Wireless Signal Propagation Concepts

NARUC 2017
Presented as part of:
Mobile Broadband, Wireless Propagation, and the 706 NOI

Presented by

Adam Nelson
Senior Consultant
Federal Engineering, Inc.

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Topics

- WIRELESS 101
- CAUSES AND IMPACTS OF PENETRATION LOSS
- COVERAGE MAPS – DEVELOPMENT AND INTERPRETATION
- COVERAGE MAPS IN USE TODAY – WHAT DO THEY MEAN?
- Q & A

Wireless 101

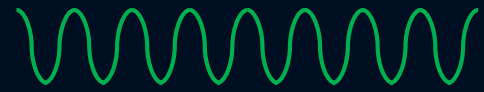
What is Wireless Signal Propagation?

Wireless communications systems are composed of one or more “Antenna Sites”, “Tower Sites”, or “Cell Sites”.

Antennas mounted on these structures pump out wireless communications signals to devices in the field via electromagnetic waves.

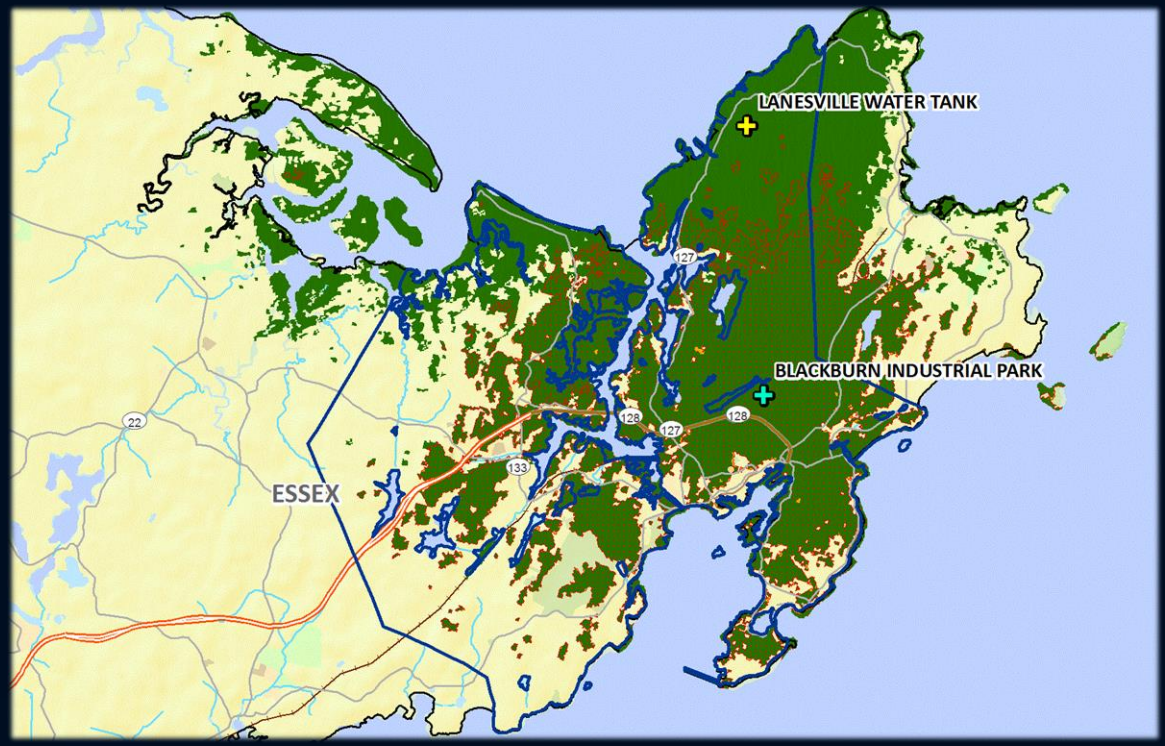
In addition to receiving these signals from the sites, user devices transmit similar types of signals back to the sites. This creates two-way communication.

Wireless signal propagation is the movement of these radio waves (which move at the speed of light) to and from these sites and devices.



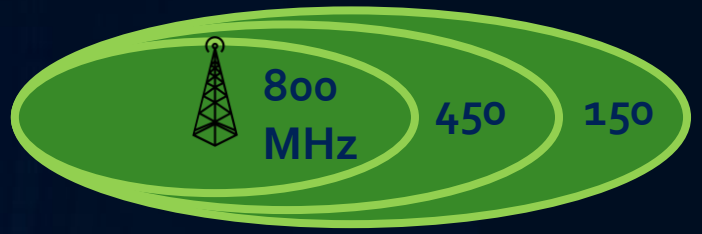
What is Coverage?

Areas where two-way communication can occur **at a defined level** are said to be "covered." Areas where either inbound or outbound directions fail, **or exist below a defined level**, are considered "uncovered."



Green areas are considered "covered"

What impacts Coverage?

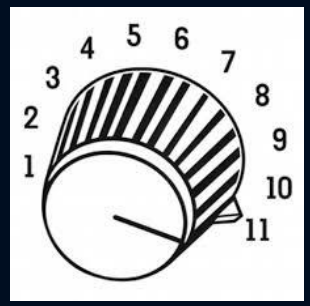


FREQUENCY

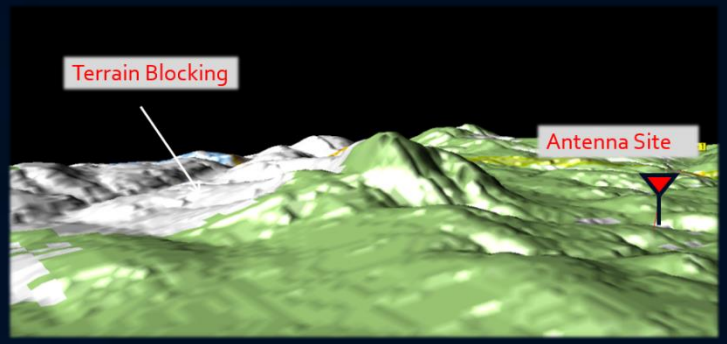
Typically, the lower the frequency, the farther the usable signals will go.

POWER

A doubling of power (in Watts) equates to a 3 dB boost in signal strength.



OBSTACLES



Topography

Buildings

Trees

Other Considerations

- Diffraction
  - How signals behave moving around obstacles
- Multipath
  - How reflected signals can either help or hinder reception
- ATTENUATION, aka “Penetration Loss”
  - Predicted weakening of the signals through obstacles

Causes and Impacts of Penetration Loss

Terrain

Signals are significantly diminished (or completely blocked) by terrain in canyons, river valleys, and mountainous regions.

Above-Ground Obstructions (aka Clutter)

Trees have a significant impact on wireless signals, due in large part to the water content in the leaves.

Whether the leaves are on or off can make a substantial impact.

All above ground vegetation, environments, and structures interact with radio waves.

Table 17 - Local Clutter Attenuation in dB as a Function of Frequency and Land Use Classification

	Frequency (MHz)					
Classification	**30-50**	**136-174**	**220-222**	**380-512**	**746-941**	**Reclassified Number**
Open land	1	3	3	3	5	1
Agricultural	2	3	3	4	18[1]	2
Rangeland	1	9[1]	9	10[1]	10	3
Water	0	0	0	0	0	4
Forest land	3	8[1]	9	12	25[1]	5
Wetland	1	3	3	3	3	6
Residential	3	14[1]	15	16[1]	20[1]	7
Mixed urban/ buildings	4	15[1]	16	17[1]	20[1]	8
Commercial/ industrial	4	14[1]	14	15[1]	20[1]	9
Snow & ice	0	0	0	0	0	10

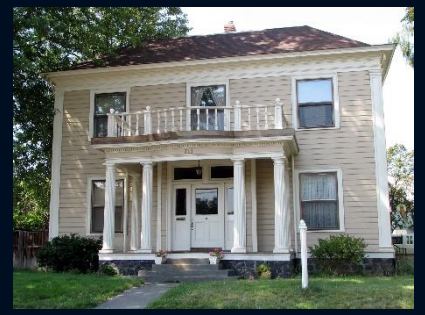
1. Taken from [Rubinstein 98]. Non-superscripted values are derived from industry sources.
2. The density of foliage in a particular urban environment can heavily influence values for urban settings. Heavily forested urban environments can exhibit clutter losses in excess of those published here.

Source: TIA TSB-88.2-D

Buildings

TYPICAL HOUSE

Signals enter through:
Windows (minor loss);
Drywall (moderate loss)



MODERN OFFICE BUILDING

Signals enter through:
Steel (heavy loss);
Low-emission windows
(moderate loss)

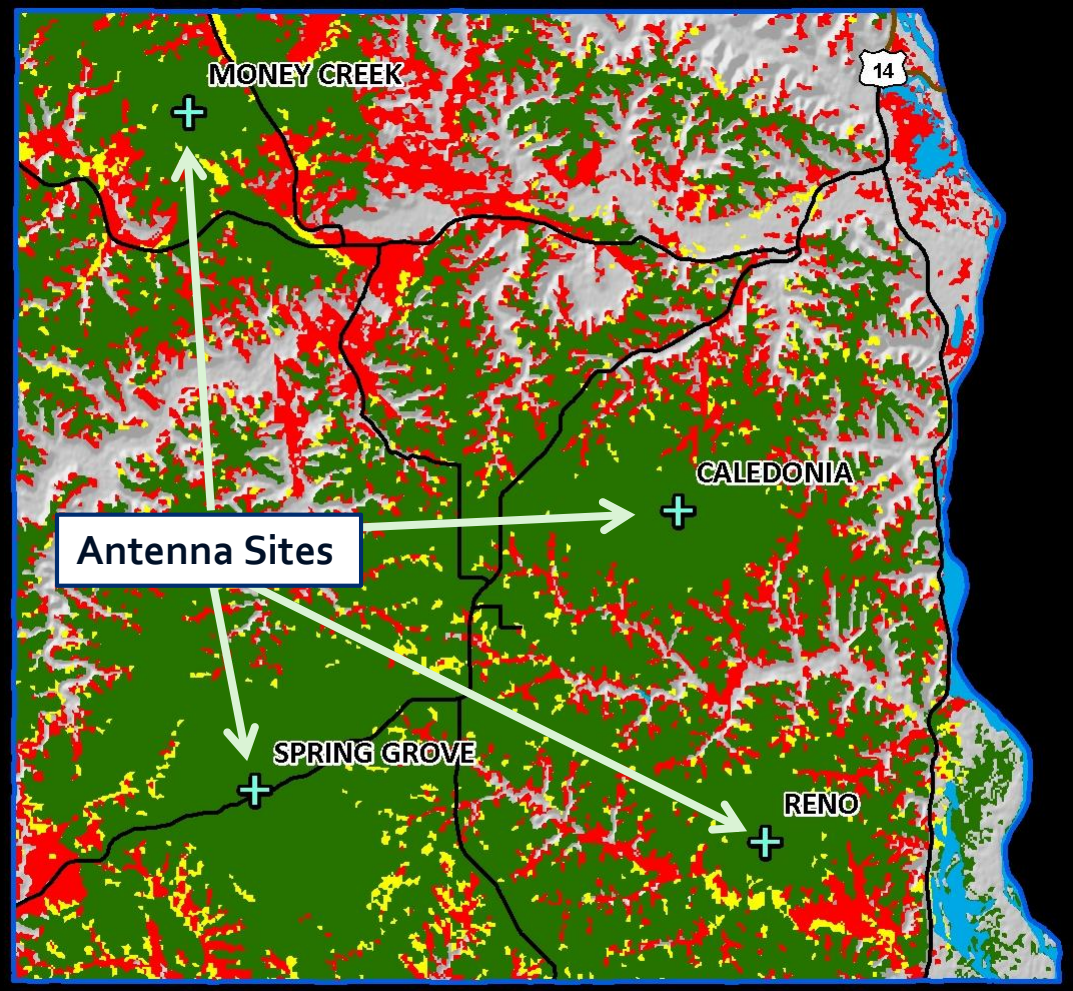
HEAVY-DUTY FACILITY

Signals enter through:
Thick building
materials (heavy loss);
Multiple internal walls
(heavy loss)

Coverage Maps – Development and Interpretation

Wireless Propagation Software

- Software ranges from free online software to coverage-on-demand services to expensive stand-alone applications
- Many have terrain and clutter databases, and many accept specific building layers
- Input: All technical parameters (site locations, antenna heights, transmit power levels, application type, etc.)
- Output: Coverage maps that show areas where a defined threshold (or thresholds) has been met



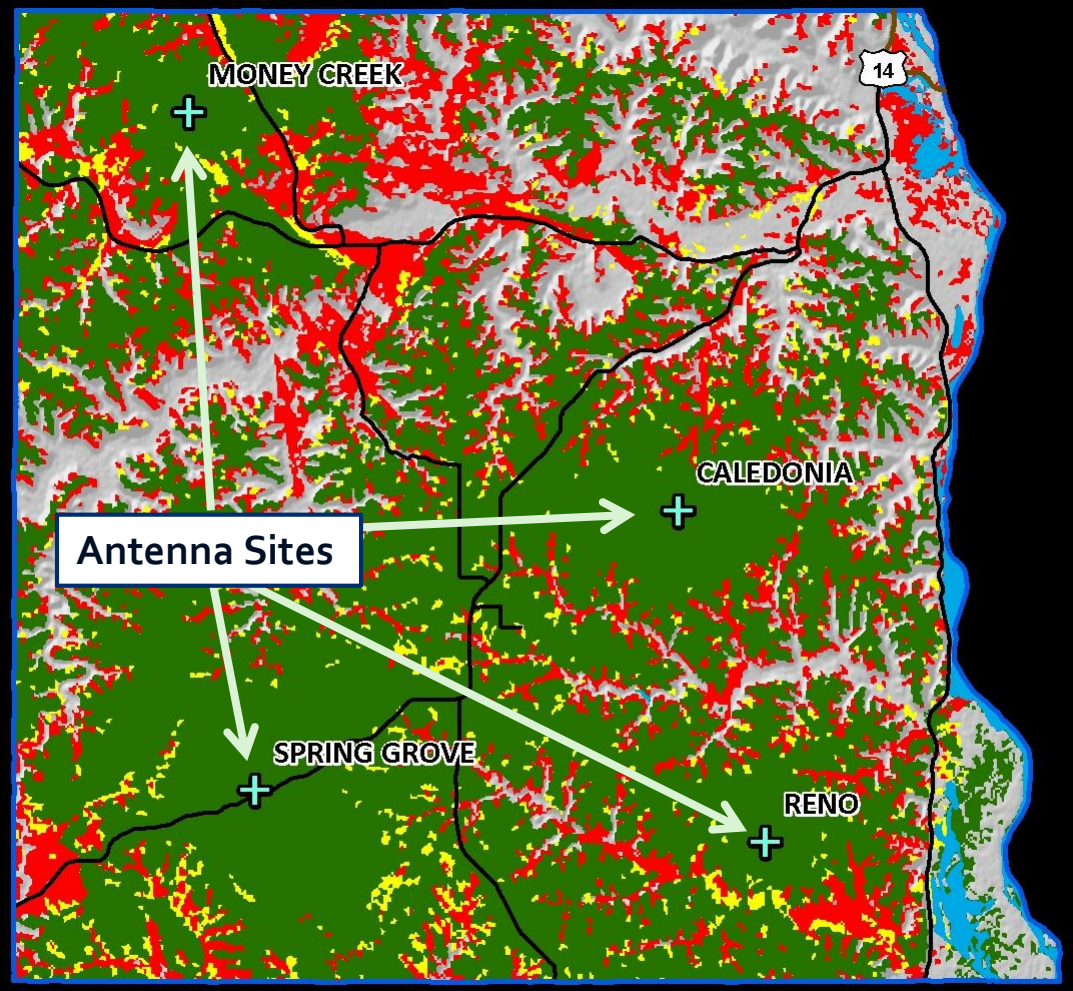
Good Coverage

Fair Coverage

Poor Coverage

No Coverage

TOO VAGUE!



Office Building Coverage

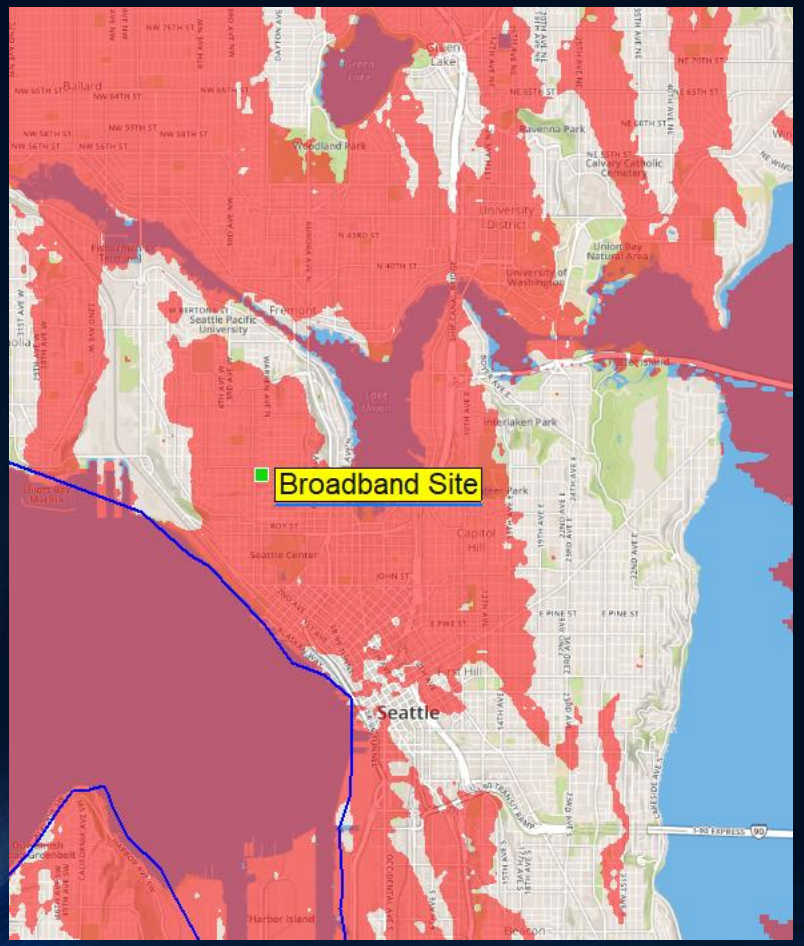
Residential Building Coverage

"On-Street" Coverage

No Coverage

BETTER!

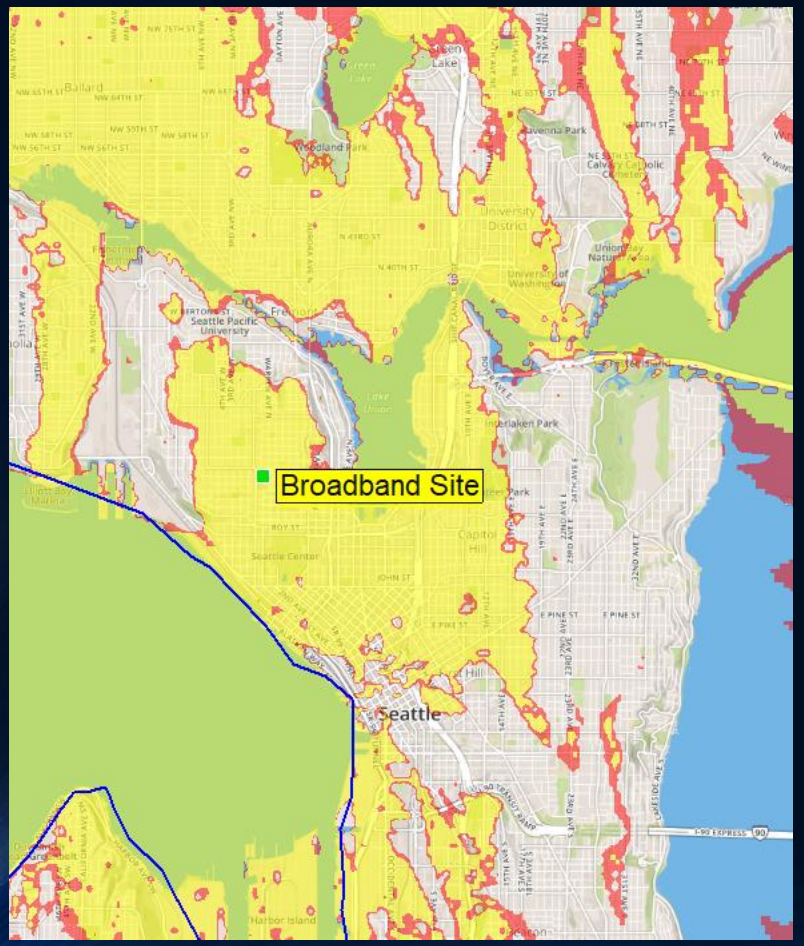
Mobile Broadband Coverage Map, by Application



Voice Over LTE Coverage

No Coverage

Mobile Broadband Coverage Map, by Application

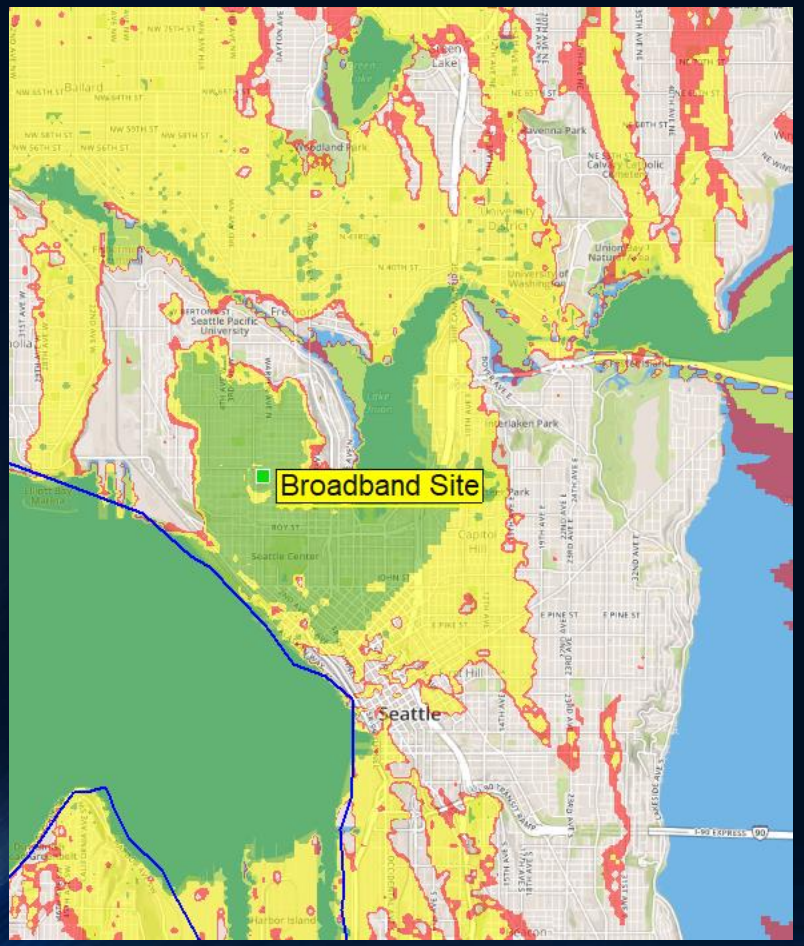


Lo-Res Streaming Video Coverage

Voice Over LTE Coverage

No Coverage

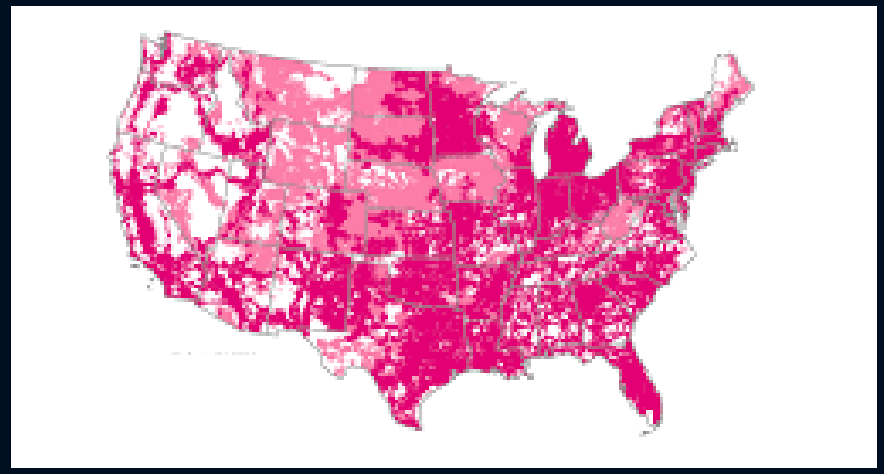
Mobile Broadband Coverage Map, by Application

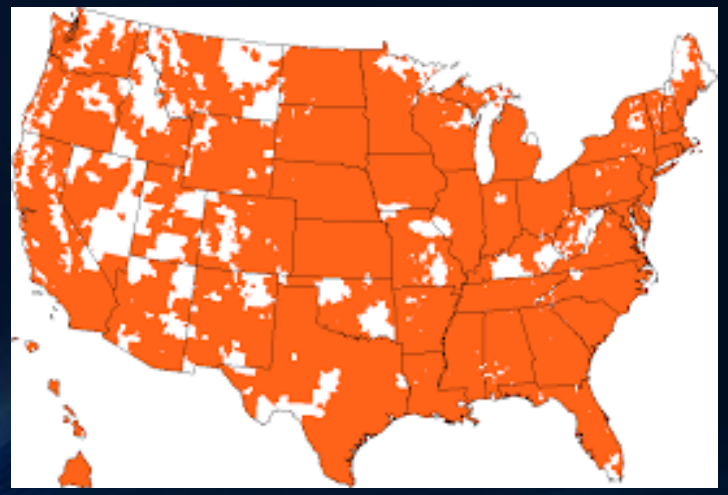


- Hi-Res Video Chat Coverage
- Lo-Res Streaming Video Coverage
- Voice Over LTE Coverage
- No Coverage

Coverage Maps in use today – How can we interpret them?

Commercial Networks – Marketing Maps





Commercial Networks – Marketing Maps

- Frequently do not provide specifics about what the coverage footprint is actually showing:
  - What application?
  - In-building, or on-street?
  - What is the reliability of the signal in the covered areas?
  - Is this during peak or off-peak times?
    - Congestion can decrease the effective coverage

Form 477 Data

- FCC requires all broadband providers (those who advertise at least 200 kbps in at least one direction
- Wireless providers give the FCC polygons (usually in electronic shapefiles) showing their coverage of:
  - All broadband technologies (LTE, HSPA+, etc.)
  - Voice
  - Broken down by frequency bands
- Providers certify their submissions are accurate

Form 477 Data – Potential Issues

- Coverage footprints may not be specific enough to know what level of service/coverage is actually being provided
- We don't know how many houses, businesses, public facilities are located within these polygons, so it's difficult to gauge broadband penetration
- Don't know tower/antenna sites either, making it difficult to independently model the coverage

Form 477 Data – Current Activities

- The FCC is seeking ways to modify the collection of the 477 data
- Several agencies/organizations want more structured and comprehensive collection techniques
- Industry associations want less burdensome collection techniques, as well as publication methods that respect their IP and competitive needs

Questions...?

Contact Information

Adam Nelson, Senior Consultant

- Office: 703-359-8200
- Cell: 540-809-6096
- Email: anelson@fedeng.com