The Institute for Telecommunication Sciences (ITS)

October 15, 2019

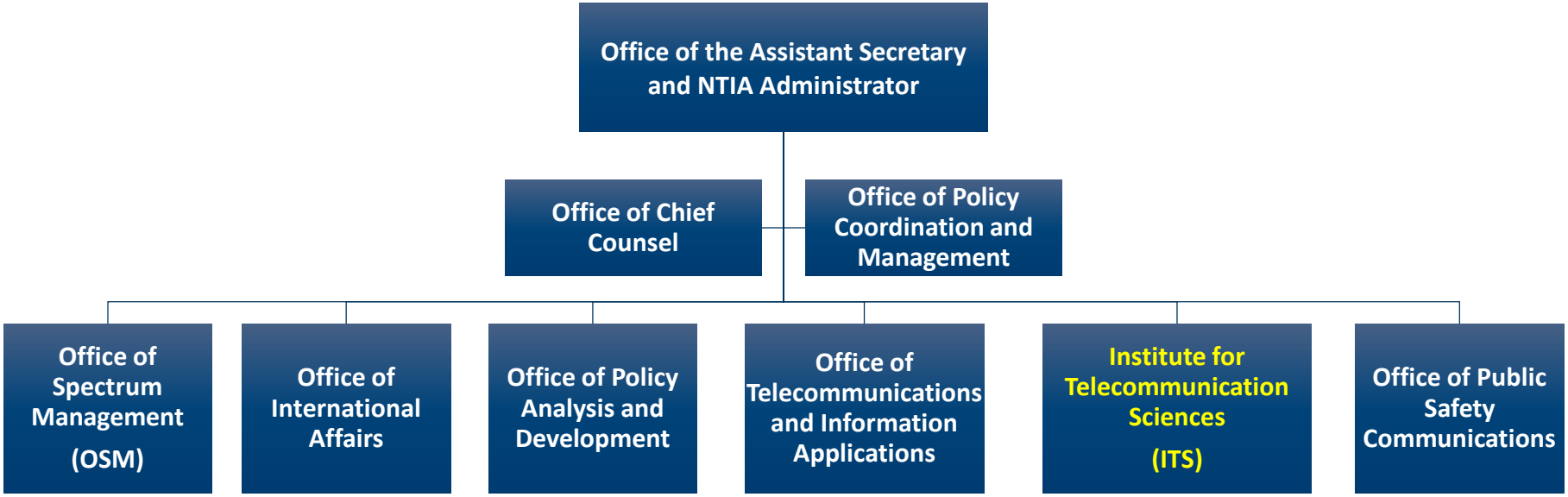
Michael Cotton, Division Chief

Theory Division

Institute for Telecommunication Sciences (ITS)

National Telecommunications and Information Administration (NTIA)

NTIA's Organization

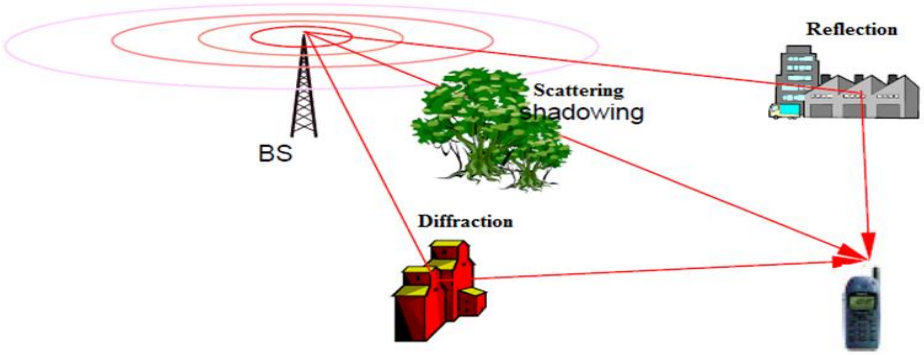


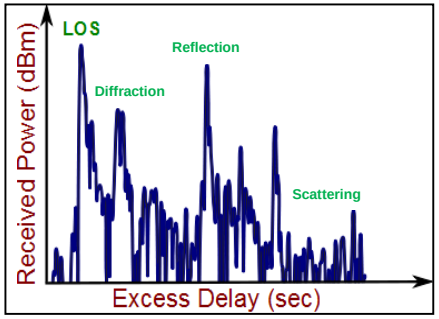
- NTIA is the President's principal advisor on telecommunications and information policy
- NTIA also manages federal spectrum
- ITS is the research and engineering branch of the NTIA

Institute for Telecommunication Sciences (ITS)

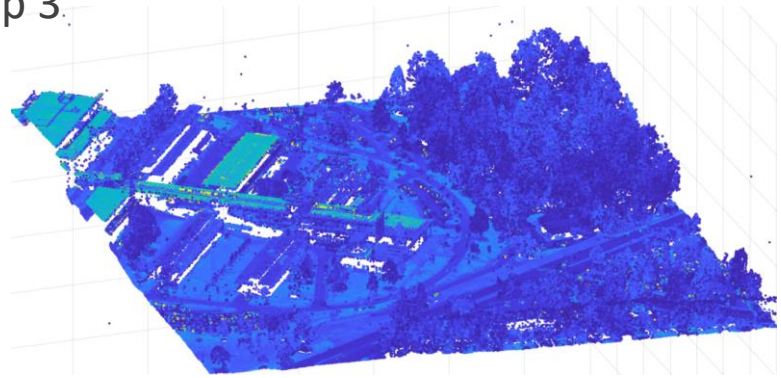
- The Institute for Telecommunication Sciences (ITS) is the U.S. government's premier telecommunications laboratory
  - Located in Boulder, CO
  - ~80 technical staff, scientists, and engineers
- ITS mission
  - Perform research and engineering required to inform policy
  - Solve telecommunications concerns of other Federal agencies
  - Perform analyses to manage and share spectrum efficiently
- ITS core capabilities
  - Systems standards and evaluation (4G/LTE, 5G, user experience)
  - Radio frequency (RF) propagation measurement and modeling
  - Spectrum monitoring
  - Electromagnetic compatibility (EMC) analysis

Propagation Modeling

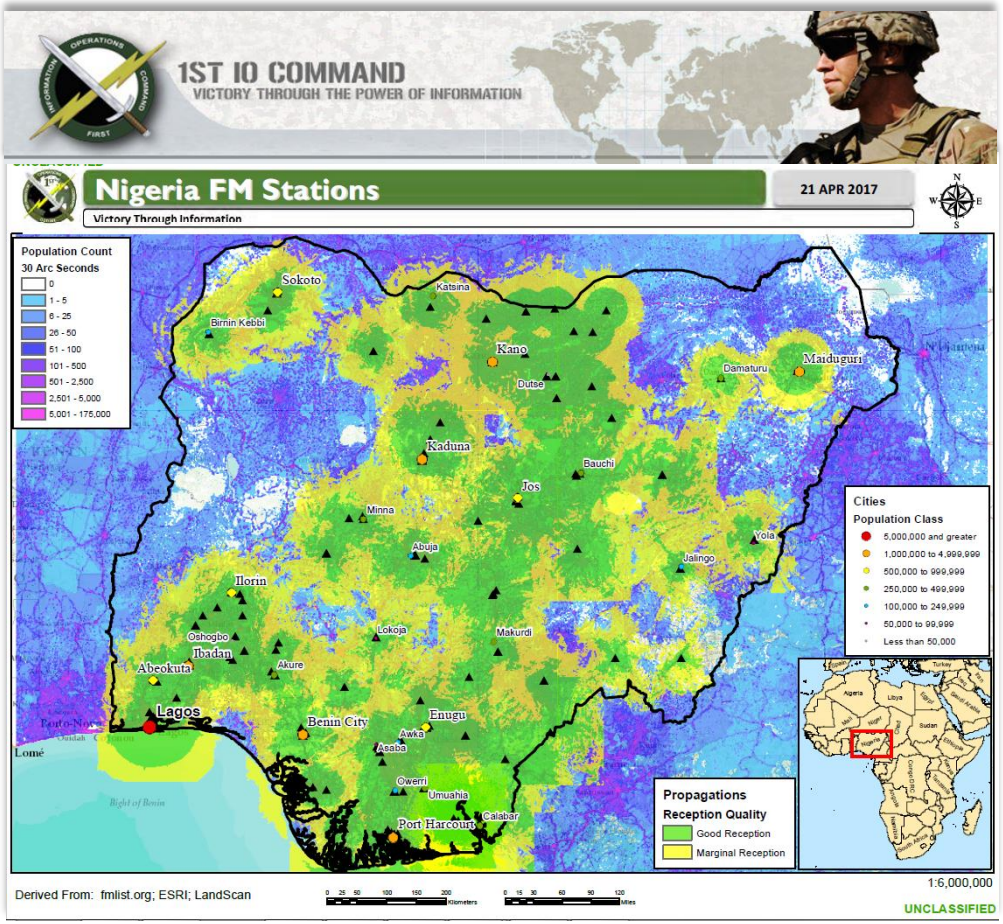




- Propagation world experts: ITU-R Study Group 3
- Derivation from first principles: IF-77, ITM
- Validation of propagation mechanisms for simple geometries
- Data-driven propagation models: urban, forest clutter
- mm-wave Propagation Model (MPM): atmospheric and hydrometeor propagation impairments

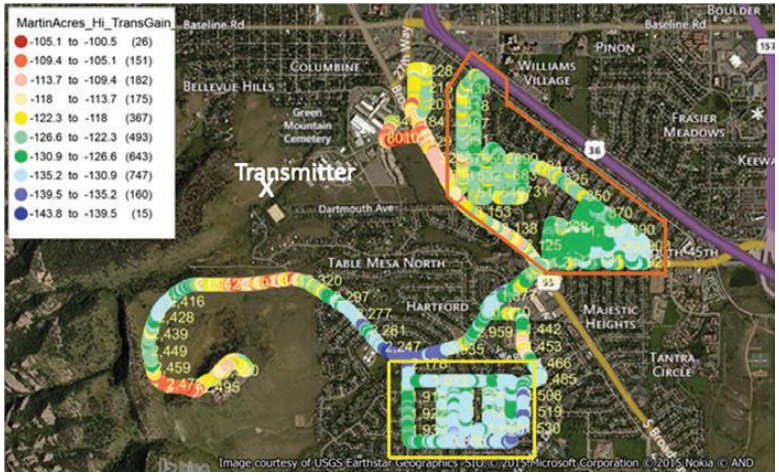


Propagation Modeling Website (PMW)



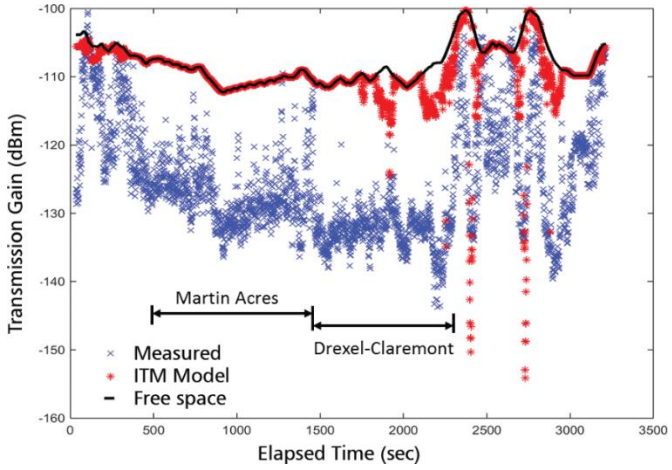
- Use case: US Army First IO Command
- Information and cyberspace operations
- Modular, adaptable to 5G
- Visualize system coverage and identify gaps

Propagation Loss Measurements



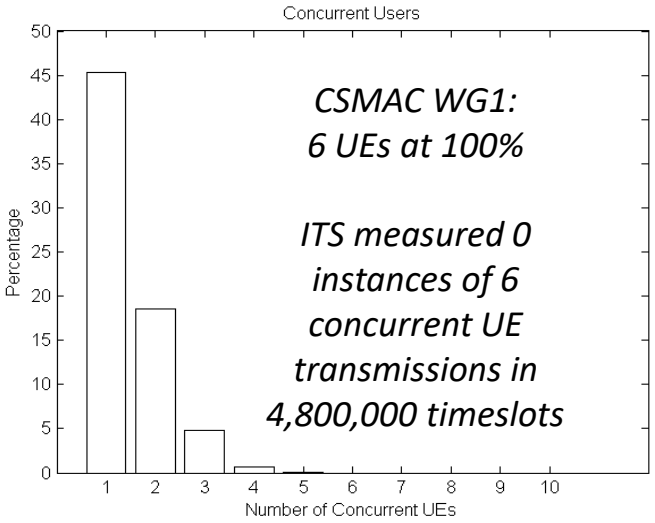
Typical drive test route in Boulder used to validate measurement system

ITS-authored best practices guide prepared for DISA/DSO



Comparison of measured to modeled pathloss for end-point corrections

RF Systems Measurements

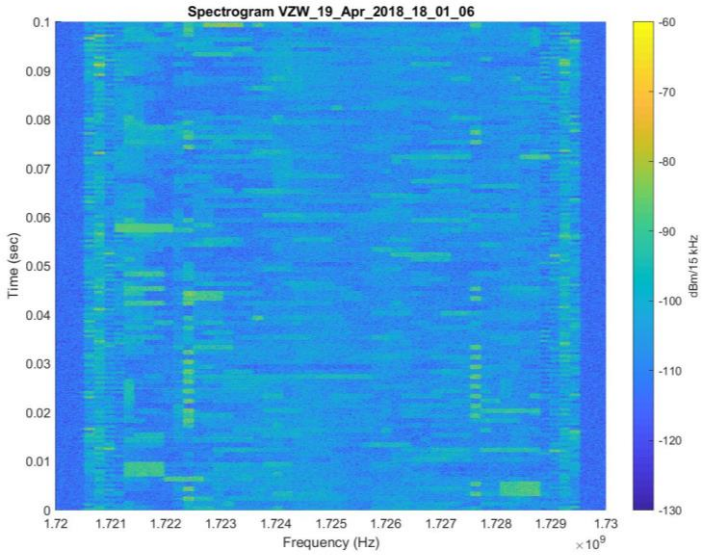


CSMAC WG1:
6 UEs at 100%

ITS measured 0 instances of 6 concurrent UE transmissions in 4,800,000 timeslots

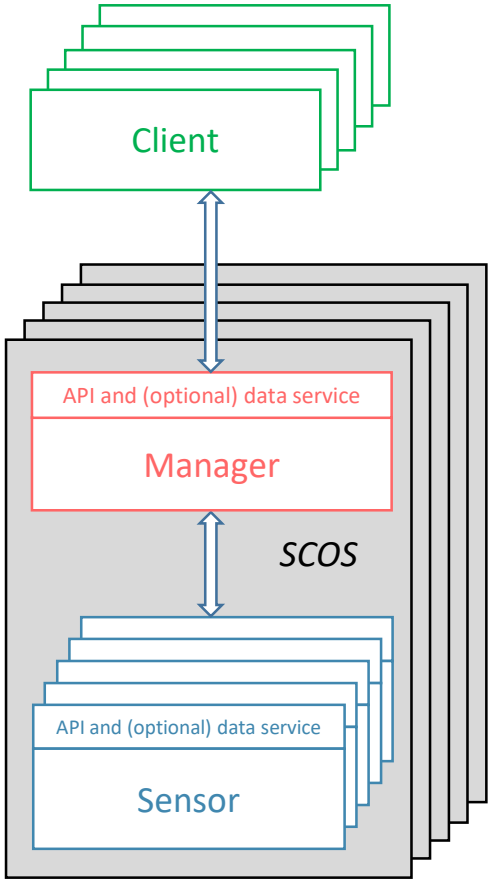
ITS inspired LTE over-the-air protocol analysis challenges assumptions used in DoD models

ITS field measurements are the benchmark for aggregate LTE model validation



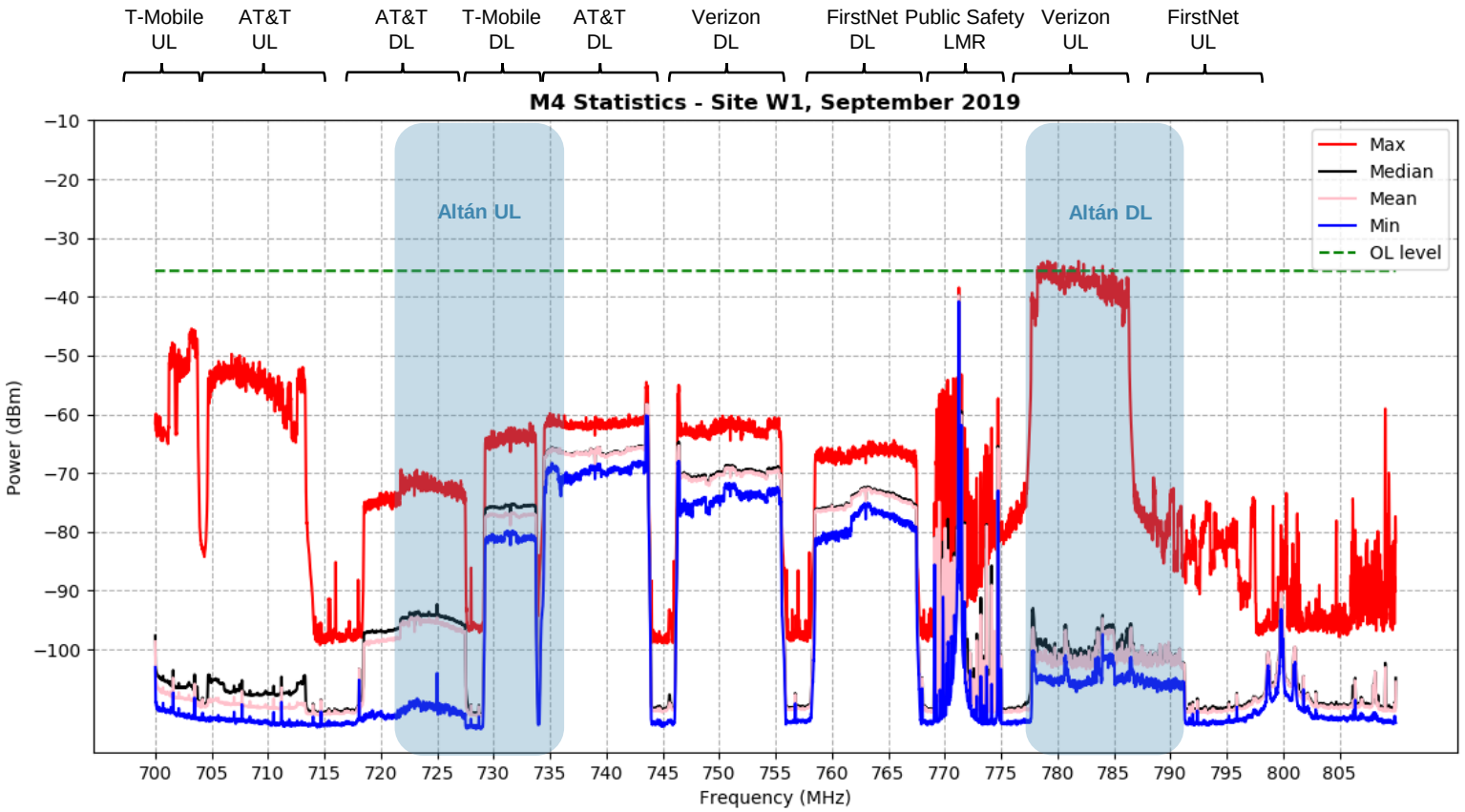
Spectrogram of LTE uplink in Longmont, CO

Spectrum Monitoring

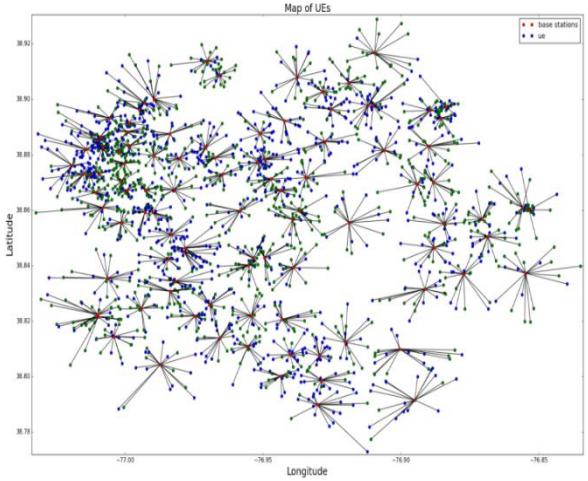


- Monitoring paradigm shift
- Drive down sensor cost
- Standardized and open software for distributed sensing and automation
- Real-world research test bed to experiment and spur innovation
- Operationalize production data distribution adhering to government security controls

Spectrum Monitoring at 700 MHz near San Diego

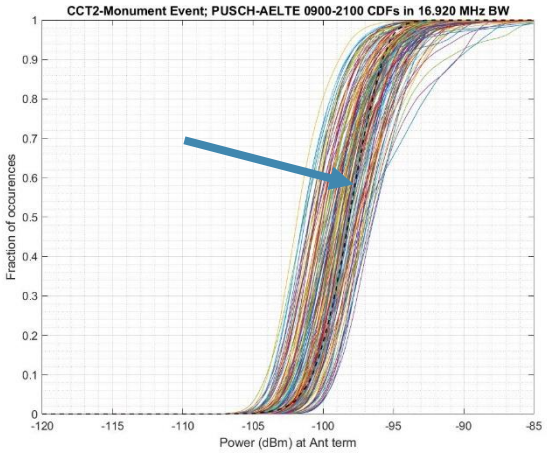


Electromagnetic Compatibility

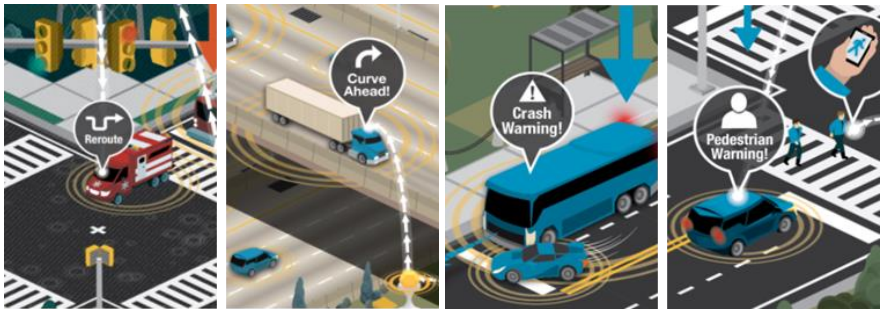


One instance in a Monte Carlo simulation of LTE UE aggregate interference.

- Link- and system-level simulation
- Interference protection criteria
- Aggregate modeling
- Specialization in high-priority verticals, e.g., radar, mobile comms, SAS, Intelligent vehicle
- Real device testing — DSRC, c-V2X
- Traffic emulation — hardware that simulates 500 UEs



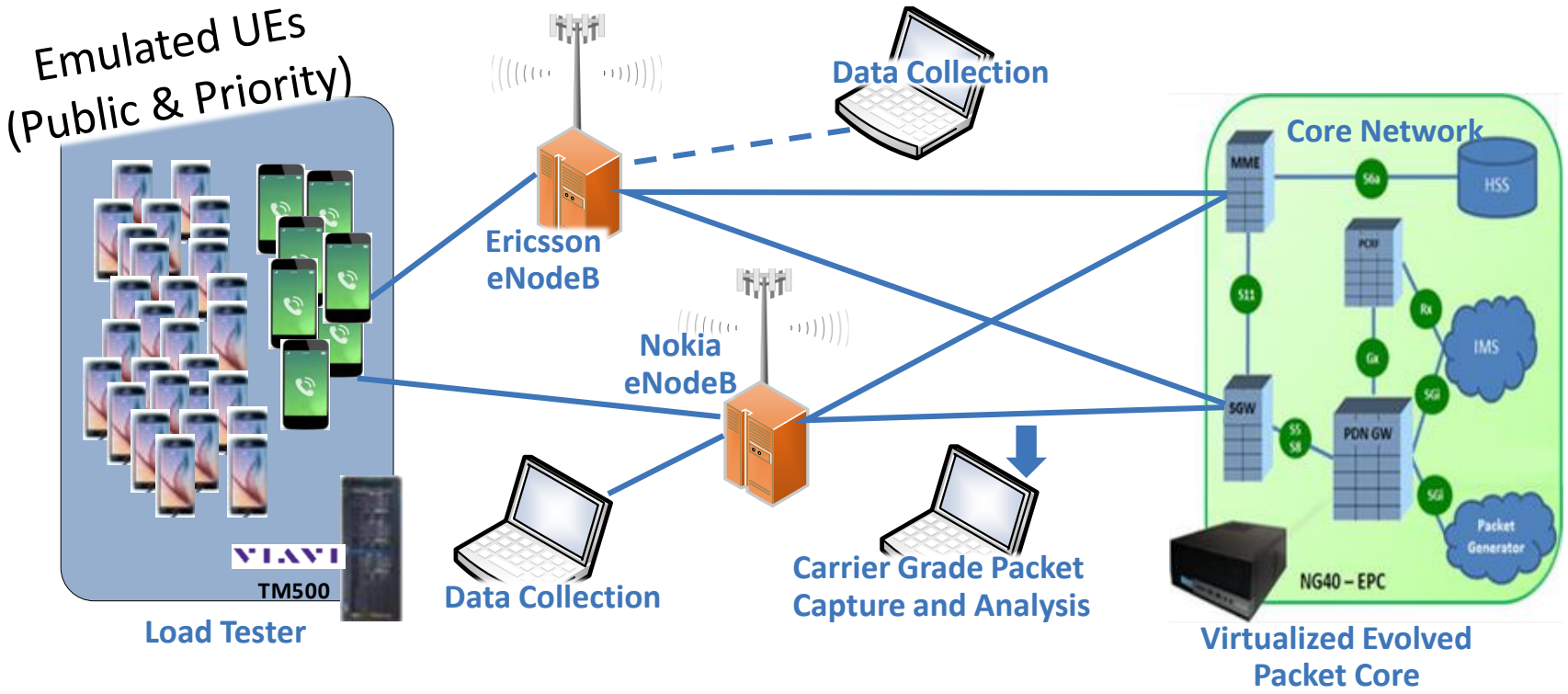
ITS predicted LTE uplink aggregate interference (dashed line) compared to field measurements



LTE Priority Services Test Bed

- Emulate emergency scenarios
- Test commercial cellular equipment
- Verify and optimize WPS feature functionality

Upgradable to 5G

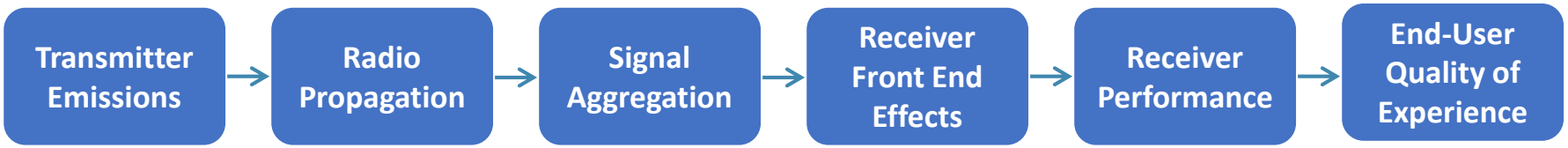


Quality of Experience (QoE)

Engineers

Users

End to End Systems Analysis



- Weather satellites
- GPS satellites
- Radars
- Cell phones
- WiFi devices
- FCC Part 15 devices
- Broadcast
- UAVs
- DoD AWS-3 assets
- Threat sims
- Broadband
- IoT devices

- In-building, foliage, and dense urban
- Atmospheric
- Ionospheric
- Air-to-ground
- Terrestrial
- Visualization tools (PMW)
- Model Validation
- Open Propagation Architecture
- AWS-3 Coord.

- Aggregate emissions
- Spectrum monitoring
- Spectrum occupancy
- Modeling
- Analysis

- Overload
- Adjacent-band interference
- Intermod-ulation effects
- Measurement methods

- Satellite receivers
- Land mobile radios
- Radars
- 3.5 GHz ESC receivers
- DFS (U-NII) devices
- GPS devices

- Speech Intelligibility
- Image quality
- Audio quality
- Video quality
- Data integrity
- In-building coverage
- Encryption keying

ITS is a cohesive, multidisciplinary team

5G

FirstNet & DOT Standards Approach

Requirements Development

Gap Analysis

SDO Selection

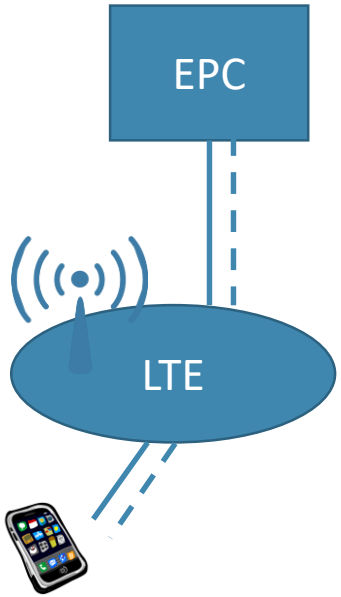
Participation

5G Architecture

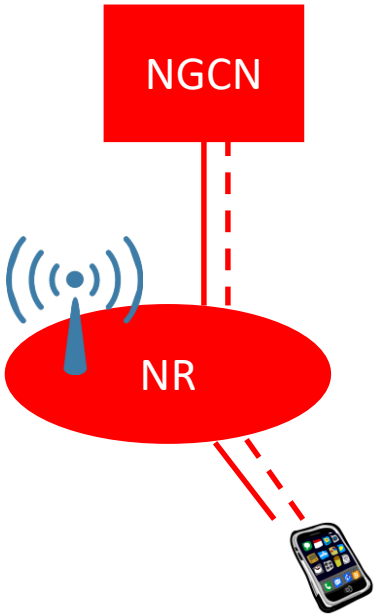
- Two radio technologies
  - LTE (based on Release 15)
  - Next Generation Radio (NR)
- Two core networks
  - Evolved Packet Core (EPC – with potential evolutions)
  - Next Generation Core Network (NGCN)

Options for Cellular Configurations

Option 1) Standalone LTE, EPC connected, Legacy

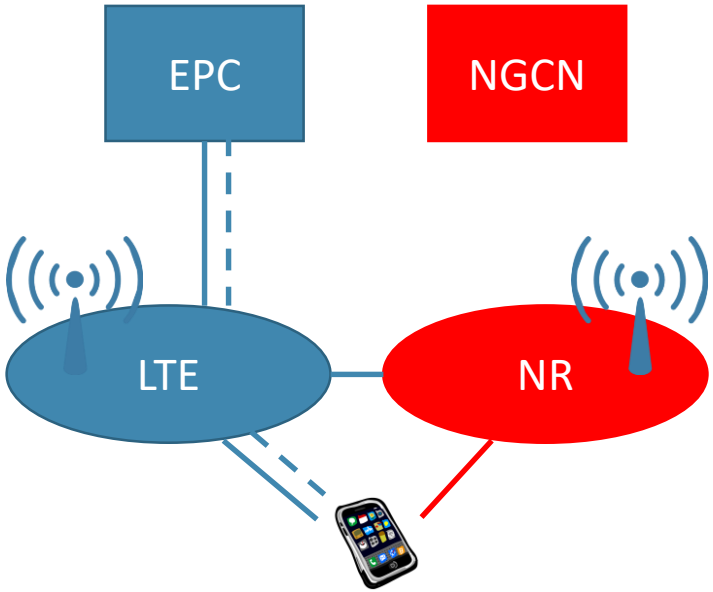


Option 2) Standalone NR, NGCN connected

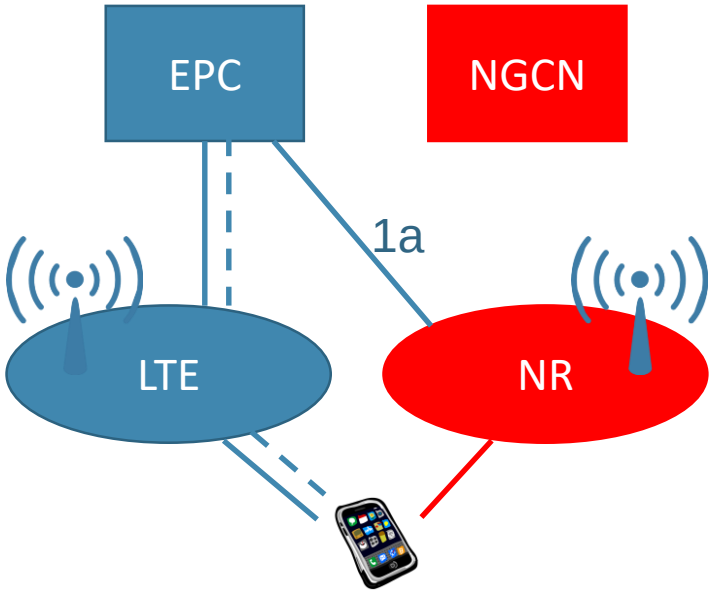


Options for Cellular Configurations (cont.)

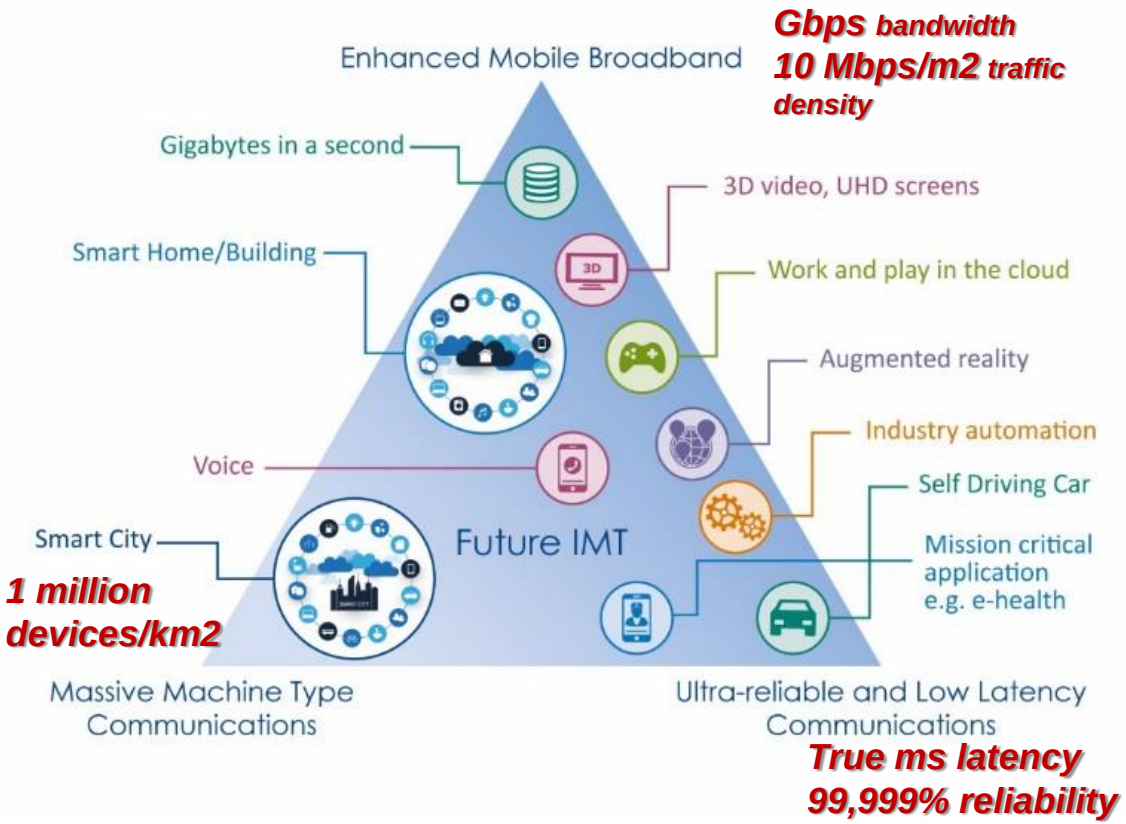
Option 3) Non-Standalone/"LTE assisted", EPC connected



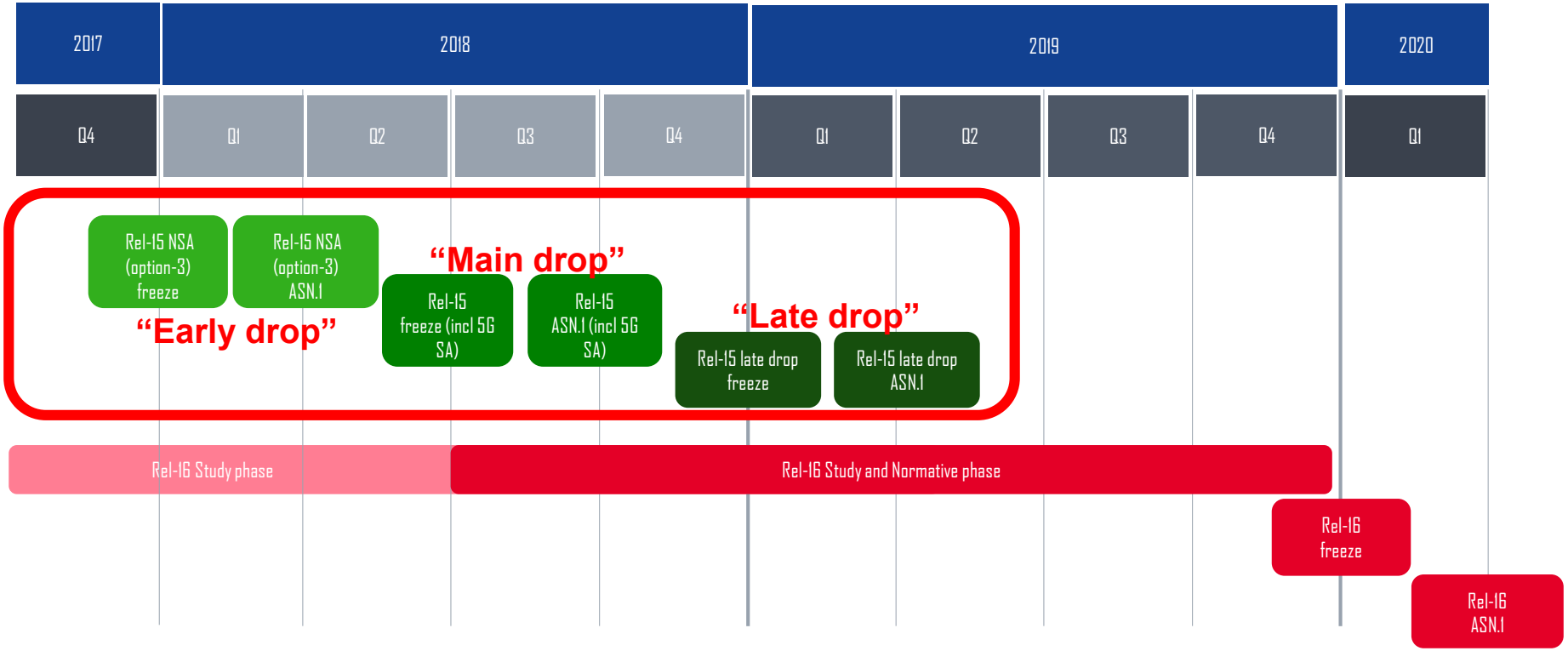
Option 3a) Non-Standalone/"LTE assisted", EPC connected



5G vision - at the outset



Timeline


2017
2018
2019
2020
Q4
Q1
Q2
Q3
Q4
Q1
Q2
Q3
Q4
Q1
Rel-15 NSA (option-3) freeze
Rel-15 NSA (option-3) ASN.1
"Early drop"
"Main drop"
Rel-15 freeze (incl 5G SA)
Rel-15 ASN.1 (incl 5G SA)
"Late drop"
Rel-15 late drop freeze
Rel-15 late drop ASN.1
Rel-16 Study phase
Rel-16 Study and Normative phase
Rel-16 freeze
Rel-16 ASN.1