ADMS over P-LTE

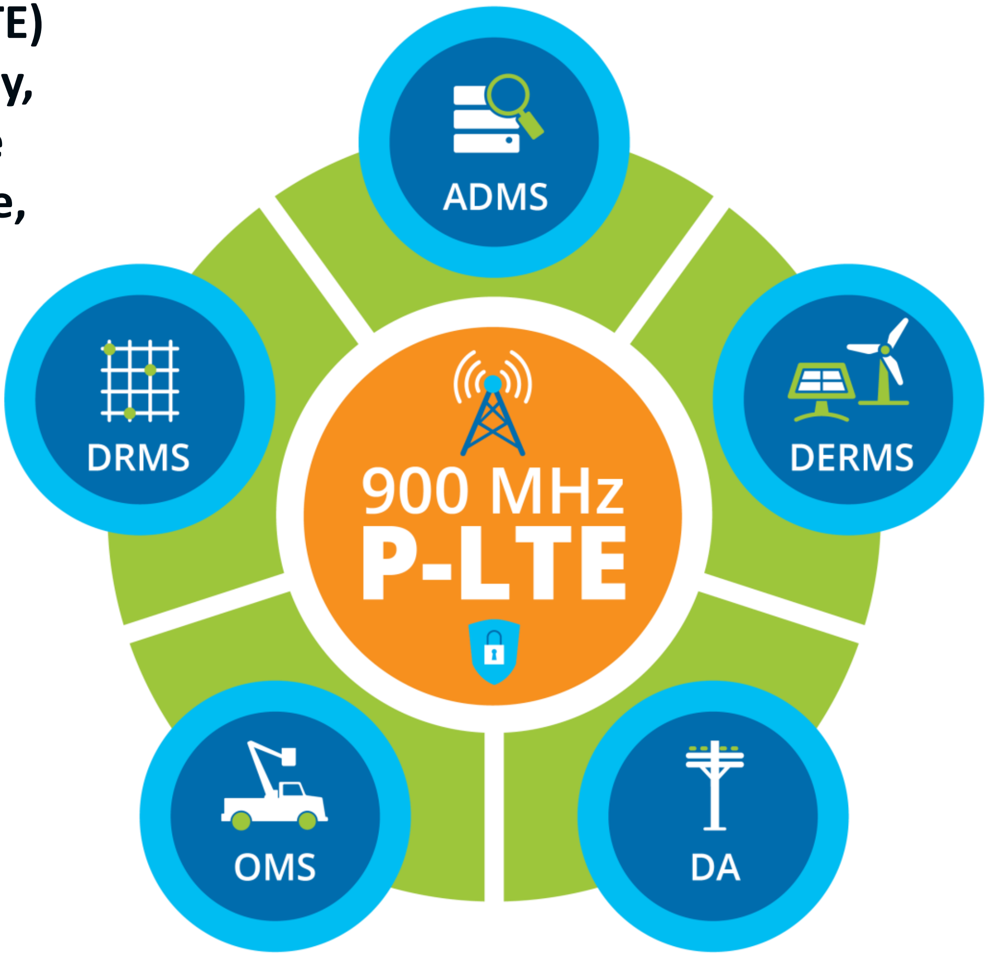
Phase 1 Update

October 28, 2019

Project Overview

NATIONAL RENEWABLE ENERGY LABORATORY

Technologies



Develop a realistic private LTE (P-LTE) wireless communications capability, integrated with an ADMS, for the evaluation of secure, cost effective, and resilient grid operations

- Integrate P-LTE into NREL's ADMS/DERMS systems
- Characterize performance of various DERMS/ADMS applications over P-LTE

Project Guidance from DOE

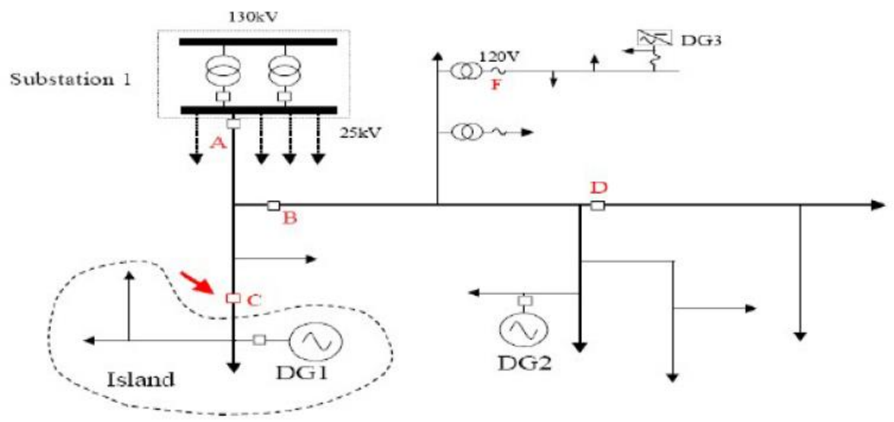
Ensure ESIF capabilities are relevant to support any communications system (i.e. national scalable): *latency communications measurements are relevant to all forms of comms.* (*wire or wireless*) – *plug-n-play-type comms. inclusion.*

Carefully consider communications role in utility resiliency: *resilience considerations are two-fold – the enabled power system resilience by implementing greater utility control* (*ADMS, etc.*) *and the resilience of the comms itself* (*poor signal strength, congestion scenarios, etc.*)

NREL/DoE High-Impact Initiative:
Enabling Realistic Communications Evaluations for ADMS (ERCEA)
Project Timeline

Milestone Name/Description	End Date	Type
Installation of Anterix's private LTE wireless 900 MHz system in ESIF	6/1/19 (Completed)	Quarterly Milestone
Completion of laboratory evaluations including DTT scenario under congestion (Phase 1)	9/12/19 (Completed)	Quarterly Milestone
Completion of ADMS integrated laboratory evaluations (Phase 2)	12/1/19 (Tentative)	Quarterly Milestone
Development of final project report highlighting laboratory results	2/22/20 (Tentative)	Quarterly Milestone

Sample Distribution Feeder Grid with DERs



(Source) national grid

High Impact Milestone

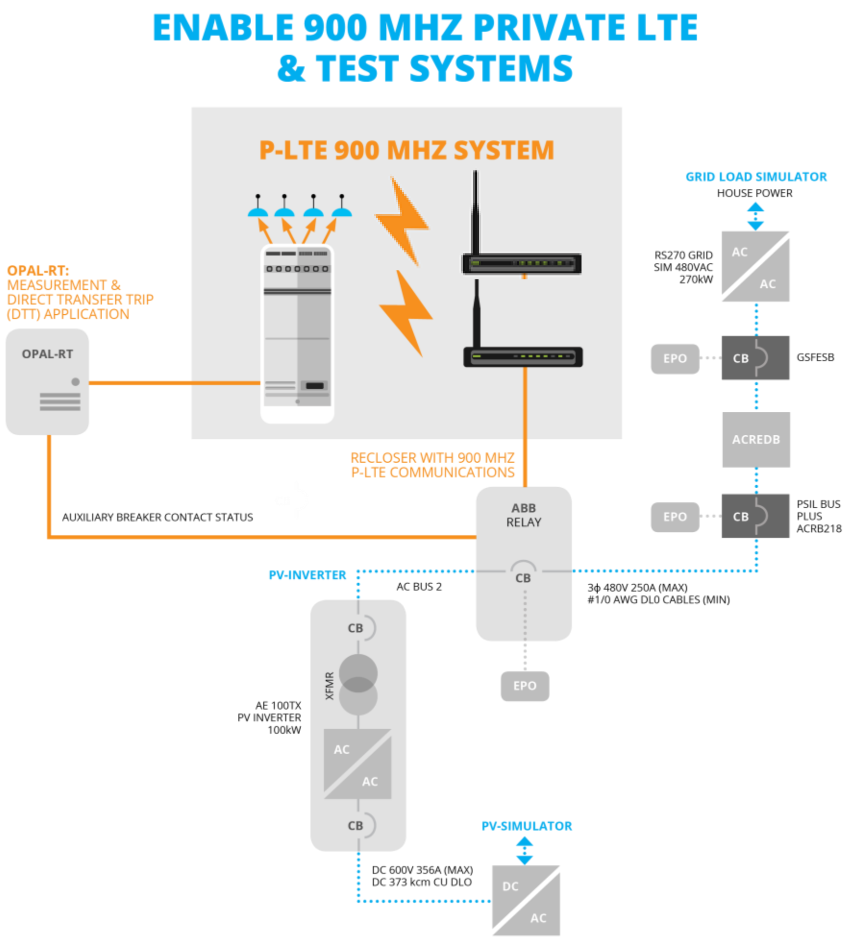
Description	Criteria	Date
Notable outcome – lab demonstration of private LTE wireless network enabled DTT of a PV inverter	Measurement of round-trip latency of the wireless communications system used in conjunction with distribution-level control system.	9/12/2019

- Phase 1 of the project is completed with the integration and demonstration of the PV-inverter DTT application over wireless P-LTE.
- Phase 2 will further develop capabilities for use-cases utilizing ADMS test-bed.
  - Integration into a realistic ADMS system (Holy Cross Energy Use-cases)
  - Stress test coverage and congestion

Research Overview

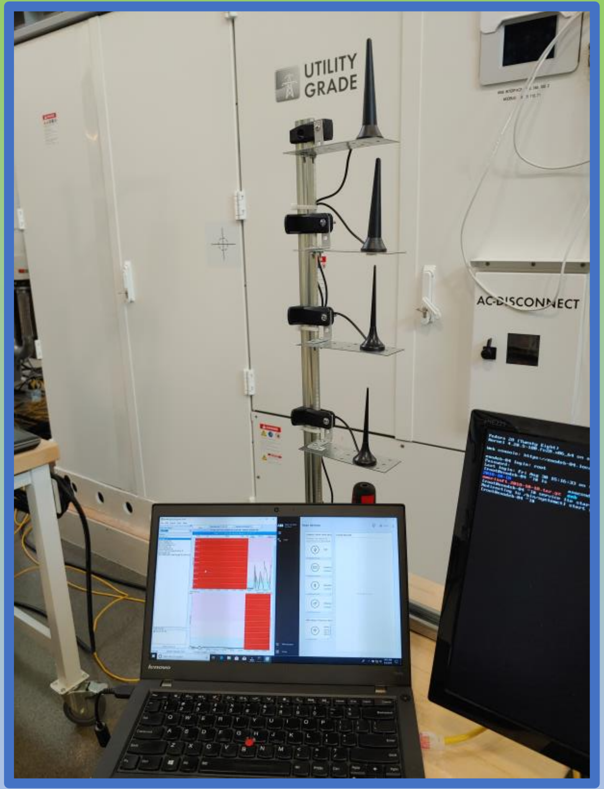
A P-LTE system integrated with ESIF's PV inverter & load system will be used to trigger DTT (low-latency protection function)

- Comparing strong vs. weak LTE signal propagation
- Comparing congestion scenarios (light vs. heavy loading)
- Comparing high vs. low priority air-interface traffic prioritization

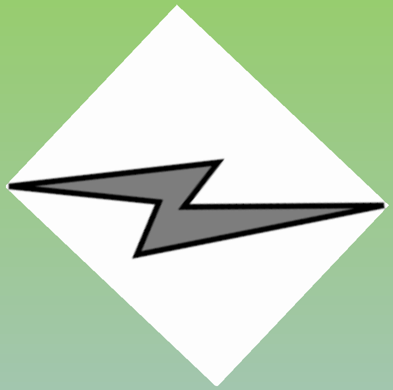


NREL-ESIF Laboratory Wireless Testbed Equipment implementing a DTT sequence for a PV inverter

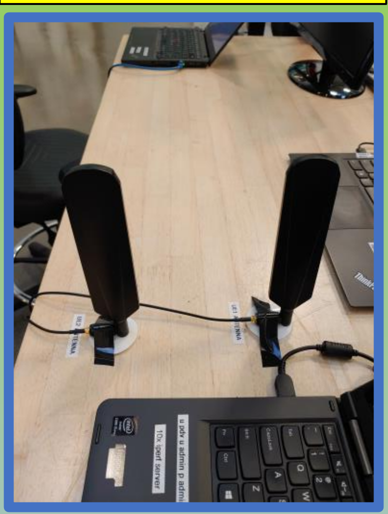
LTE: Wireless tower antennas



DTT server



LTE endpoint antennas



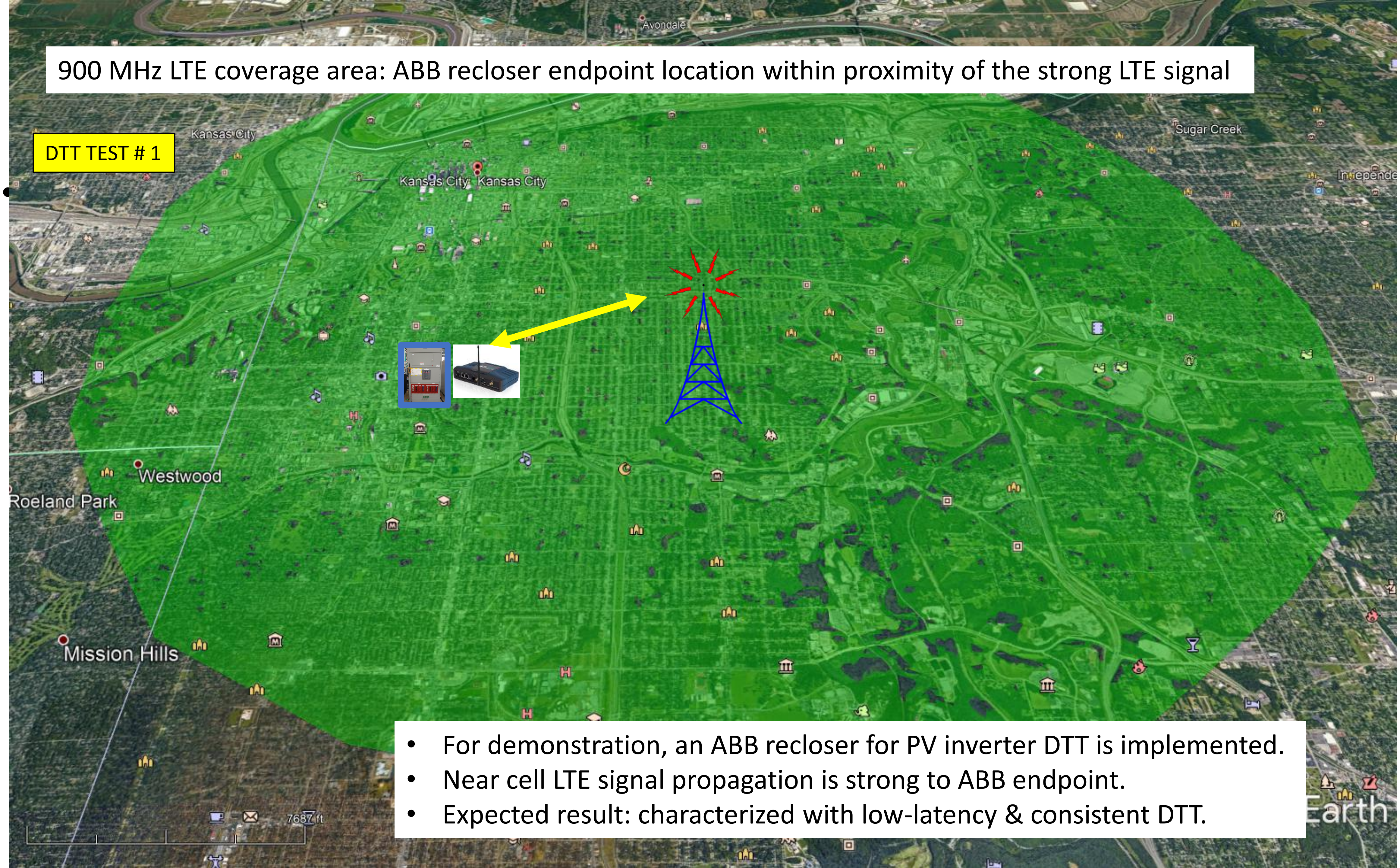
LTE gateway access endpoint equipment

Recloser

PV inverter

- Various test scenarios characterizing the wireless coverage and capacity will be demonstrated.

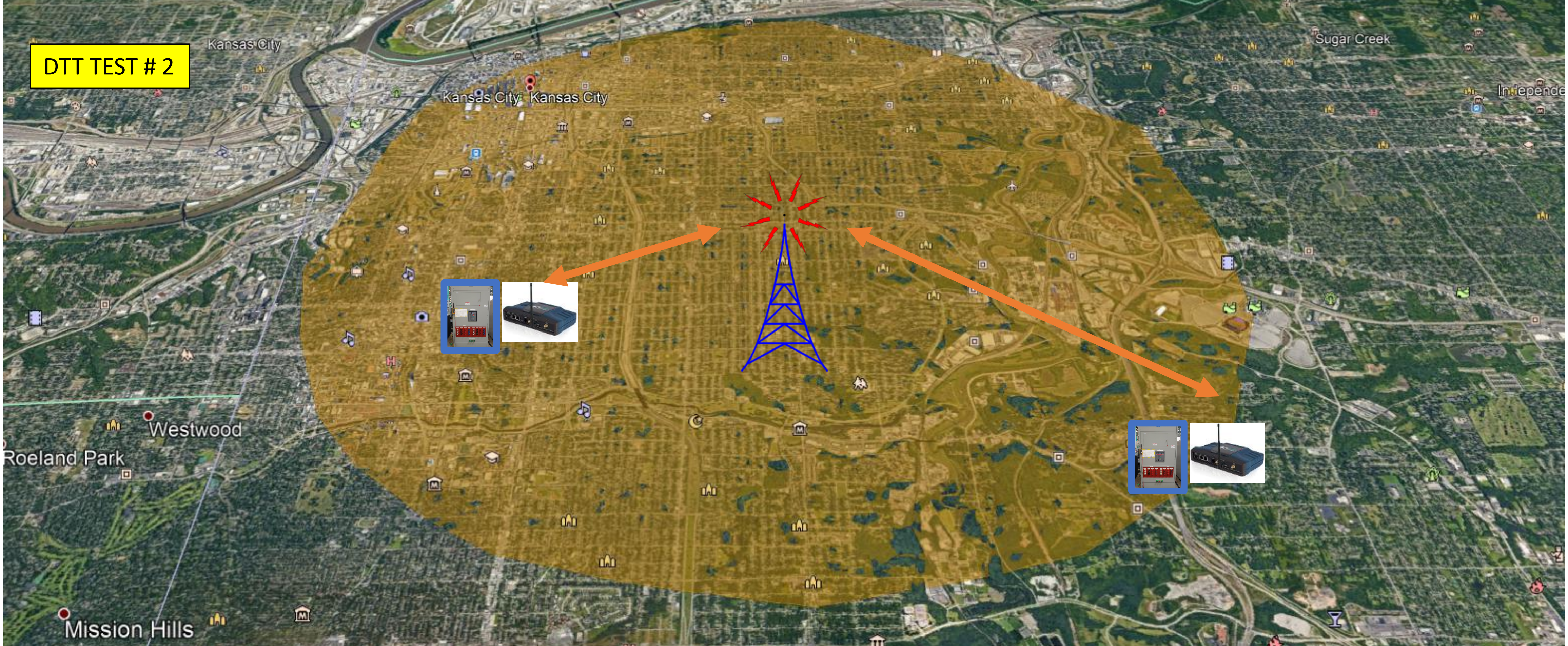
900 MHz LTE coverage area: ABB recloser endpoint location within proximity of the strong LTE signal



- For demonstration, an ABB recloser for PV inverter DTT is implemented.
- Near cell LTE signal propagation is strong to ABB endpoint.
- Expected result: characterized with low-latency & consistent DTT.

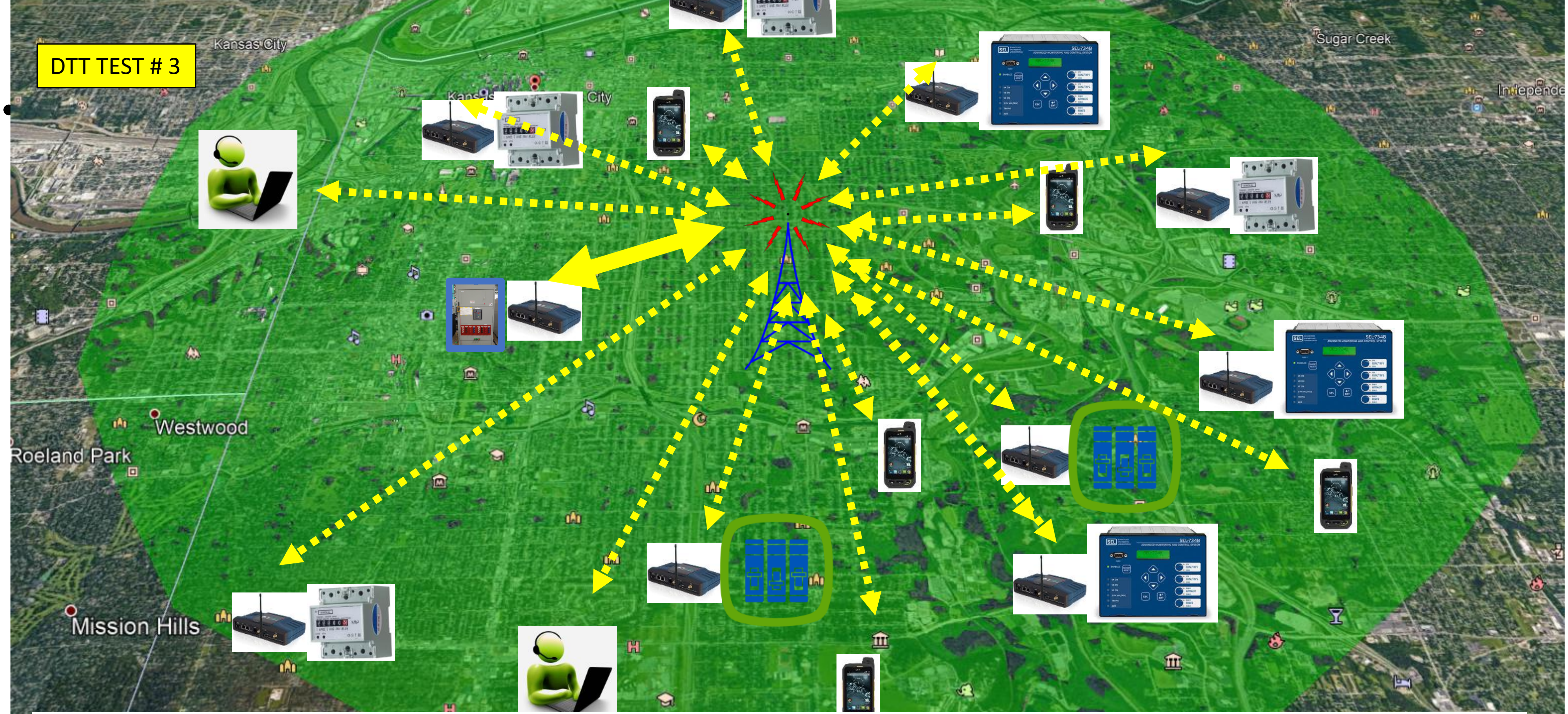
2 GHz LTE coverage area: ABB recloser endpoint location within coverage of a weaker LTE signal

DTT TEST # 2



- Smaller cell coverage area approximately 50 square miles (2 GHz channel)
- Weaker signal due to propagation characteristics of high frequency EM wave
- Weaker signal can also be due to the LTE endpoint being closer to the wireless coverage edge.
- Expected result: Characterization of impact due to weaker LTE signal impacting latency slightly but consistent DTT results.

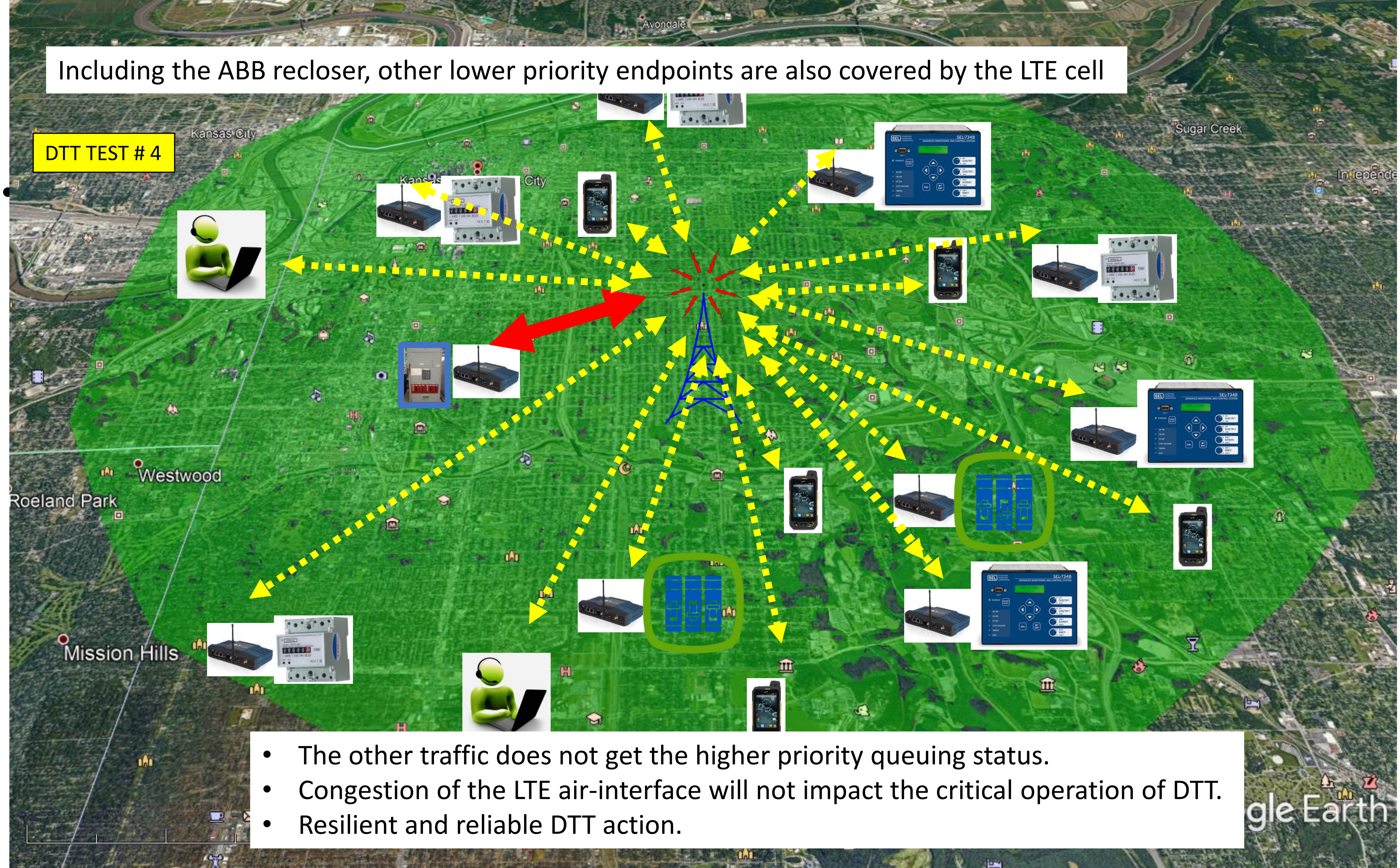
Including the ABB recloser, other endpoints are also covered by the LTE cell



- The LTE system can support hundreds, thousands of endpoints (e.g. SCADA, meters, other DA assets).
- The other traffic will congest the wireless capacity of this cell tower.
- Result: Inconsistent / unreliable / erratic DTT behavior

Including the ABB recloser, other lower priority endpoints are also covered by the LTE cell

DTT TEST # 4



- The other traffic does not get the higher priority queuing status.
- Congestion of the LTE air-interface will not impact the critical operation of DTT.
- Resilient and reliable DTT action.

Next Steps

- Finalize DTT timing for more scenarios
- Continue integration into further related ADMS and DERMS use-cases

Follow-on Work

Data collected on this project will further opportunities not only in distribution protection methods, but also enables other potentially cost-effectives measures for ADMS, and DA applications. The IAB will review these findings, and hopefully propose new use-cases for grid operations.

Deployment & Impact

There have been numerous trials with utilities using P-LTE in 900 MHz with a focus on existing DA applications. Development at NREL on this project enables low-latency application such as DTT on a PV inverter system and similar applications. Further enhancement could be to optimize and improve protection applications for electric distribution.