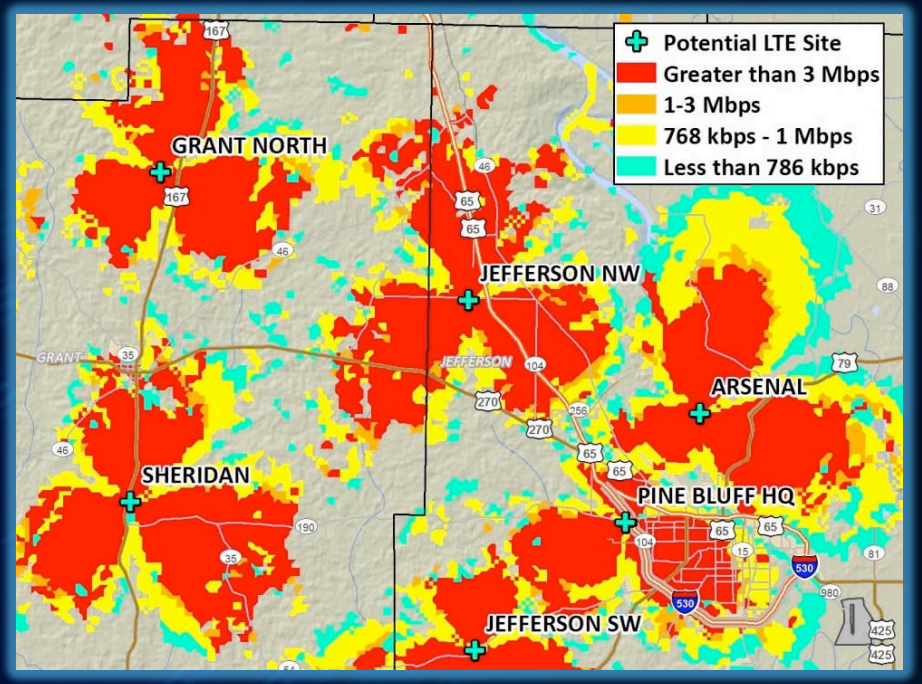
LTE vs. LMR: An Analysis of Coverage

Virginia NENA/APCO Spring Conference
May 10, 2018
Session 2 (1PM – 2PM)



Presented by:

Neil Horden
Chief Consultant
Federal Engineering, Inc.

Agenda

- PROPAGATION TOOLS
- LMR COVERAGE PROCESS
- LTE COVERAGE PROCESS
- Q & A

Introductions; Who are we?

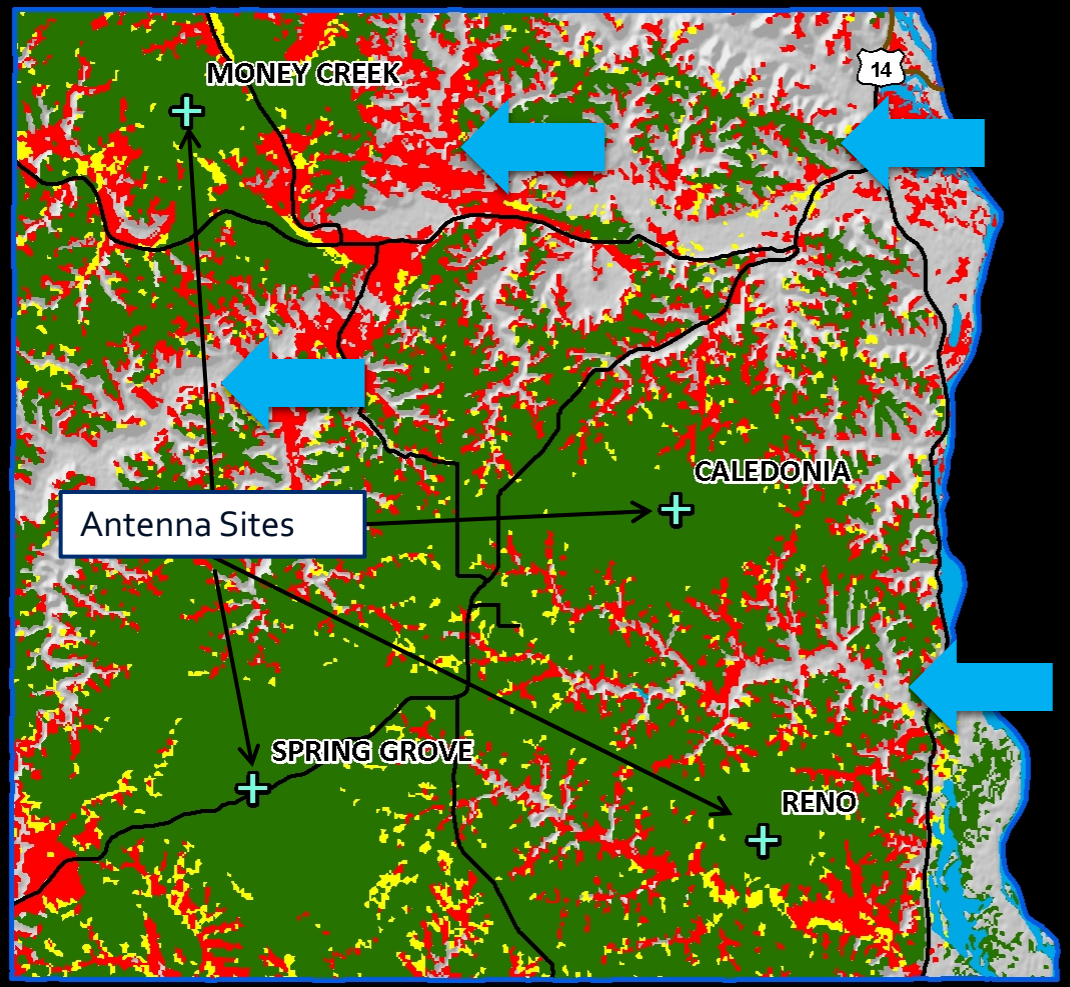
- Neil Horden, Chief Consultant
- Adam Nelson, Senior Consultant;
  - Propagation and GIS Subject Matter Expert
- Federal Engineering, Inc.
  - Nationwide independent consulting firm
  - Focused on Public Safety communications

Participant Expectations: Who are you?

- What is your roll?
- What are your expectations from this session?
- What would you like to take away?
- How can we help you do your job?

Propagation Tools

Determine Bad Areas



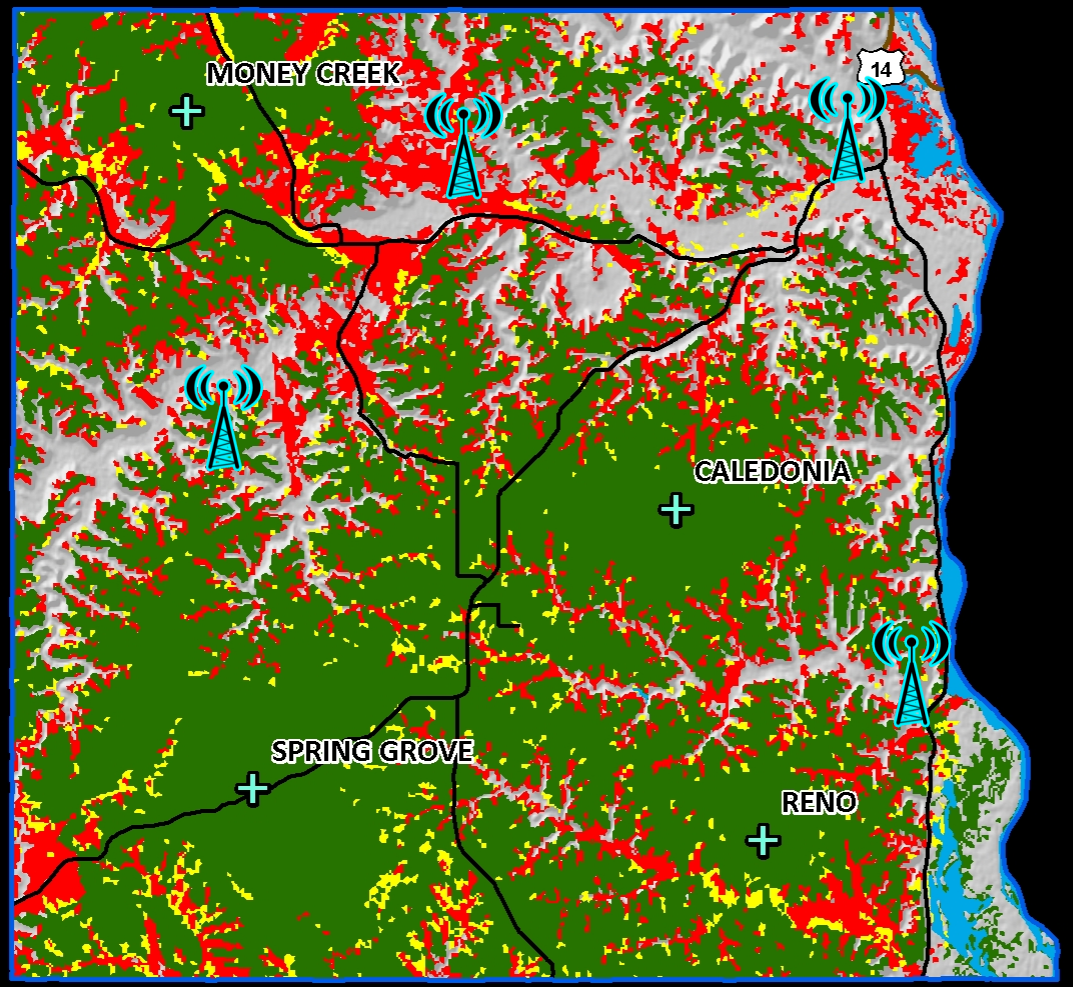
Good Coverage

Fair Coverage

Poor Coverage

No Coverage

Add Hypothetical Antenna Sites



Good Coverage

Fair Coverage

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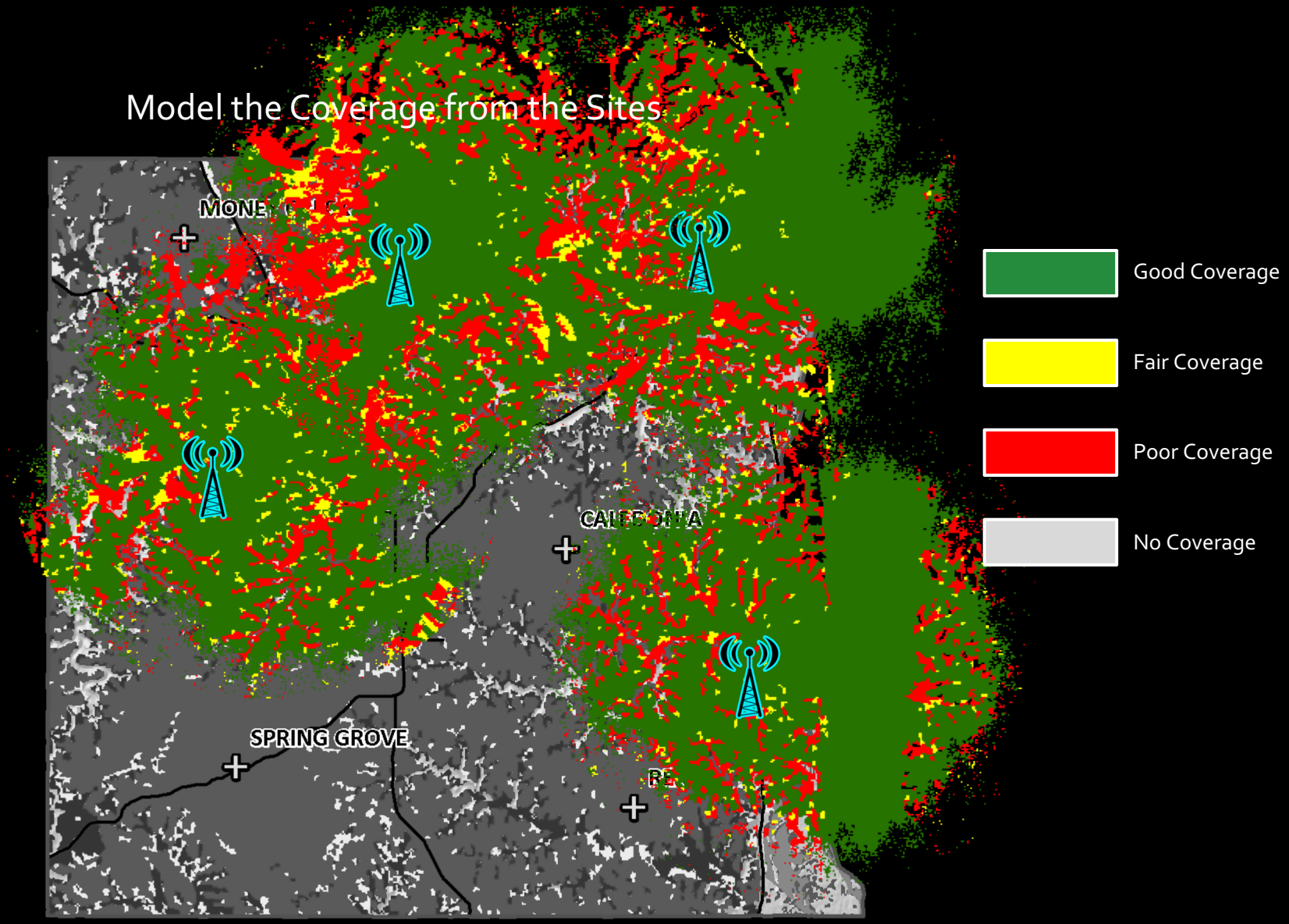
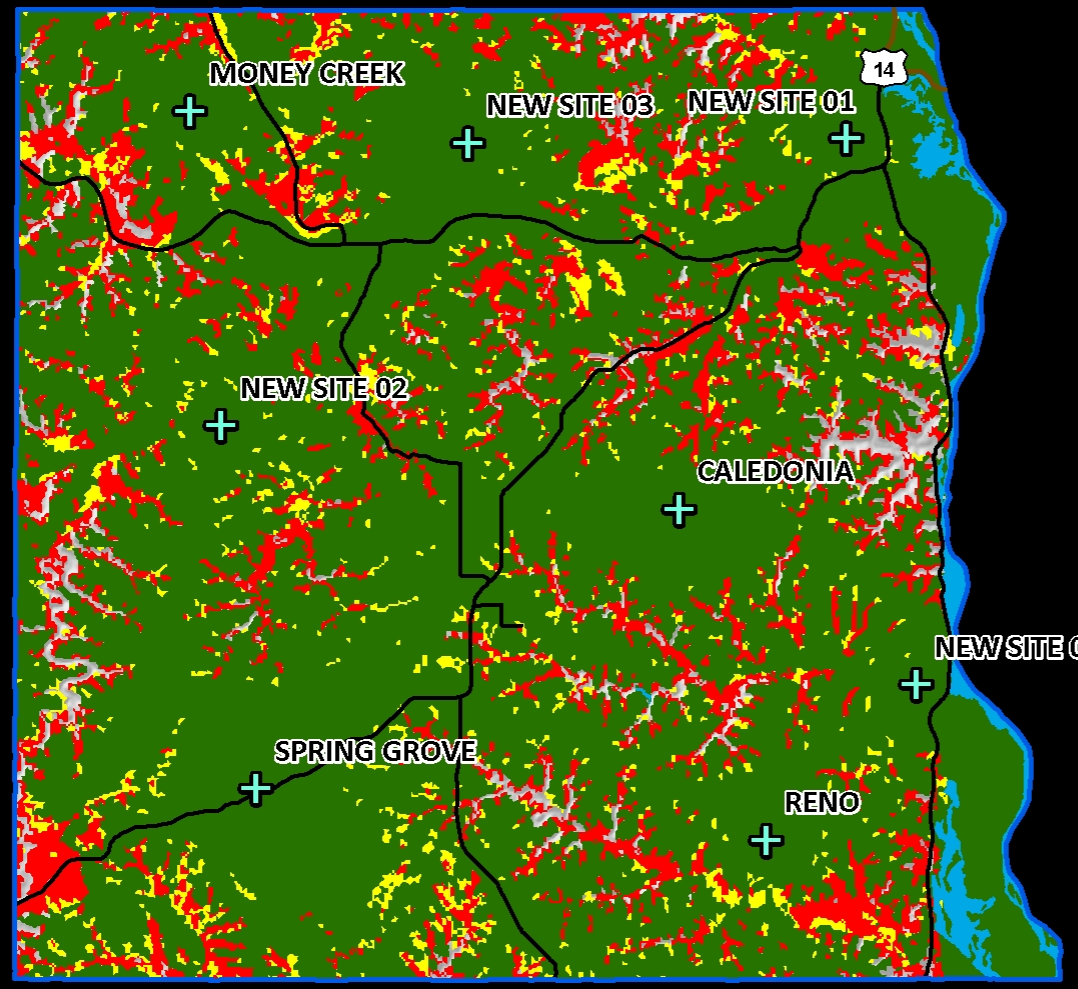
No Coverage

Model the Coverage from the Sites



Assess the Potential Coverage



Good Coverage

Fair Coverage

Poor Coverage

No Coverage

LMR Coverage

Initial Processes

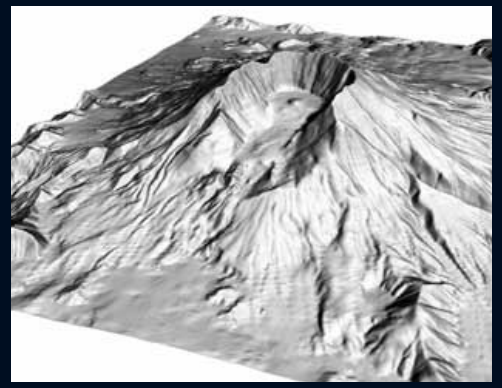
- Develop basic system, site, and subscriber parameters
  - Frequency band and technology
  - Site locations (geographic coordinates)
  - Antenna characteristics (model, gain, mounting height)
  - Power limitations
  - Usage (trunk-mount mobile antenna, hip-mount portable antenna, etc.)
- Input the parameters into the tool
- Verify the locations (important when dealing with database discrepancies)
- Run the prediction studies

Subset of Parameters

- Geographic coordinates
- Elevation
- Frequencies
- Antenna models
- Antenna heights
- Antenna gains
- Antenna beamwidths
- Transmit power out
- Transmission lines
- Transmit combiners
- Receive multicouplers
- Tower-top amplifiers
- Jumpers/connectors
- Effective radiated power (ERP)
- Receive sensitivity
- Subscriber type (mobile, portable, MDT, handset)

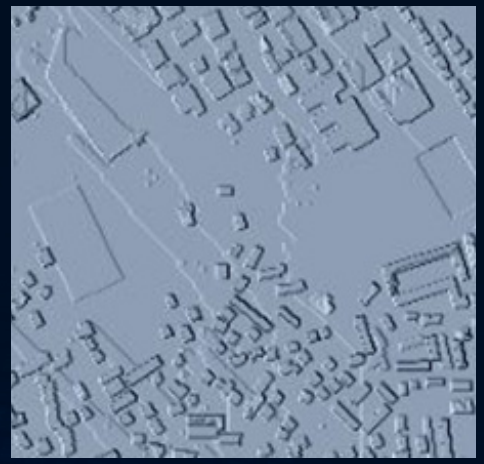
Datasets

- Terrain
  - 10-30 meter resolution is common – available through USGS
- Clutter
  - 30-meter land use / land cover
  - Developed and maintained by USGS, updated every 5-10 years
- Buildings
  - Cities/counties sometimes provide
  - USGS has LIDAR data available for much of the US
  - High-resolution
  - Increases computation time



Bare earth

Canopy



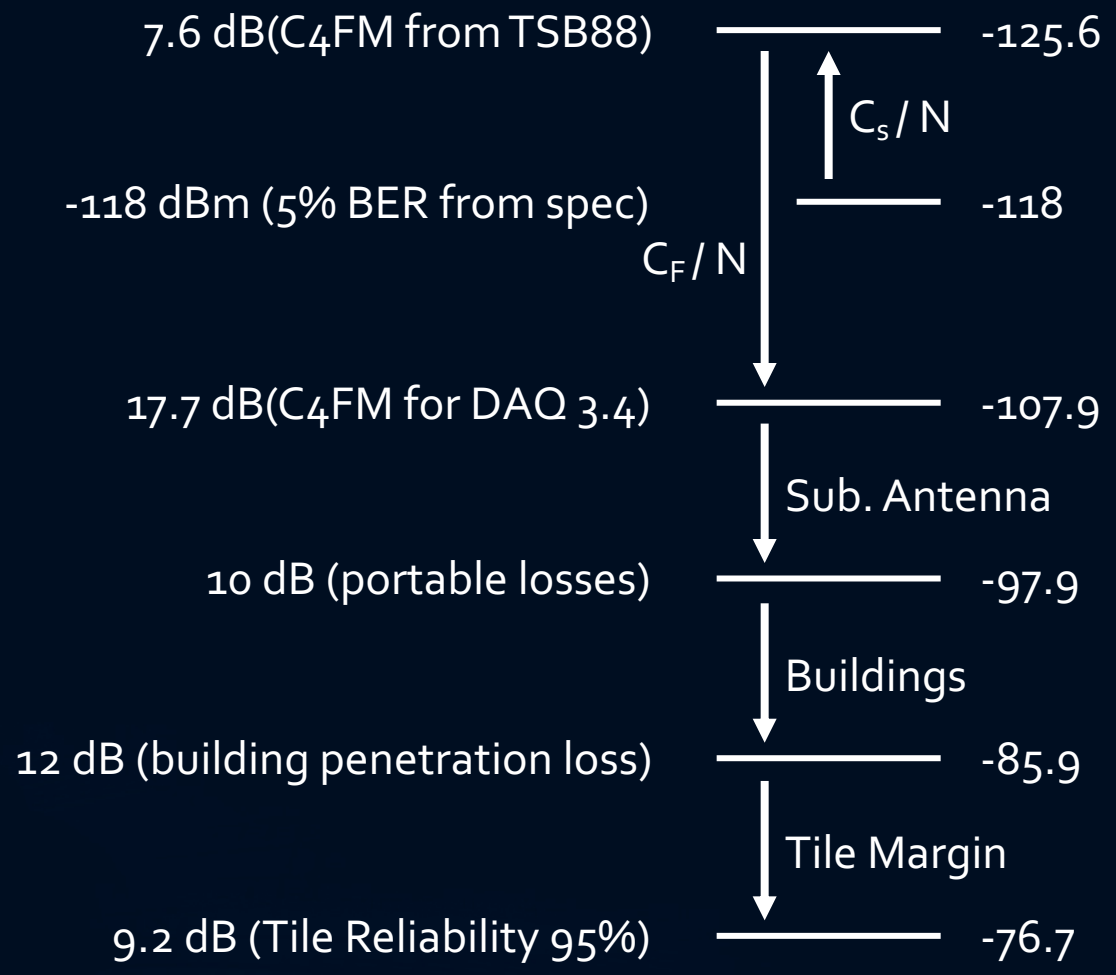
Buildings

Determine the Design Target

- Where is the coverage required?
  - In-building, on-street
  - Geographic area, roadways, population, service/CAD calls, etc.
- Recommendations for public safety and public service systems found in TIA's TSB-88 suite of documents
  - Channel Performance Criteria (CPC)
- How will the coverage be evaluated?
  - Quality levels (DAQ)
  - Bit Error Rate (digital systems)
  - Reliability (several methods in TSB-88)

Channel Performance Criteria (CPC)

- Start with the reference sensitivity of the receiver
- Subtract the C_s / N (Static Carrier to Noise) to get the Inferred Noise Floor
- Add the C_f / N (Faded Carrier to Noise) to get the Faded Performance Threshold (FPT)
- Add other factors to obtain Design Target
  - Antenna Characteristics
  - Building Loss (if applicable)
  - Tile Reliability Margin
- Result = Design Target of -76.7 dBm

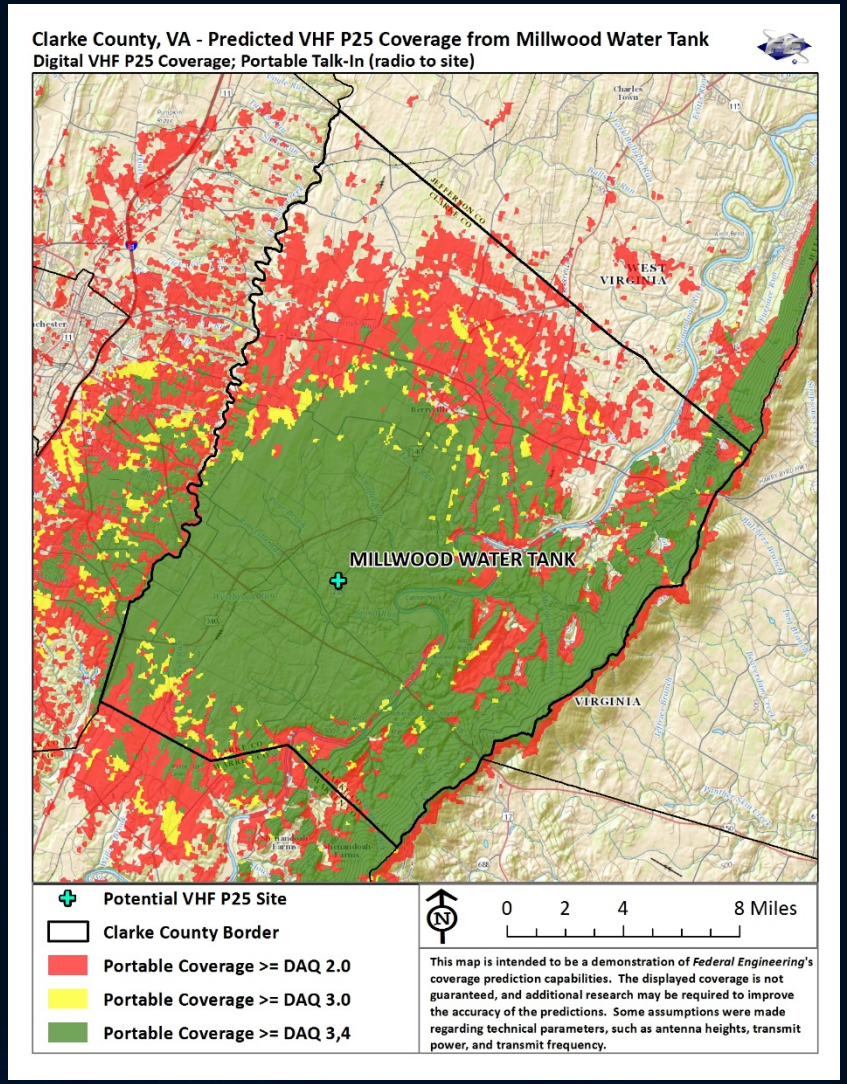


Other Factors that May Affect Your Design

- Interference
  - Co-channel / adjacent channel
  - Inter-system / intra-system (**simulcast – time-delay interference**)
- Spectrum
  - Can channels be licensed, and can they be licensed at the heights/power levels you modeled?
- Other system technology alternatives
- Interoperability
- Operational concerns
- **These considerations make the design effort an iterative process**

Outputs / Deliverables

- Static
  - Image files
  - Hard copies
- Dynamic
  - GIS layers
  - KML layers
  - Interactive PDF



LTE Coverage

Broadband Data Considerations

- Application types
- Desired/required bit rates
- UE Types
- Amount of UEs
- How will traffic be modeled?
  - Noise Rise Method (quicker)
  - Monte Carlo analysis in propagation tool (more accurate)

Initial Processes

- Define system/project parameters
  - Propagation model
  - Frequency band / duplexing
- Channel Model
  - Urban, Vehicle, Pedestrian
- Develop RAN site (eNodeBs) and UE parameters
  - Equipment specifications
  - 3GPP standards
  - Power Classes
  - MIMO

Determine the Design Target

- Define user requirements
  - Who will use the system?
  - What will they do?
- Where is the coverage required?
  - In-building, on-street
  - Geographic area, roadways, population, service/CAD calls, etc.
- Data Rate Requirement
  - Often expressed as a throughput level, or data rate (e.g. 768 kbps downlink, 256 kbps uplink)
  - TSB-88 – Data Rate CPC

Determine the Design Target, continued

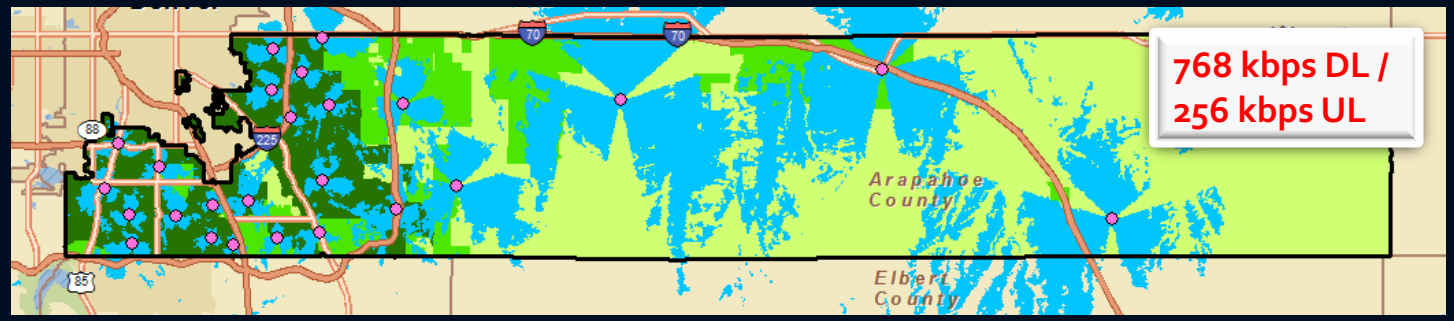
- Determine the SINR to obtain your required throughput
  - LTE is self-interfering (everyone using the same spectrum)
  - The interference (originated from other UEs and other cells' activity) causes SINR to decrease, and therefore data rates to drop.
  - **Manufacturers have SINR to Throughput tables for their equipment (often in bits / Resource Block)**
- Use link budgets to balance paths
  - Develop the Maximum Allowable Path Loss (MAPL) for both directions
  - Modify eNodeB power to balance paths (if feasible)

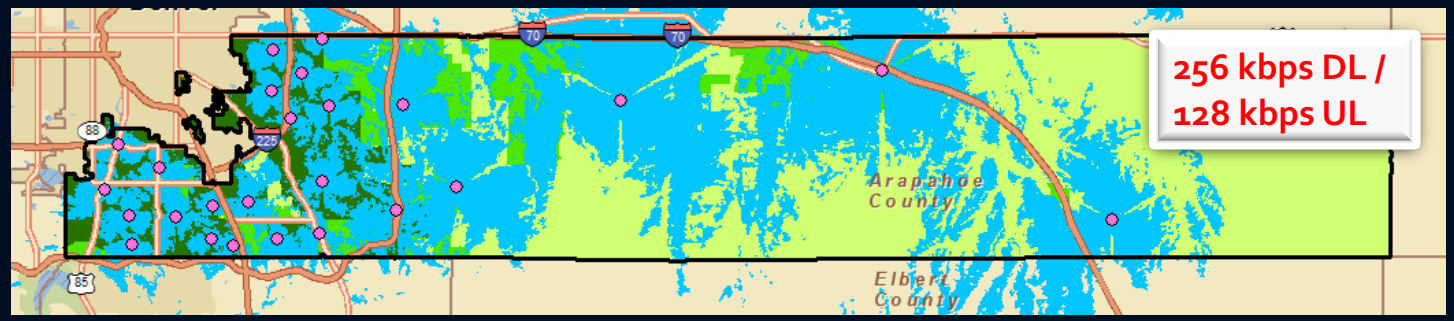
Key Performance Indicators (KPIs) to Evaluate

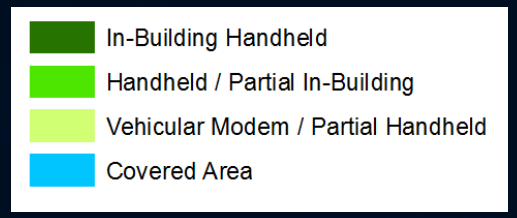
- RSRP - Reference Signal Received Power (DL)
- RSRQ - Reference Signal Received Quality (DL)
- **SINR – Signal to Interference plus Noise Ratio (DL / UL)**
- Throughput (DL / UL); a.k.a. Data Rate
- Latency
- CQI (Call Quality Index)
- BLER (Block Error Rate)

Outputs

- System performance reports
- Optimized site locations
- Neighbor list
- Static Maps
  - Image files
  - Hard copies
- Dynamic Maps
  - GIS layers
  - KML layers
  - Interactive PDF

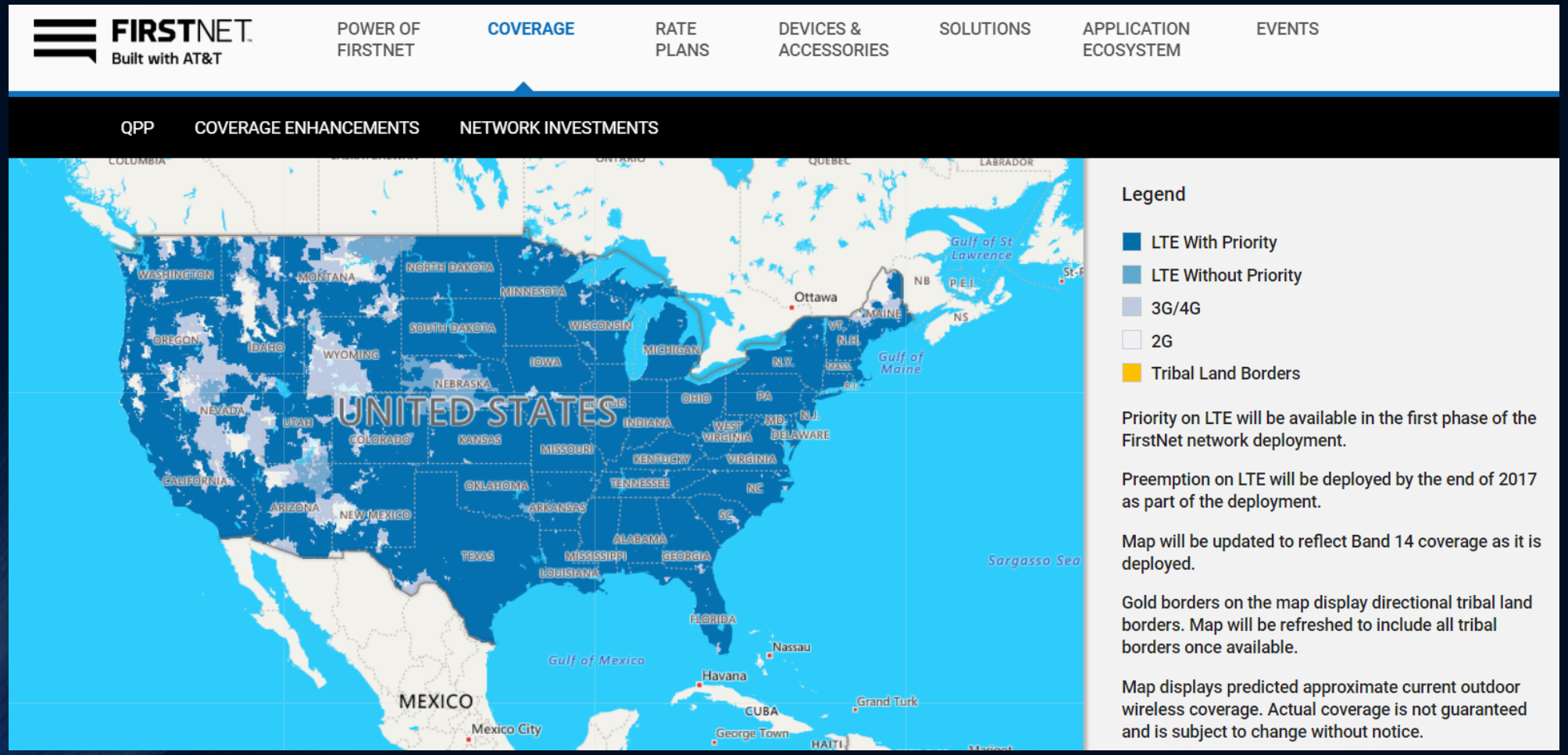






Metric Name	Cell Loading	DL/UL Throughput (kbps)	UE Type	Coverage Percentages over Objective Regions		
				In-Building	On-Street	Vehicular
Heavy Throughput	50%	768/256	Roof-mount	34	40	31
Light Throughput	50%	256/128	Roof-mount	64	64	39

FirstNet



Source: firstnet.com

Conclusion

- LMR and LTE coverage are developed, predicted, and analyzed very differently.
  - Inputs
  - Datasets
  - Operational areas
  - Application Types
  - Evaluation Criteria
    - Voice quality – LMR
    - Data rate – LTE

Discussions

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Thank You!

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