

Current Optimization Work at the FCC

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Presenters

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Disclaimer

- ▶ Views expressed here are our own and not of the FCC.
- ▶ While some information contained herein may be based on public information from the auction, these slides should not be used as a substitute for reviewing the Commission's relevant orders, rules, and public notices regarding the Incentive Auction and the post-auction transition.

Incentive Auction Background

- ▶ In order to satisfy ever-increasing wireless demand, Congress authorized the FCC to conduct an auction to repurpose spectrum from over the air TV to wireless licenses
- ▶ To create the new wireless licenses, TV stations were assigned to new channels in a reduced TV spectrum band. This freed the upper frequencies for wireless use

Incentive Auction Results

► Benefits to Broadcasters

- 175 winning television stations
- 93% will channel share and stay on the air
- Many non-commercial public broadcasting stations received large winnings

► 84 MHz of Spectrum Repurposed

- 70 MHz for licensed 5G wireless services
- 14 MHz for unlicensed uses

► Monetary Benefits

- \$19.9 billion in gross revenue from forward auction
- \$10.05 billion to winning broadcasters
- \$1.75 billion to move TV stations staying on the air
- \$7.3 billion into US Treasury

Incentive Auction Background

The FCC team won the 2018 Franz Edelman Award from INFORMS for their optimization work on this innovative auction



The TV Transition Problem

What needed to be done?

- ▶ Nearly 1,000 US stations and 170 Canadian stations will be moved to new channels
- ▶ Channels 38 – 51 would be lost to broadcasters
- ▶ Auction rules required that the transition be performed in 39 months

COULD THIS BE DONE?

Previous TV Transition in the US (Analog to Digital)



- ▶ Congress passed the Telecommunications Act of 1996 with original transition date of December 31, 2006. Actual transition took place in June, 2009... **13 years to complete!**
- ▶ Before transition: Channels 2-69; After transition Channels 2-51
- ▶ There were sufficient channels during this analog to digital transition for broadcasters to have 2 channels (one analog AND one digital)
- ▶ Viewers received coupons for a digital converter
- ▶ Only **7%** of viewers were affected by the loss of analog broadcasts since most of the country received broadcasts via cable, cable, or satellite services

The New Problem: The Incentive Auction Transition

- ▶ Nearly 1,000 stations will be moved to new channels.
- ▶ No longer could one broadcast on one channel and test on another channel without interference issues
- ▶ Over the air viewership is rising. The changes here require a rescan of your television rather than new equipment
- ▶ The National Association of Broadcasters argued to the FCC that it was blindly adhering to the "arbitrary and unfounded" 39-month deadline above all else.



Challenges – Consumer Impact

Frequent rescans would
inconvenience over the air TV
viewers



The longer the transition, the
longer mobile users would have to
wait before benefitting from
increased speeds and bandwidth

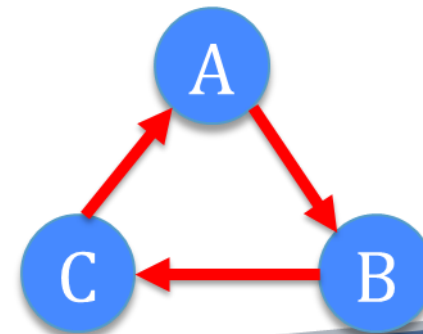
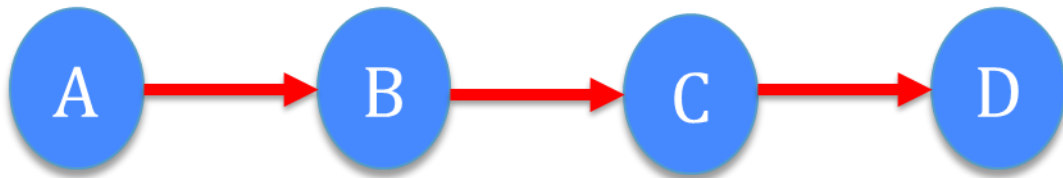


Challenges - Dependencies

- ▶ In many cases, a station must move off of a channel before another station can move onto that channel

Station	Pre-Auction Channel	Post-Auction Channel
A	25	20
B	42	25

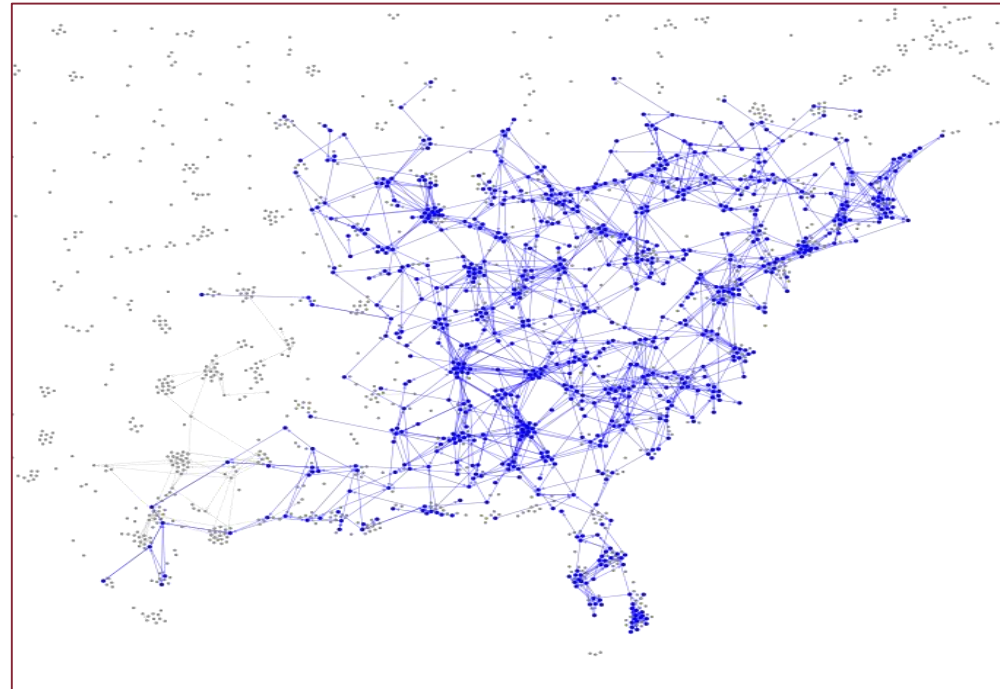
- ▶ These chains can be long, complicated, and even cycle back on themselves



Challenges – Interference

- ▶ Necessary to analyze graph structure of the problem
- ▶ Even with slightly relaxed interference protections, unraveling the constraint graph to produce logical transition schedule is very challenging

Dependency Graph



Challenges - Resource Limitations

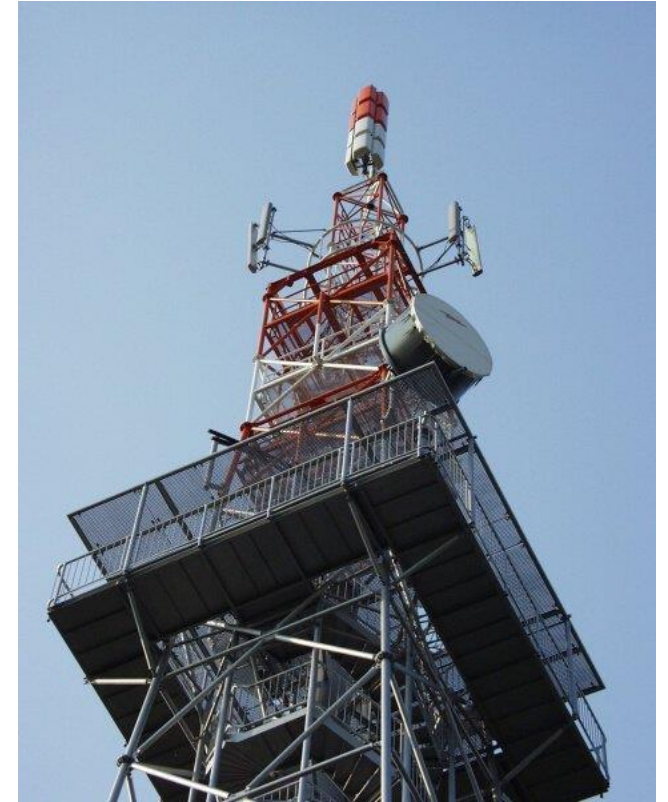
- Resources needed to complete the transition (personnel and manufacturing) are extremely limited
- Some antennas and towers are significantly more complicated than others (can be over 2000 ft high!)



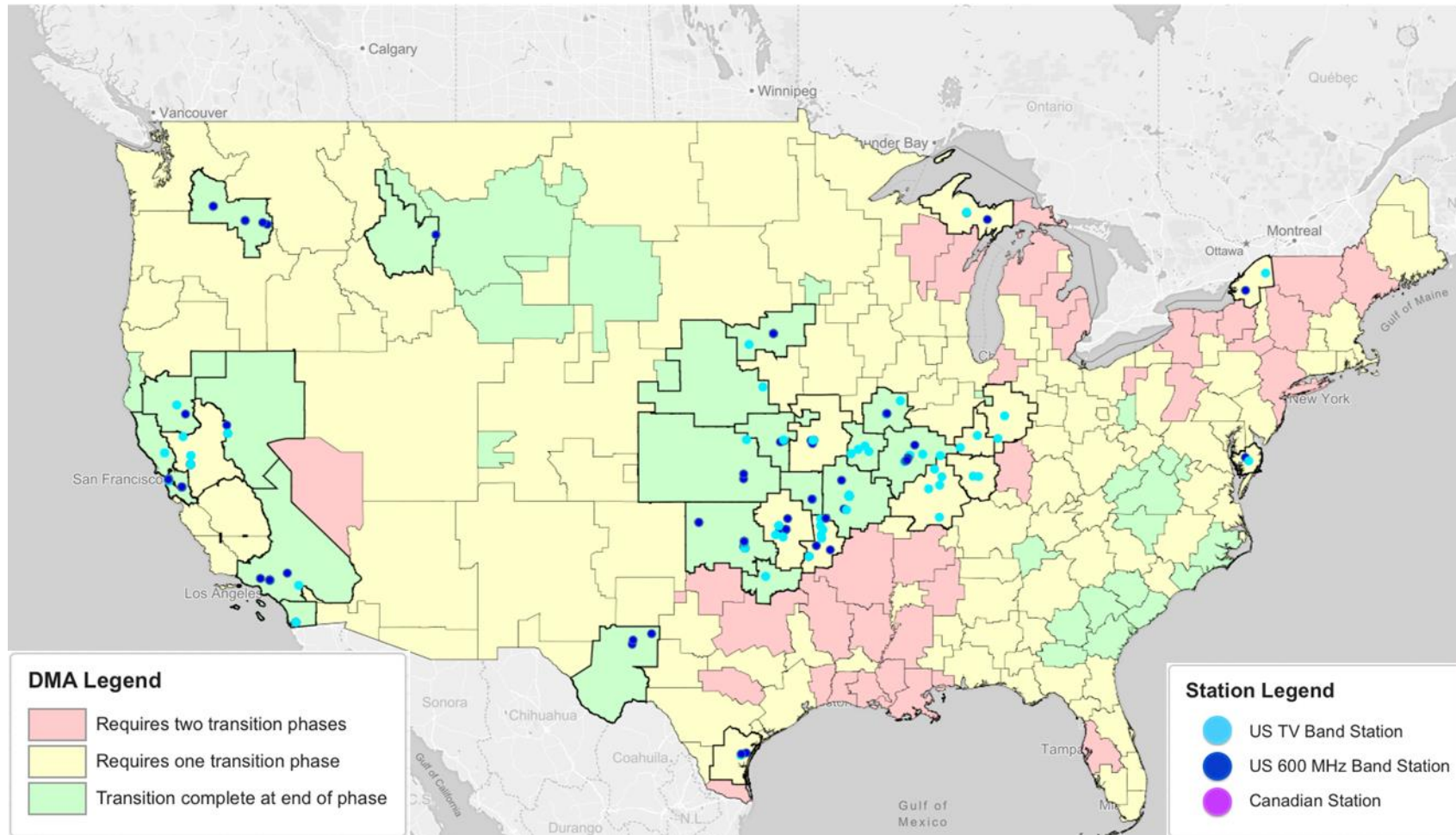
Solution Development

Collaboration

- ▶ The FCC created a taskforce for the auction to facilitate communication across the bureaus and offices. This taskforce continued into the post-auction transition
- ▶ Resource constraints
 - ▶ Limited crews for complex towers
 - ▶ Climate/seasonal issues
 - ▶ Manufacturing schedule
- ▶ Stakeholder priorities
 - ▶ Canada wished to transition later
 - ▶ TV Broadcasters wanted as few rescans
 - ▶ Wireless providers desired their licenses as early as possible



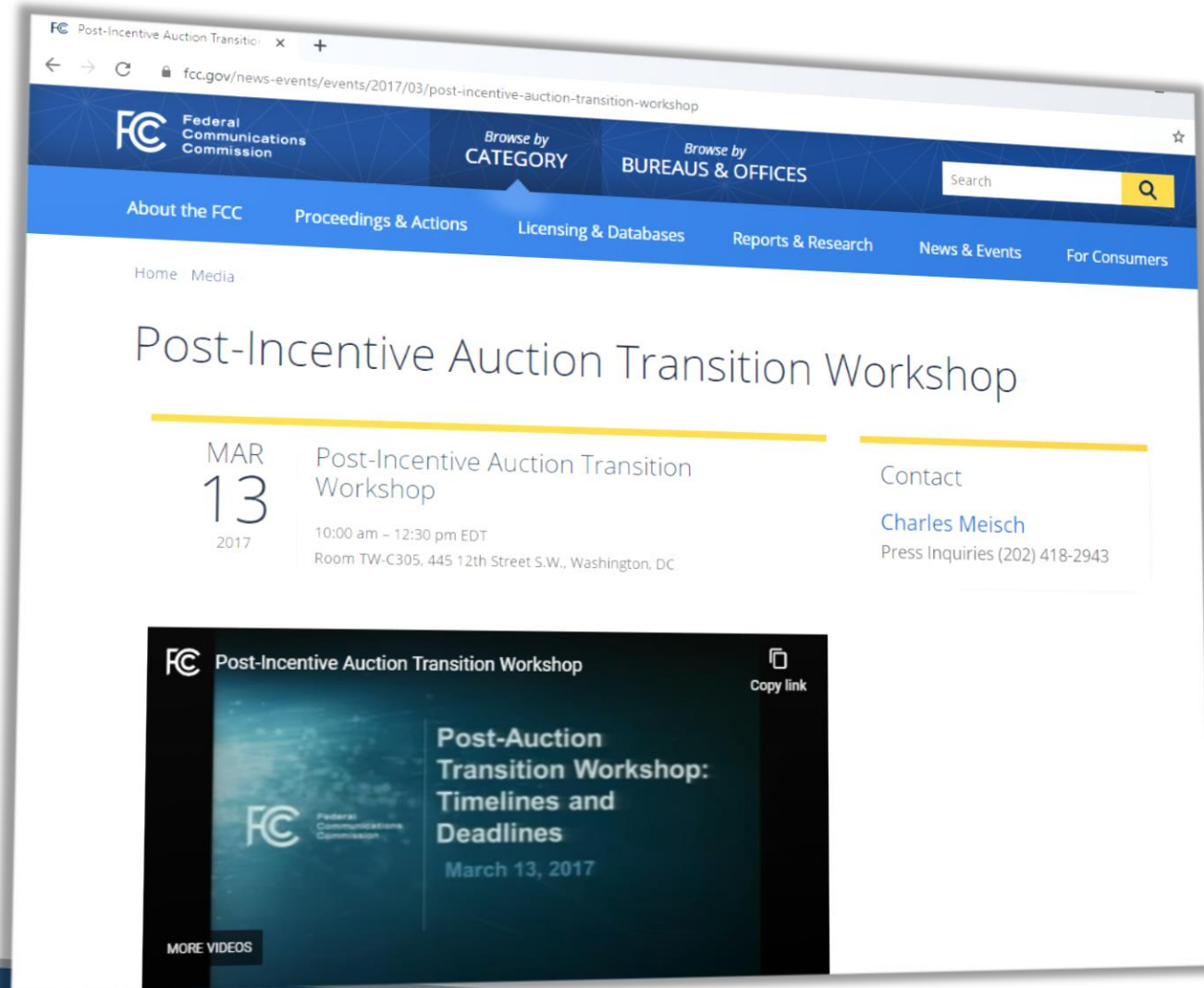
Simulation and Model Refinement



The team built multiple models to simulate end of auction scenarios and how different policy decisions changed the transition

We created a collection of visualizations to help staff understand the results

Public Notices and Workshops

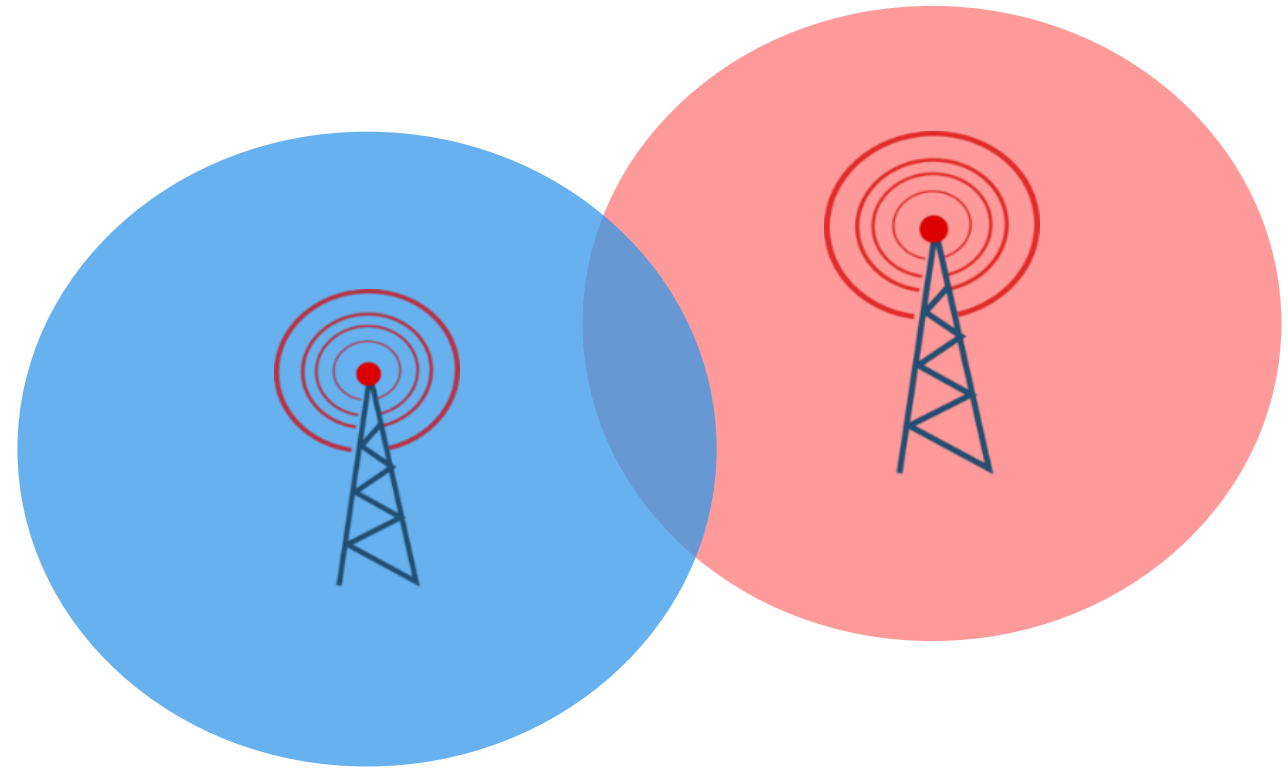


These models were presented in the form of Public Notices and the FCC hosted multiple workshops to communicate with the public

All policy proposals including models were open to public comments

Relax Interference Protections

By relaxing interference protections to up to 2% of a station's normal population, we end up with fewer dependencies and more flexibility



Creating and Releasing the Plan

Optimization Goals

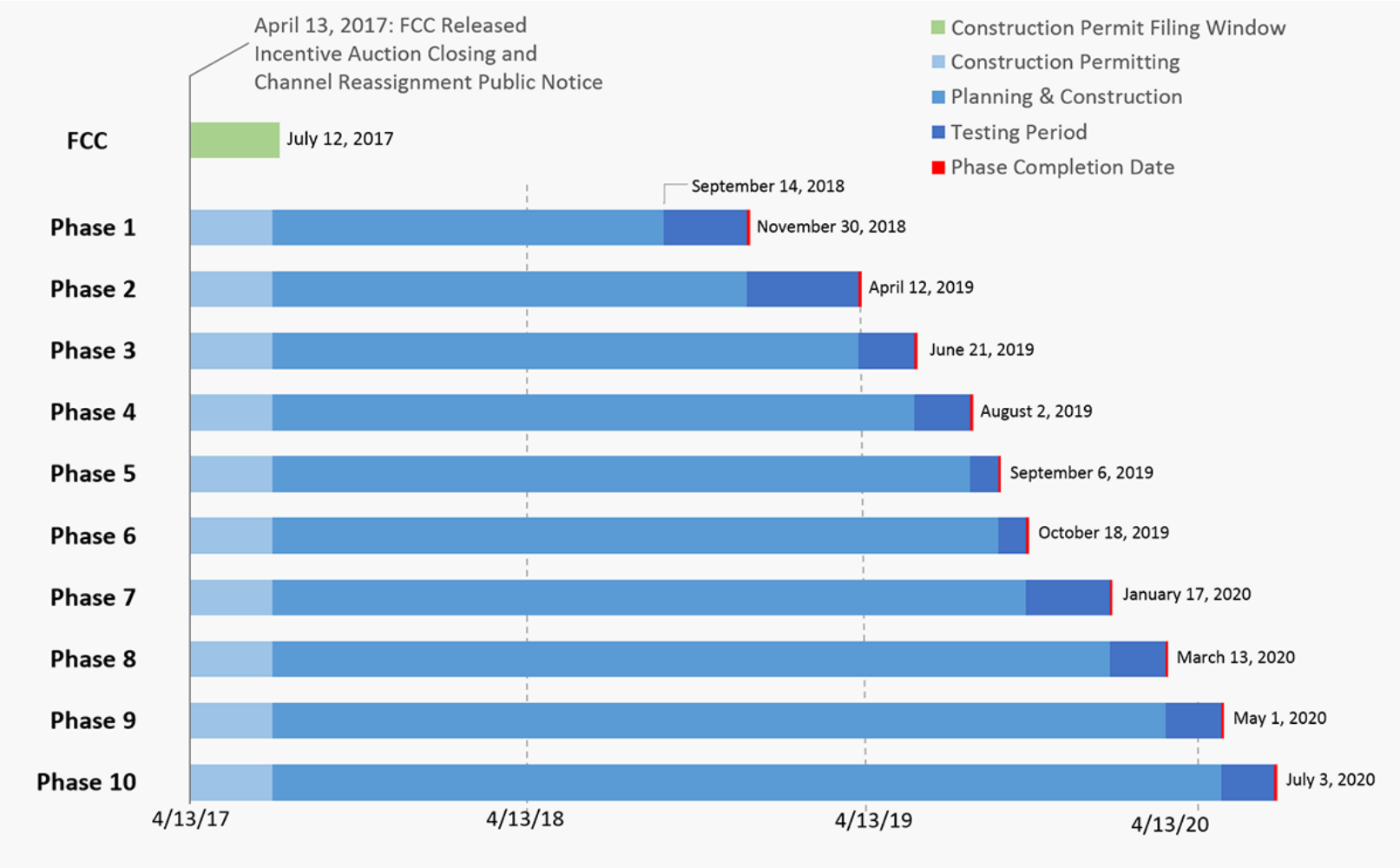
Multiple objectives in assigning stations to phases:

1. Move stations out of new wireless band as early as possible and all Canadian stations as late as possible
2. Minimize the number of rescans for each TV market (DMA)
3. Minimize the total number of dependencies within a phase
 - ▶ Objectives 2 and 3 combine to create a regional aspect to the transition
4. Attempt to balance the number of stations in each phase

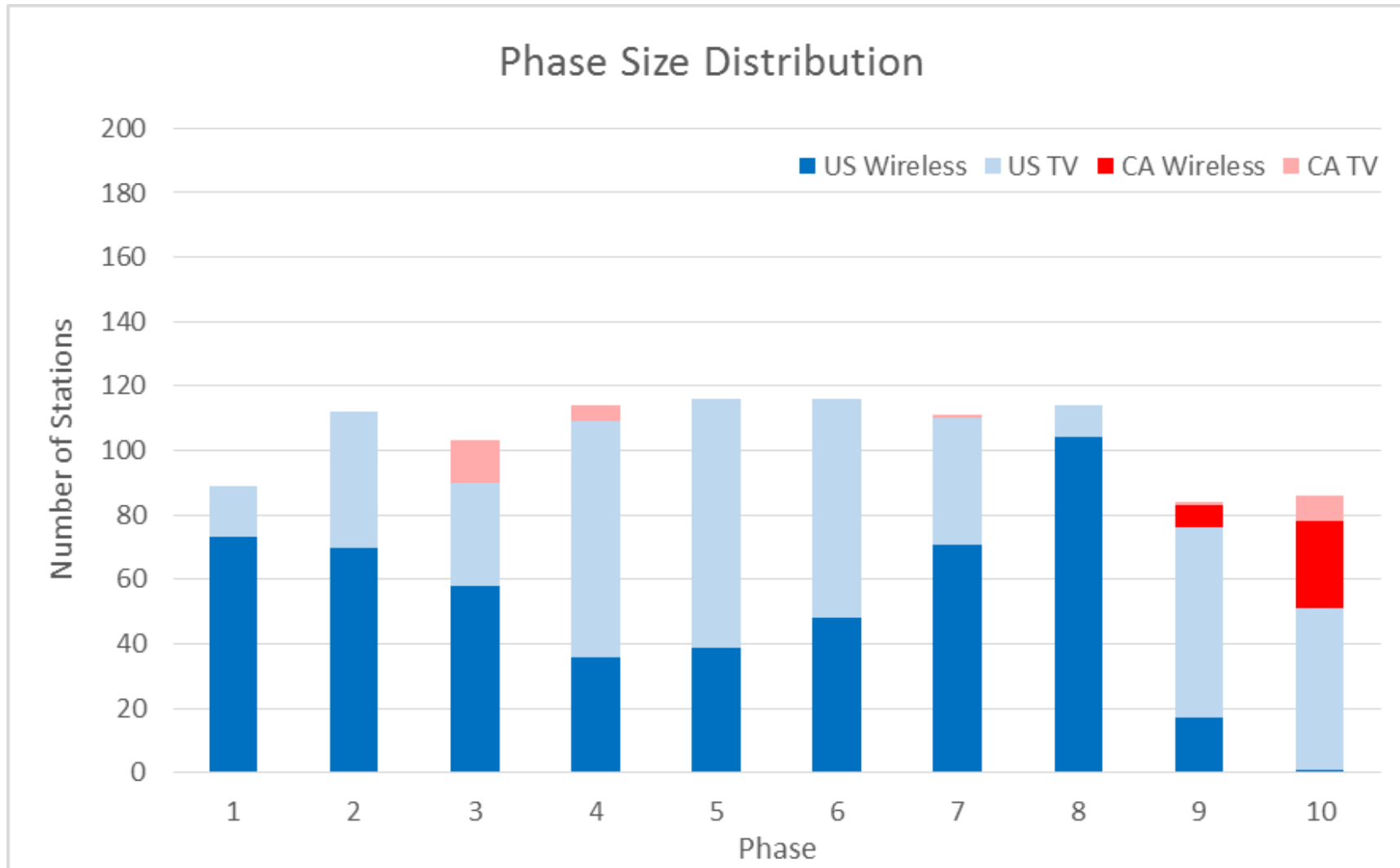
Constraints

1. No station can cause more than 2% interference to another station
2. No market can have more than 2 rescans
3. “Complicated” stations cannot be assigned to phase 1 and Canadian stations cannot be assigned to phases 1 and 2
4. No more than 125 dependencies in a phase (i.e. “linked stations”)
5. The difference between the number of stations in the largest and smallest phase can be no more than 30

Phase Transition Plan

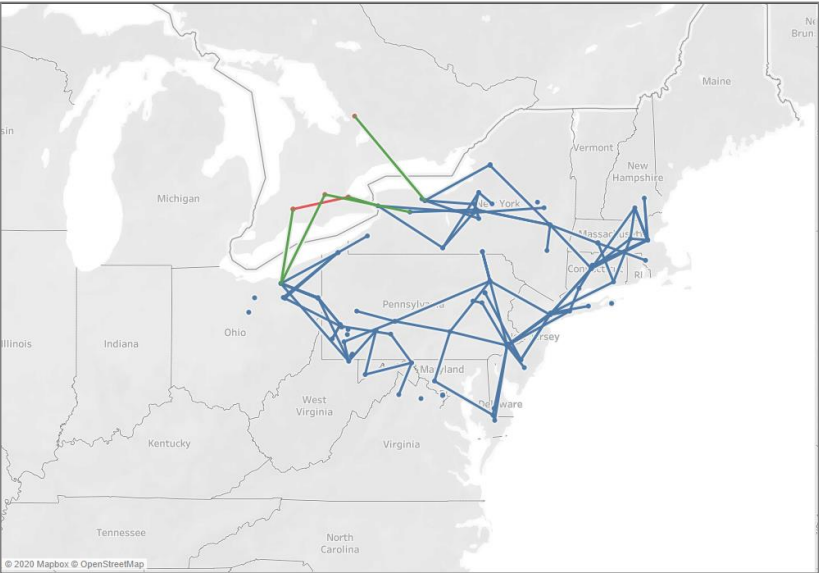


Phase Transition Plan

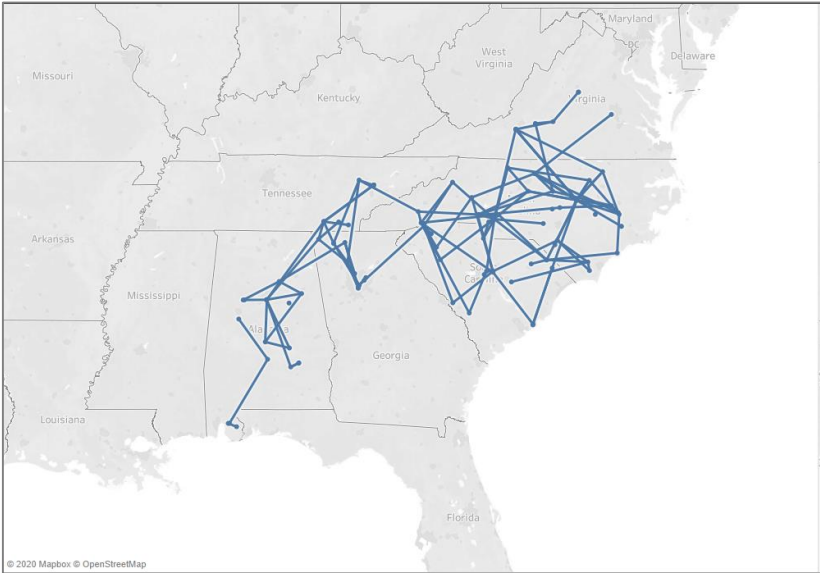


Phase Transition Plan

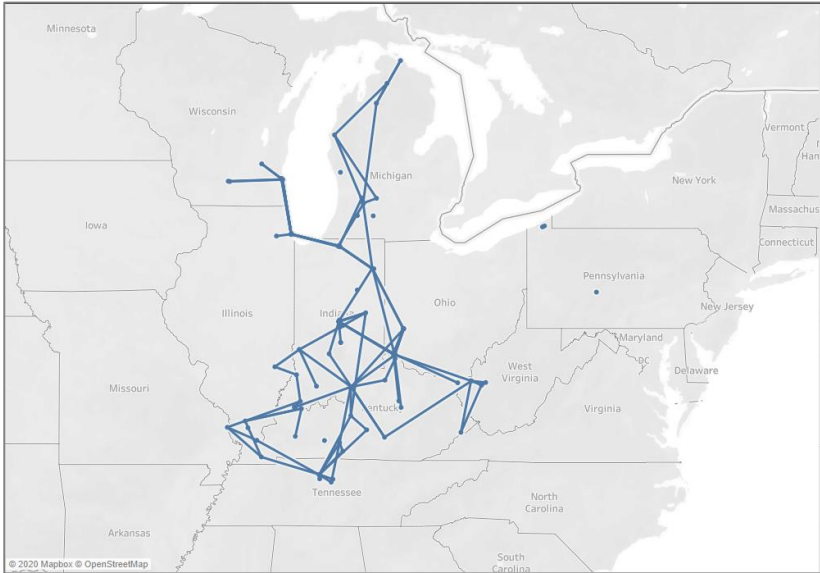
Phase 4



Phase 5



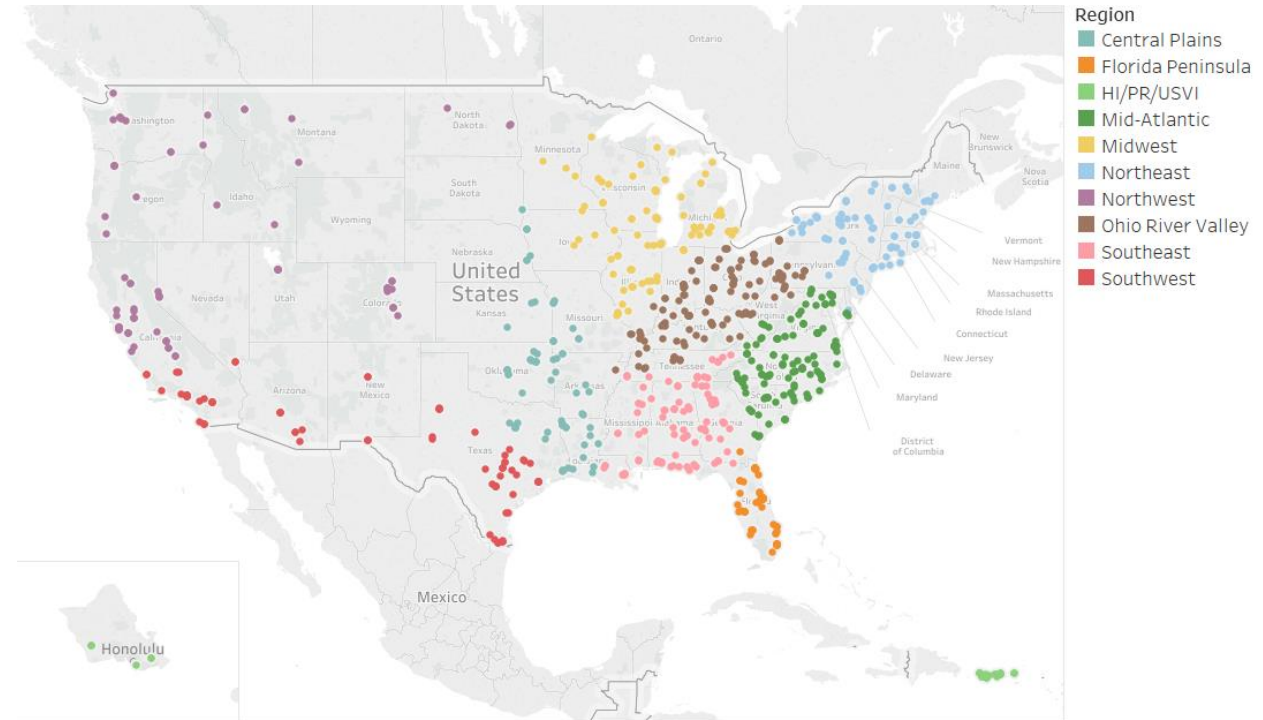
Phase 6



Supporting the Transition

Regional Coordinators

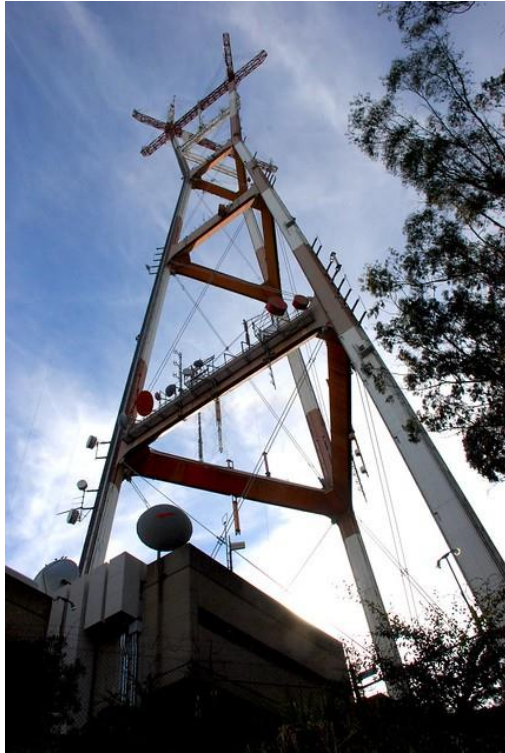
- ▶ The FCC decided to create Regional Coordinators to aid stations through the transition
- ▶ Optimization Team built model to determine regions balancing compactness, difficulty of region and number of stations



Phase Changes

The schedule was built to be able to handle changes

Some were predictable



Some were unpredictable



Phase Changes

Used the existing model to evaluate phase changes.

- ▶ Does it violate interference protections?
- ▶ Does it increase the rescans in a market?
- ▶ Does it create new coordination requirements?
- ▶ Does it delay wireless use?

Utilize Feasibility Checking to Identify Violations

We create a new schedule with all of the current requests and feed it into the model

- ▶ Allows us to evaluate easily how requests interact with each other
- ▶ Quickly can identify what requests create an issue and what type of problem is created (too many rescans, violates interference, etc.)

Current Status

The final phase, Phase 10, wraps up on July 3.



Over 90% of stations
have vacated their pre-
auction channel

Current Status

The FCC has granted over 250 phase changes

Schedule worked as designed, was able to accommodate individual station's needs

Some stations were able to move earlier to provide early access to wireless providers

Dealt with hurricanes hitting Puerto Rico and the Carolina's

Stations were able to use temporary channels or share channels with another station

Lessons Learned - Collaboration

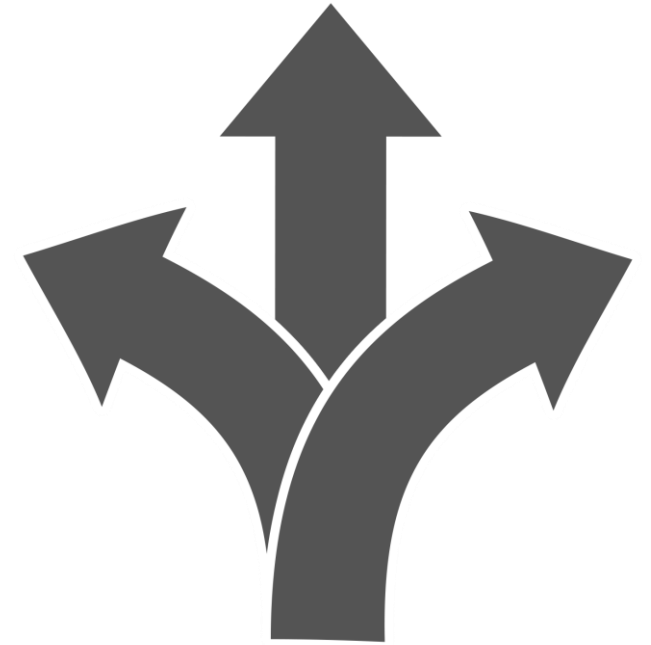
- ▶ Collaboration was key to success
- ▶ What we assumed to be top priorities were not as important to external stakeholders
- ▶ By meeting with everyone (internal and external), we built a schedule that balanced priorities

Lessons Learned - Communication

- ▶ Communication kept all involved and on track
- ▶ Communication in preparation of the plan established communication lines that could be used throughout the transition
- ▶ Stations filed a quarterly status report and additional status reports as their phase completion deadline approached

Lessons Learned - Flexibility

- ▶ We knew our information was incomplete and plans would be changing so we built in flexibility
- ▶ Breaking dependencies across phases allowed for stations to slide phases without disrupting entire schedule
- ▶ When we were hit with hurricanes, tower collapses, and now a pandemic, we were able to adjust



Beyond the Incentive Auction

- ▶ Team has been responsible for algorithm testing for all auctions
- ▶ Created a license reconfiguration optimization model to convert old wireless licenses into newer licensing framework to allow FCC to auction the newly freed spectrum (recently completed Auction 103)
- ▶ Assisting the FCC in revising Broadband Data Collection and Mapping

QUESTIONS?

Your Next Steps

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