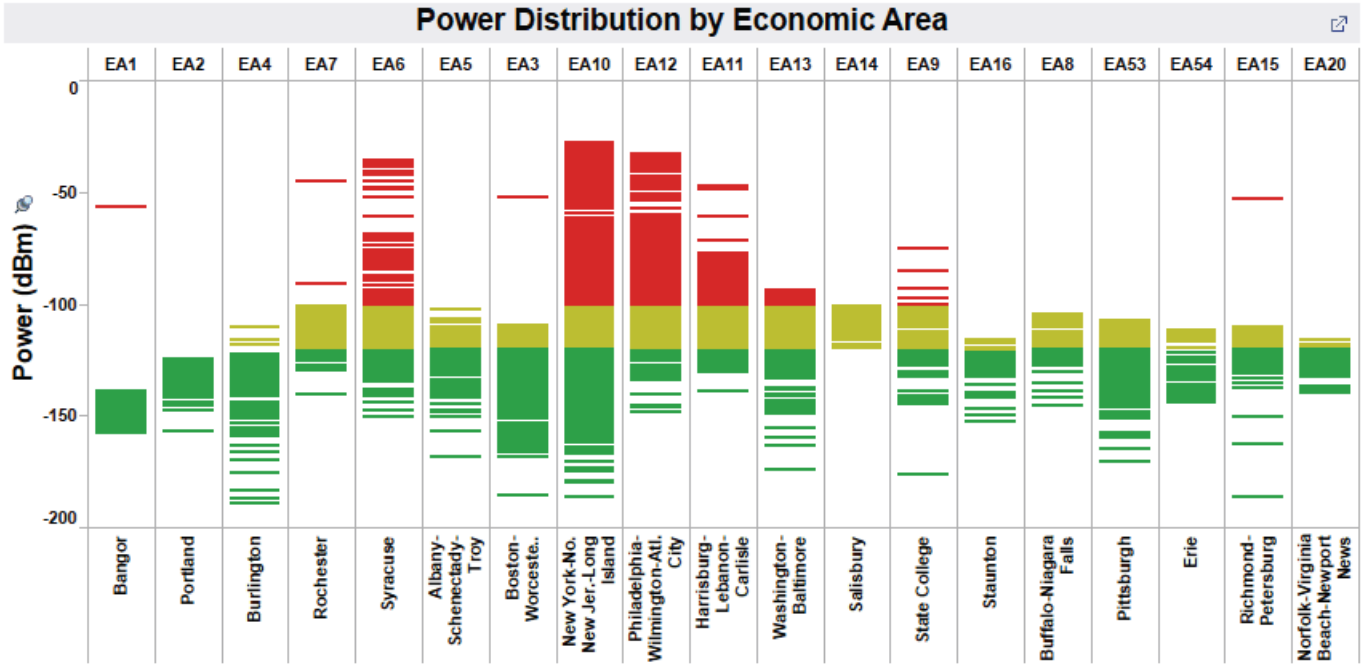
Station 11 Analysis (WNYW, New York, NY)

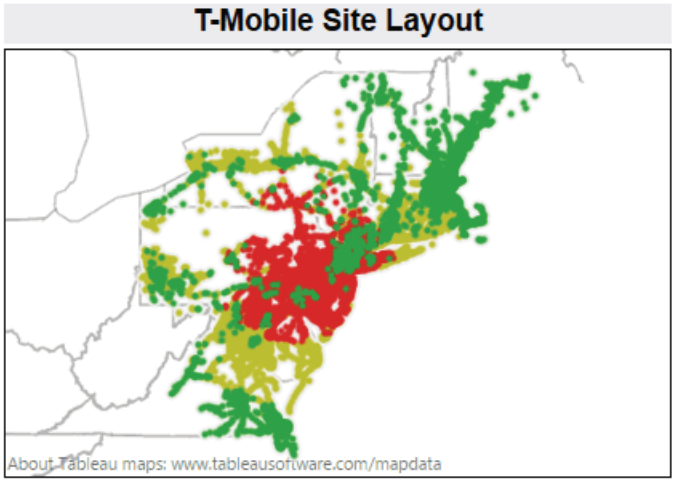


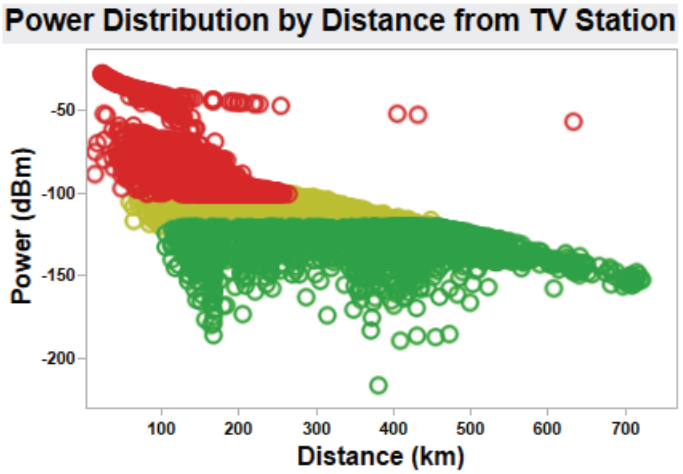




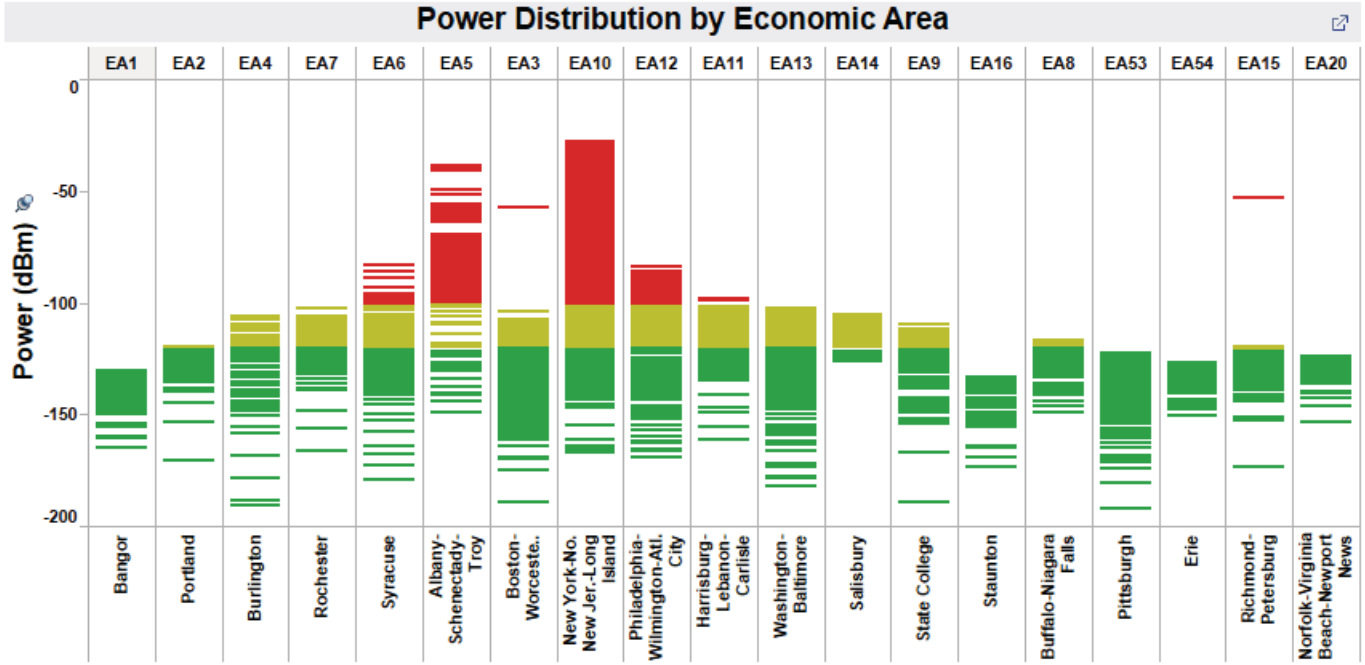
Station 12 Analysis (WOLF-TV, Hazleton, PA)

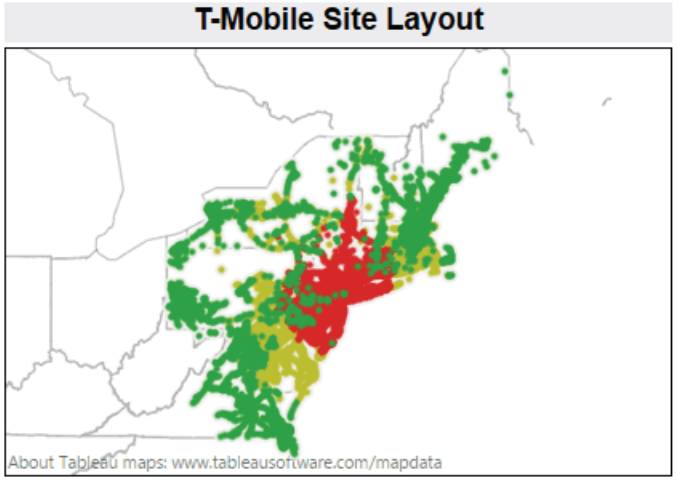


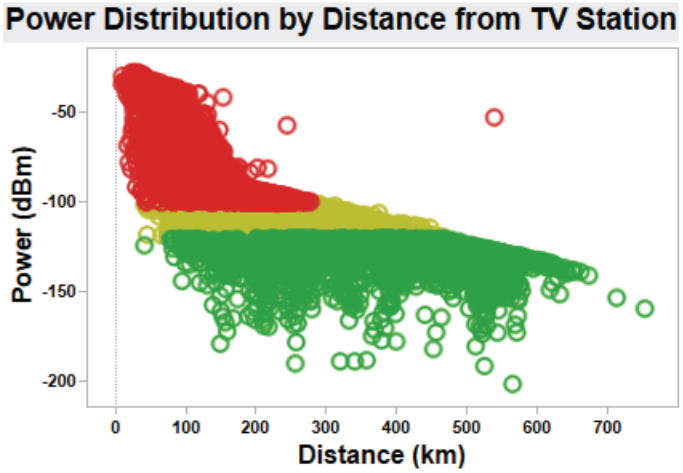




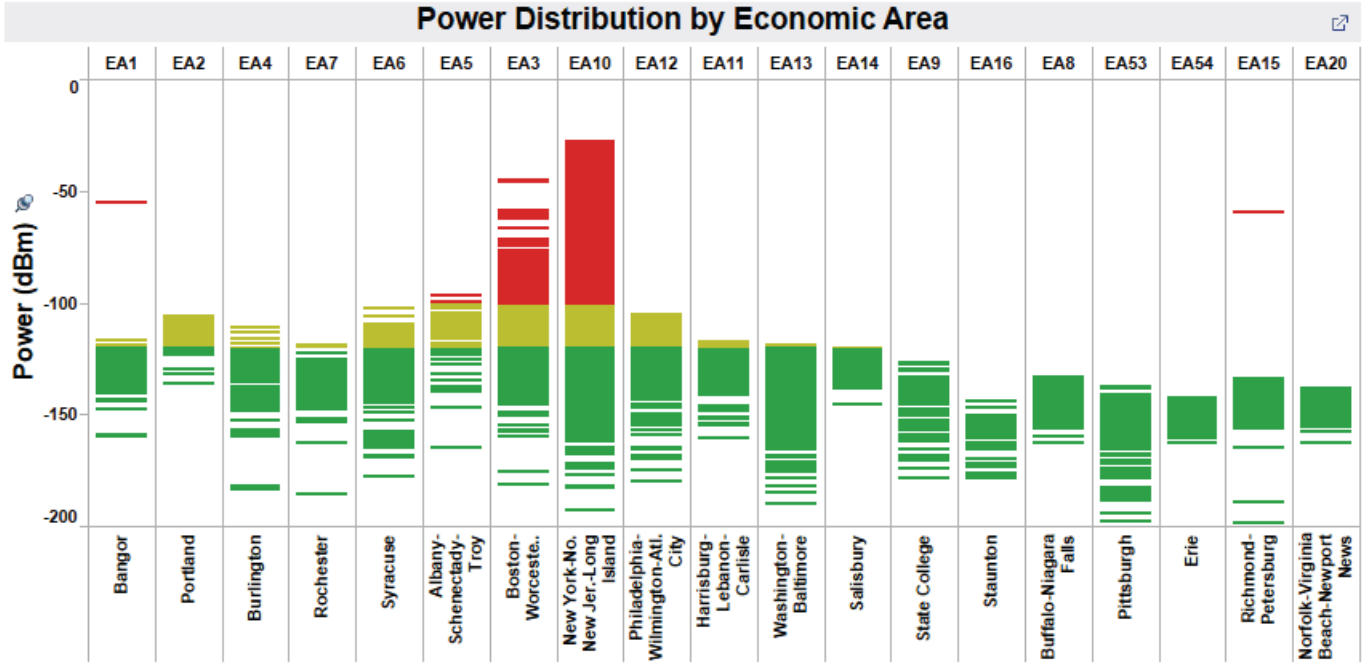
Station 13 Analysis (WRNN-TV, Kingston, NY)

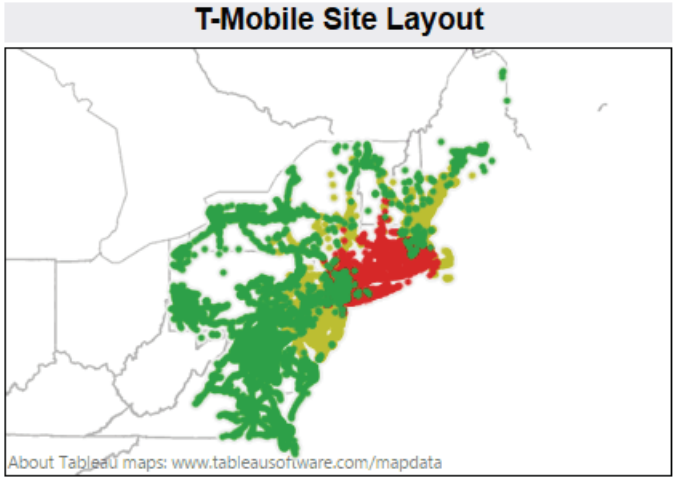


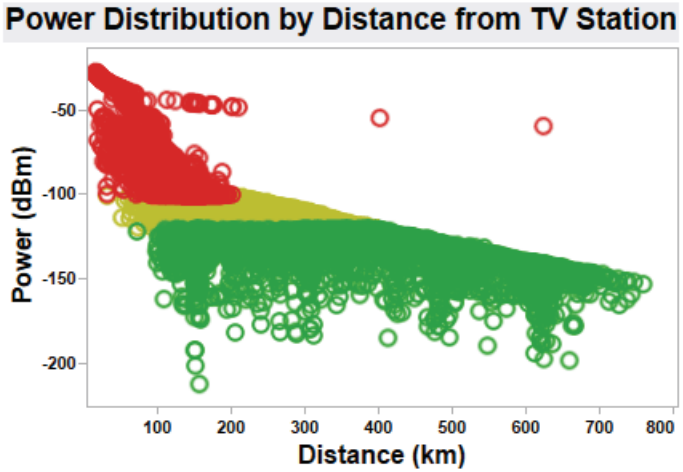




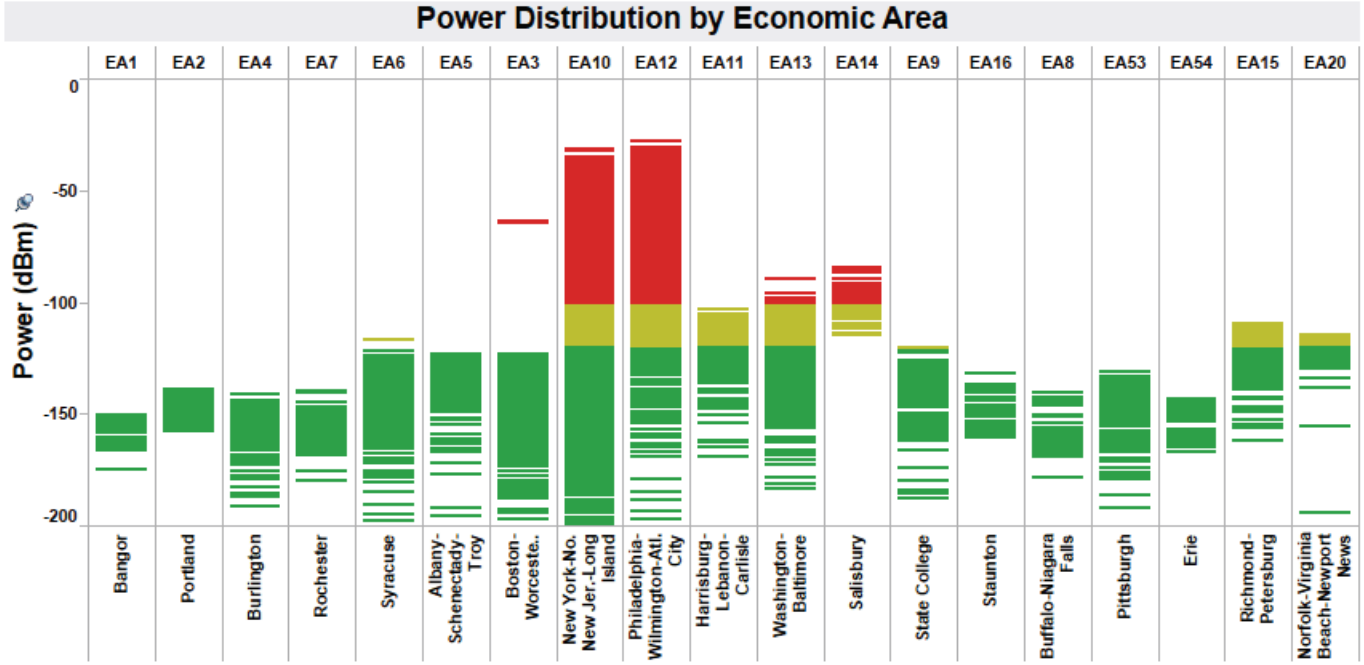
Station 14 Analysis (WUVN, Hartford, CT)

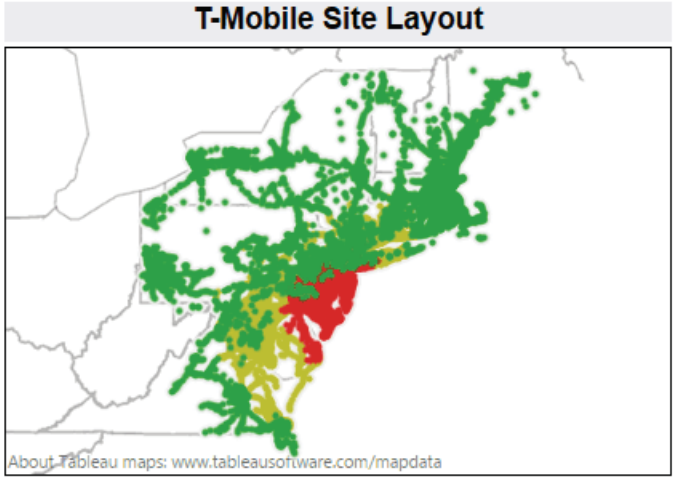


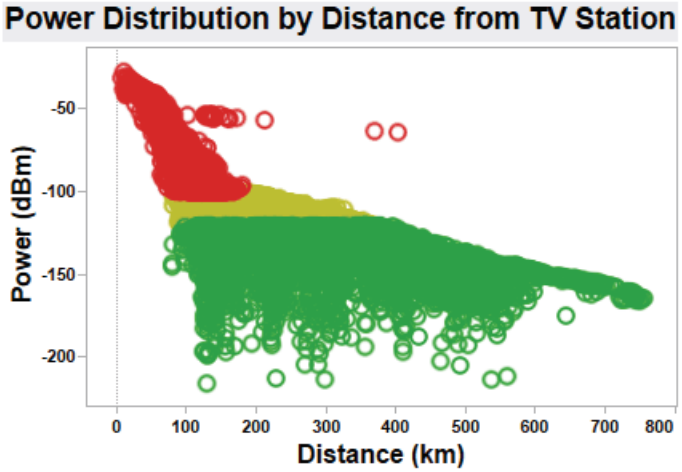




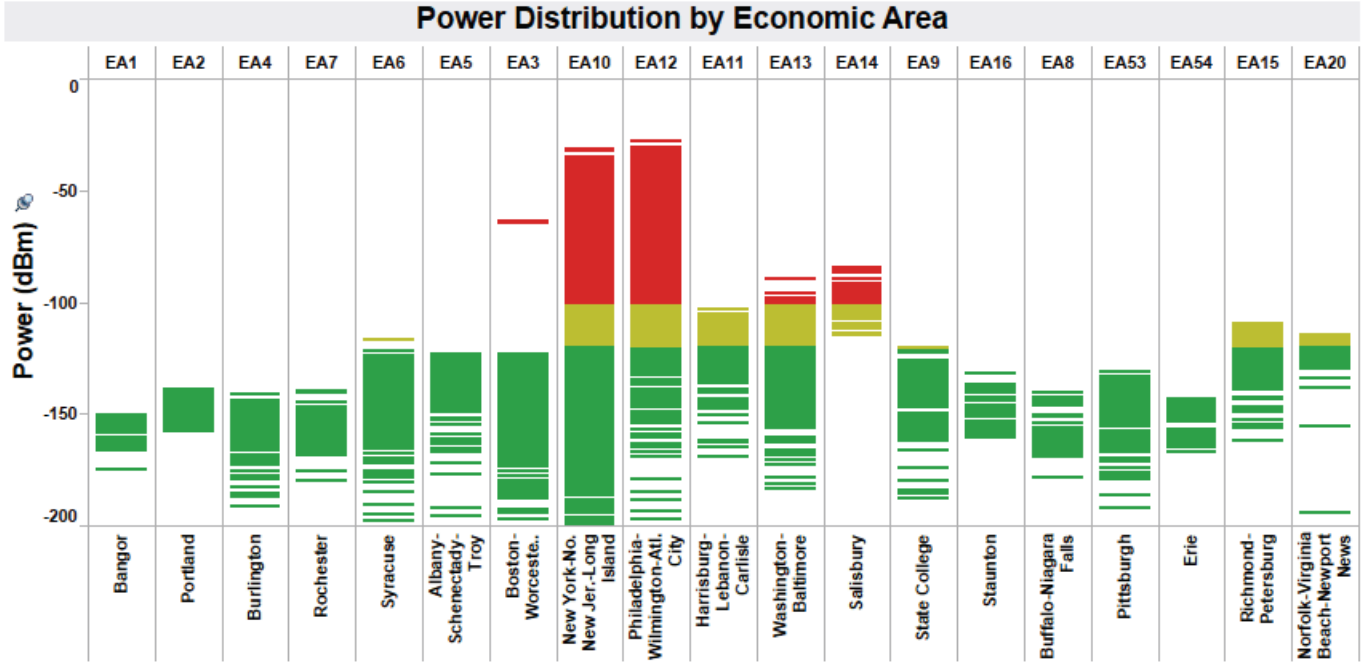
Station 15 Analysis (WVIA-TV, Scranton, PA)

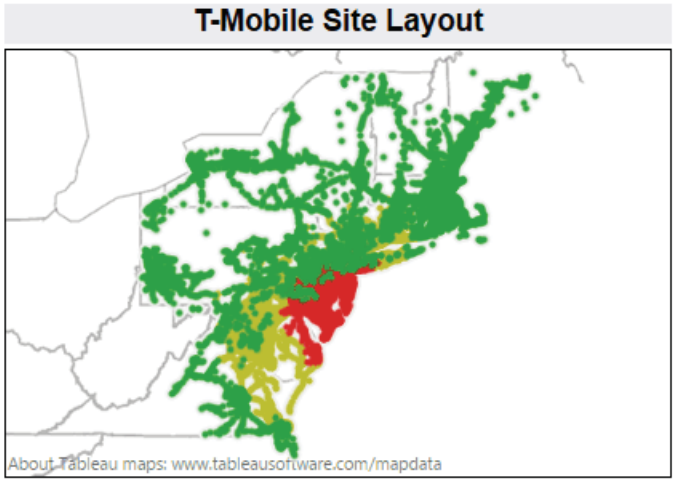


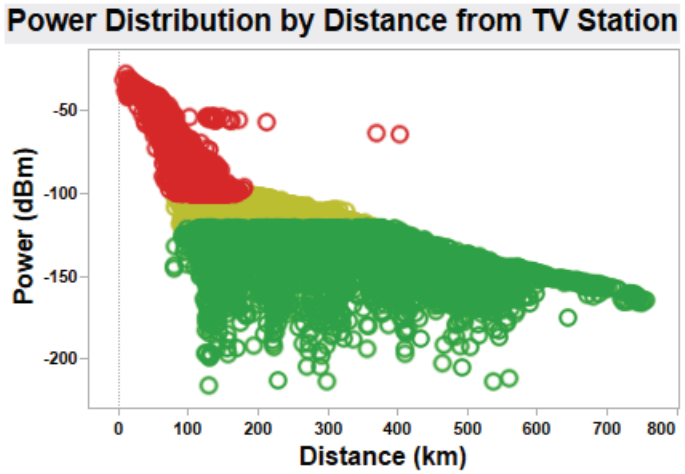




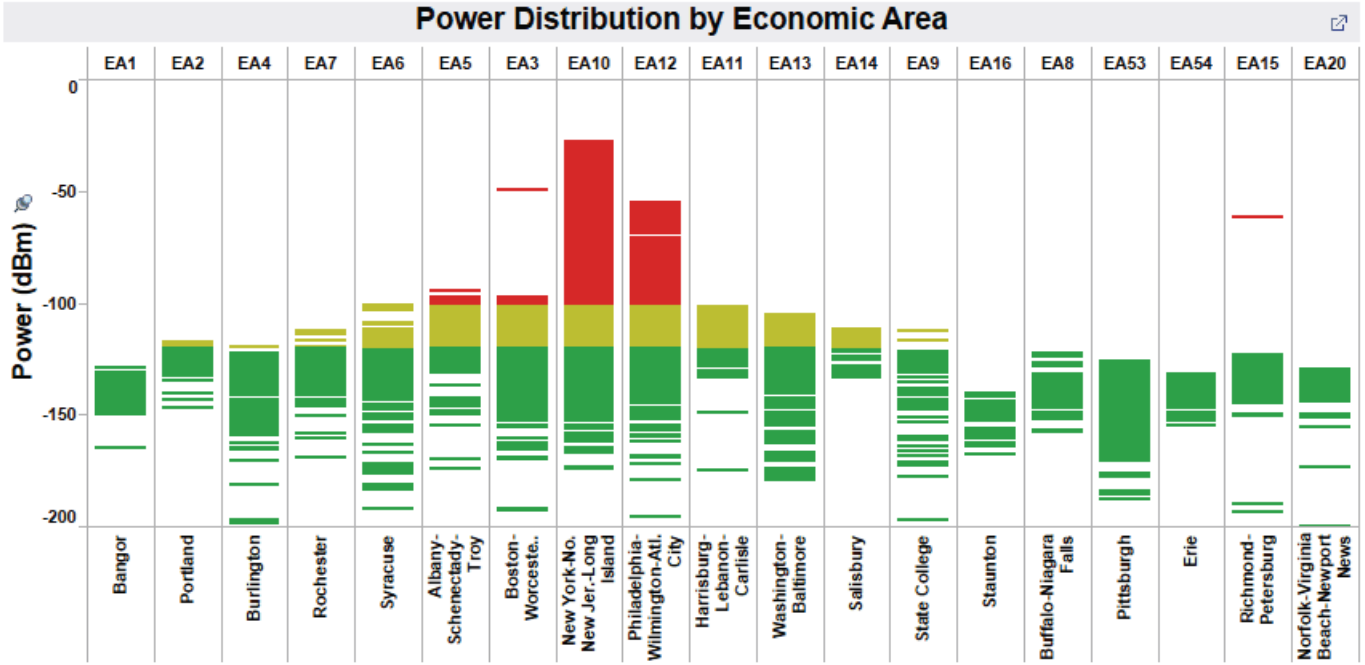
Station 16 Analysis (WWSI, Atlantic City, NJ)

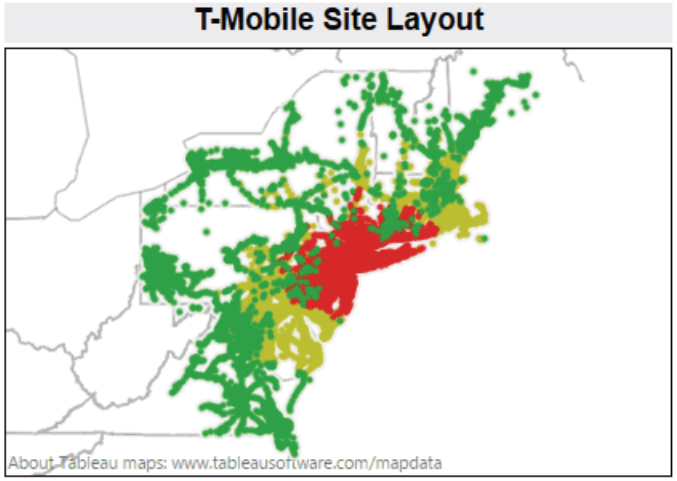


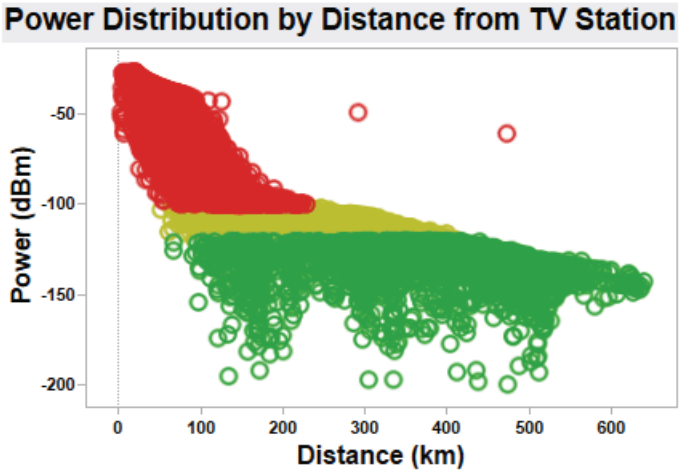
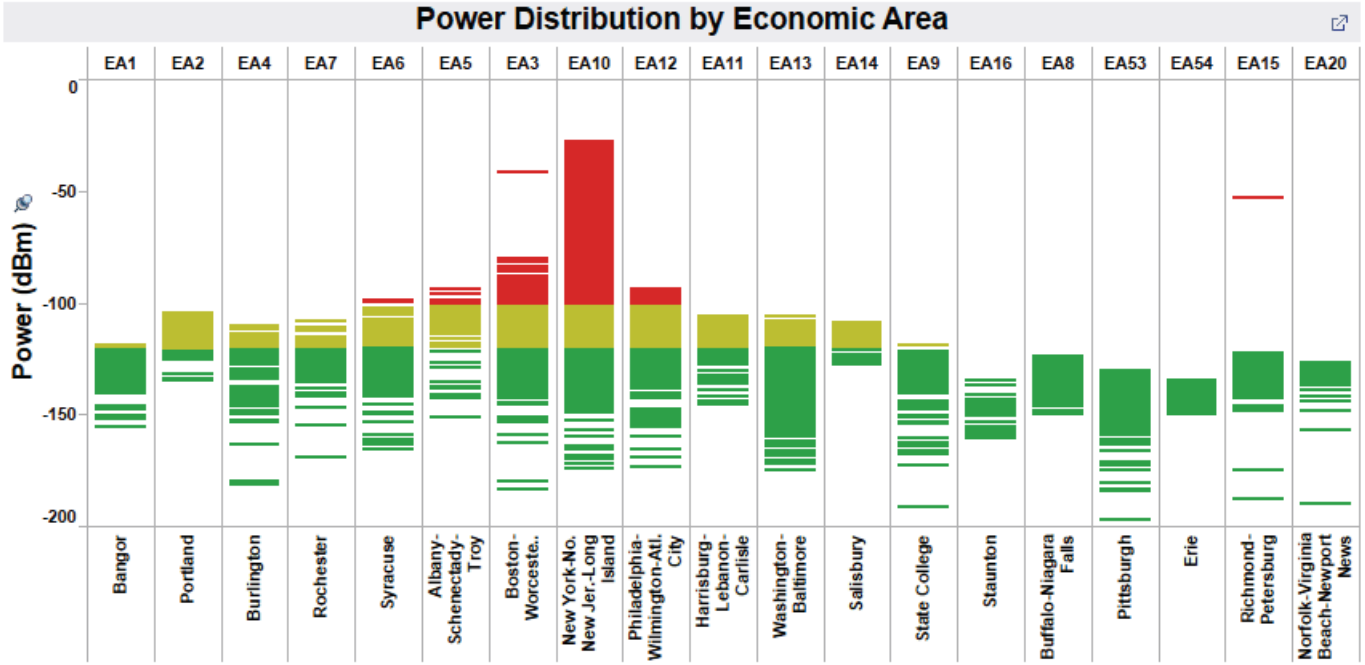
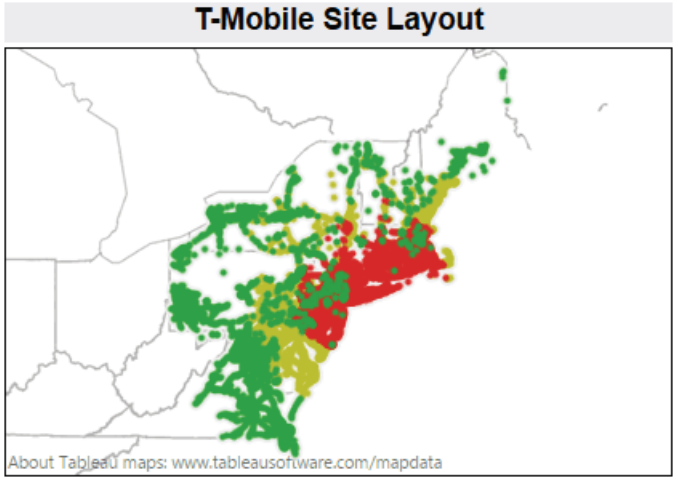
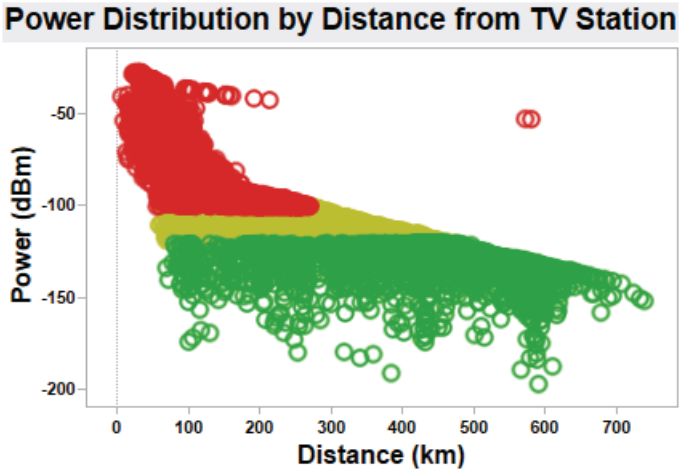




Station 17 Analysis (WXTV-DT, Paterson, NJ)







Station 18 Analysis (WZME, Bridgeport, CT)