Public Safety Communications Research (PSCR)

Department of Commerce – Boulder Labs

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Public Safety Communications Research Program

Located at the Department of Commerce Boulder Labs in Colorado

The PSCR Program is a joint effort between:

NIST's Office of Law Enforcement Standards (OLES)

and

NTIA's Institute for Telecommunication Sciences (ITS)

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PSCR Vision and Mission

VISION

The response community nationwide can exchange voice and data seamlessly to effectively respond to any incident or emergency.

Seamless voice and data exchange refers to the ability of the response community to interoperate with each other on demand, in real time, when needed, and when authorized.

MISSION

To fulfill this vision, PSCR will act as an objective technical advisor and laboratory to public safety to accelerate the adoption and implementation of only the most critical public safety communication standards and technologies.

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PSCR Sponsors

Department of Homeland Security

Office for Interoperability and Compatibility

Department of Justice

Office of Community Oriented Policing Services

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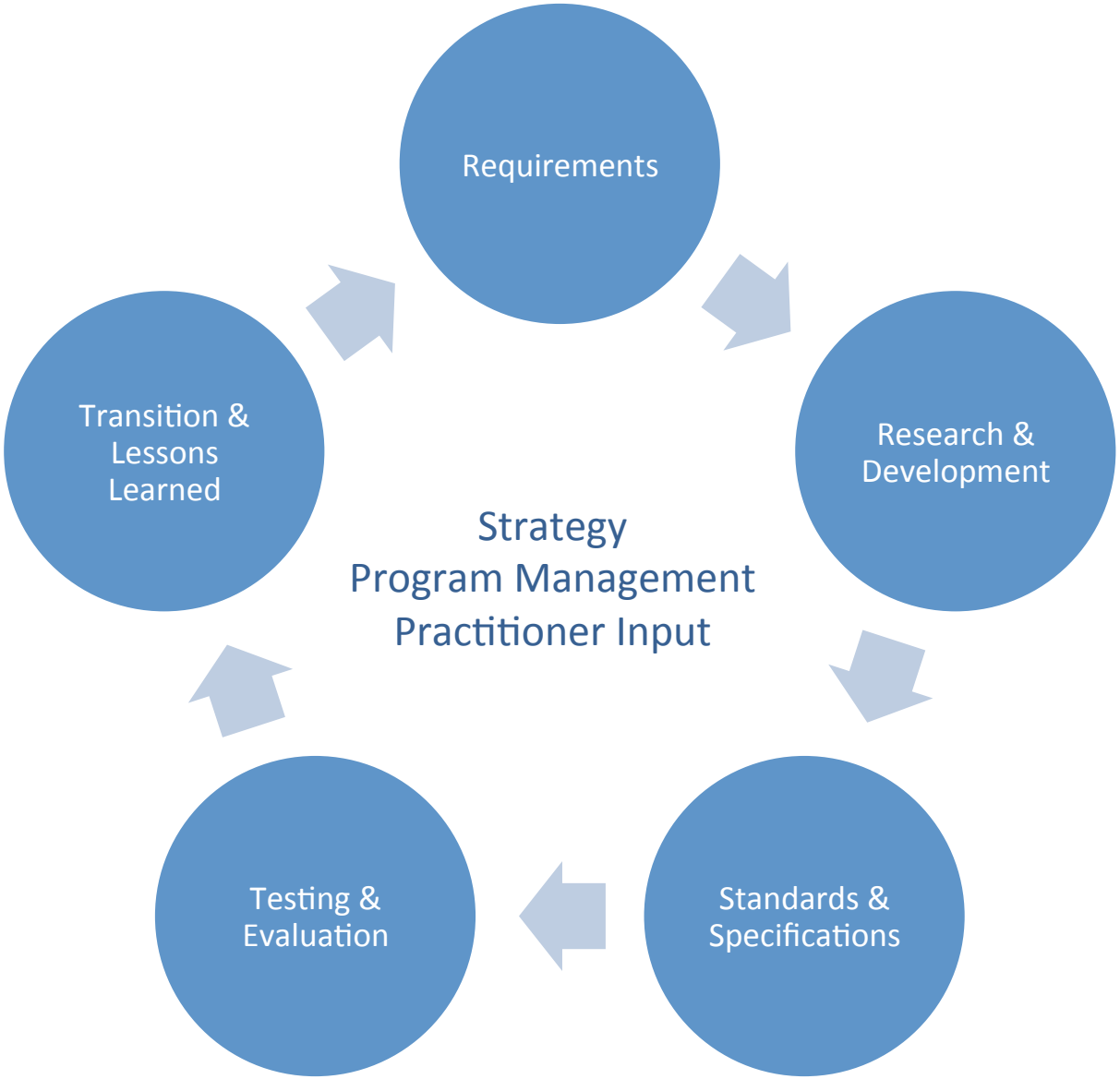
PSCR Approach & Capabilities



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PSCR Portfolio

LMR Standards and Technologies	Broadband Standards and Technologies	Emerging Standards and Technologies
P25 Standards and CAP*	Demonstration Network*	Bridging LMR & LTE*
P25 Test Tools* and Simulation	Requirements and Standards*	Video Quality*
Public Safety VoIP*	Mission Critical Voice*	
Audio Quality*	Modeling and Simulation	
RF Propagation Studies		

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* Project funded by DHS Office of Interoperability and Compatibility

DISCLAIMER

The full description of the procedures used in the following PSCR presentations require the identification of certain agencies, localities, commercial products and their suppliers. The inclusion of such information should in no way be construed as indicating that such agencies, products or suppliers are endorsed by PSCR, or are recommended by PSCR, or that they are necessarily the best materials, instruments, software or suppliers for the purposes described.

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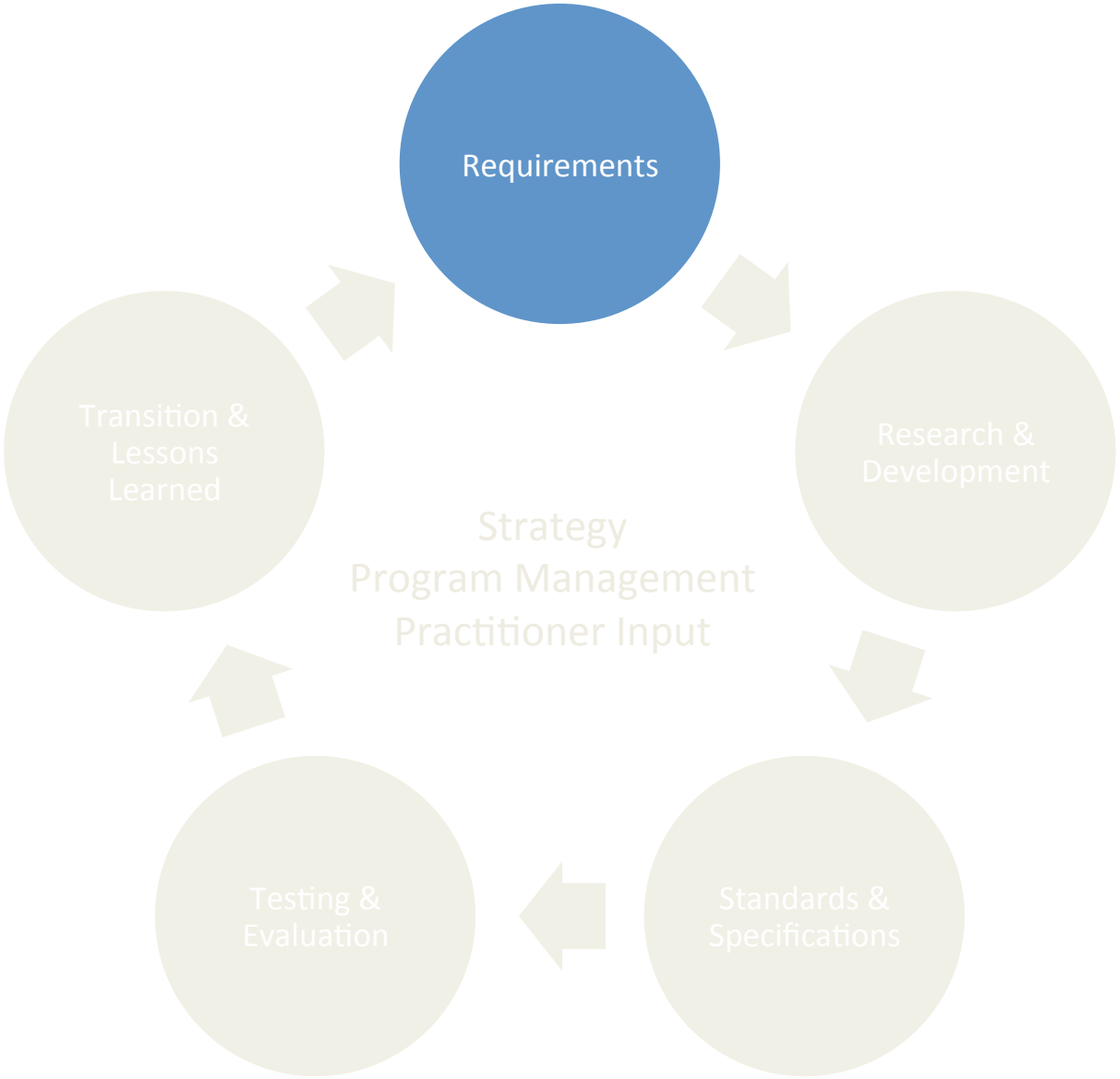
Requirements
Research & Development
Standards & Specifications
Testing & Evaluation
Transition & Lessons Learned
Strategy
Program Management
Practitioner Input

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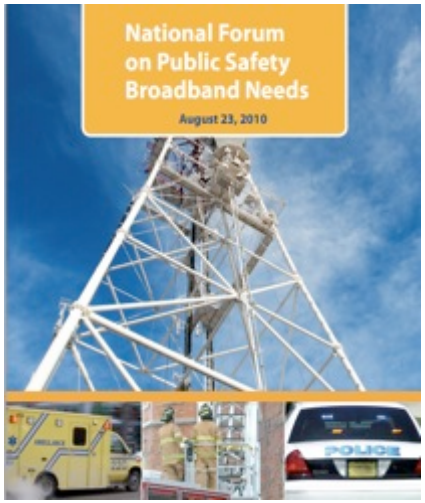
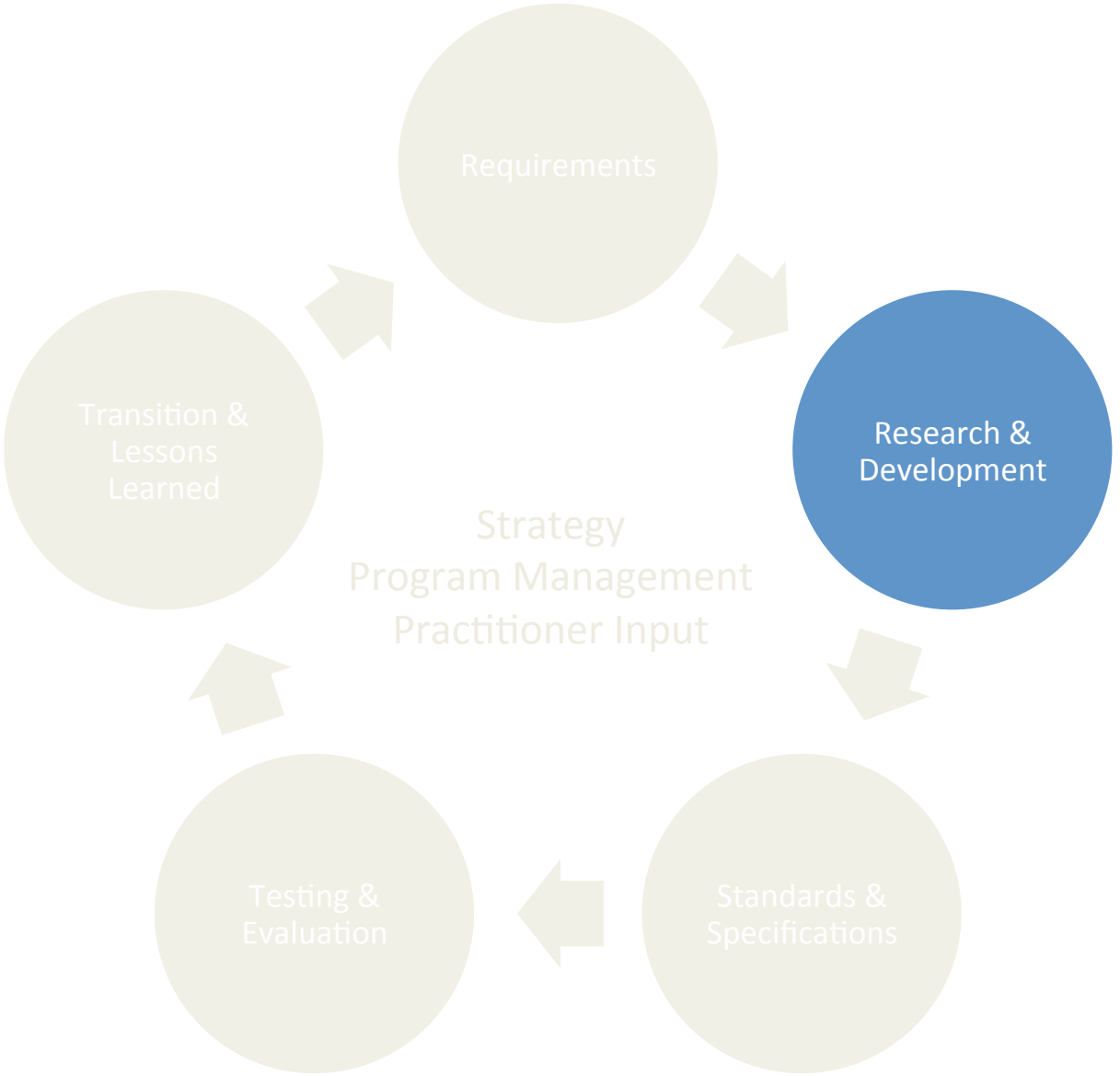
Requirements

- PSCR chairs the NPSTC Broadband Working Group
  - 200+ public safety members
  - Developed the *700MHz Broadband Statement of Requirements*
    - Currently being updated.
  - Defined Mission Critical Voice

- PSCR oversees 5 BBWG Task Groups
  - Local Control
  - Multimedia Emergency Services
  - Priority/Quality of Service
  - Security
  - Voice

- PSCR is active in other broadband requirements gathering efforts
  - APCO Broadband Working Group
  - DOJ's National Forum on Public Safety Broadband Needs
  - PSST Operators Advisory Council

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R&D: Audio Quality Testing

Audio Quality Testing:

- Firefighter reports showed that some background noises created by firefighting equipment can interfere with digital narrowband communication
- Similar audio quality issues may arise as voice is introduced to the public safety broadband network
- PSCR worked with practitioners to develop and implement tests that measure the operation of digital radios, and also tested mitigation techniques for the problems.
- PSCR is initiating broadband audio quality testing with:
  - A transcoding study between the Adaptive Multi-Rate Narrow Band vocoder (the fallback vocoder for Voice over LTE) and the Project 25 vocoder
  - A subjective experiment to understand the effect of background noise on the new vocoder

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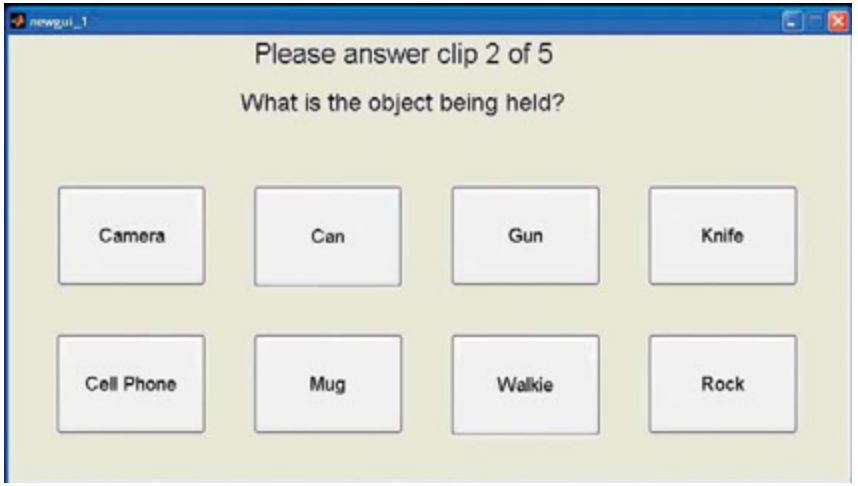
R&D: Video Quality Testing

Video Quality Testing:

Video is one of the most commonly identified use cases for the network and also the most likely to congest it.

- Traditional methods of evaluating perceived broadcast video quality are not appropriate for public safety video.
- PSCR has been conducting research to develop task-specific video quality requirements for public safety applications.
- This work has been incorporated into International Telecommunication Union (ITU) standards for subjective task-based video quality.
- Outputs of this research will allow for informed decisions on quality of service parameters for the public safety network.



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R&D: LMR to LTE Interface

LMR to LTE Interface:

For the foreseeable future, public safety will be leveraging narrowband for voice and broadband for data communications, but there must be the capability to connect the narrowband and broadband systems together to create more dynamic communications capability amongst all existing systems.

- Through the NPSTC BBWG Broadband Voice Task Group, PSCR is looking at LMR/Broadband integration, including mission-critical voice over broadband and requirements for direct mode communication

- In developing a specification for an LMR to LTE interface, PSCR is leveraging its past work in:
  - **Radio over Wireless Broadband (ROW-B)**, which successfully integrated radios operating on an existing Land Mobile Radio (LMR) system with a 700MHz broadband network
  - **Voice over Internet Protocol (VoIP)**, in which PSCR led a coalition of public safety officials and bridging systems vendors to develop an VoIP implementation profile so one emergency response agency could seamlessly connect its radio system to another agency's system over a network—regardless of manufacturer

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Modeling of the Nationwide Public Safety Broadband Network

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Outline

- Objectives
- Metrics
- Nationwide PSBN Modeling
  - Approach
  - Demo

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Objectives and Approach

- Evaluate the performance of LTE and its capacity to support public safety
  - Estimate resources required for build-out
  - Define common performance metrics
  - Provide insights on performance trends and trade-offs
- Approach
  - Use off-the-shelf (commercial and publicly available) network planning and simulation tools
  - Develop additional models and measurement tools as needed

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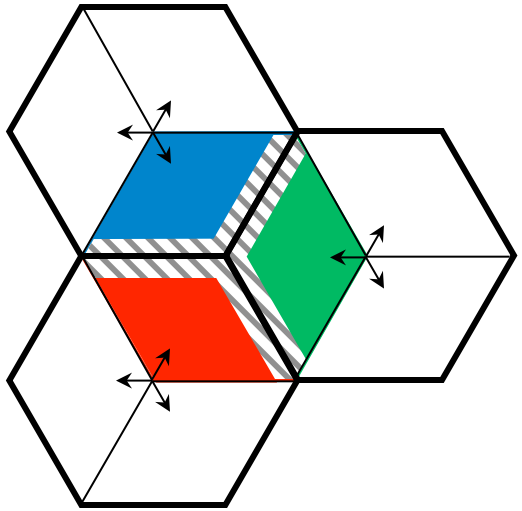
Metrics: Coverage

Percentage of target area (population) for which
Coverage Metric ≥ Threshold

- Coverage metrics
  - Reference Signal Received Power (RSRP)
  - Signal-to-Interference-plus-Noise Ratio (SINR)
- Threshold value
  - Depends on data rate and coverage probability



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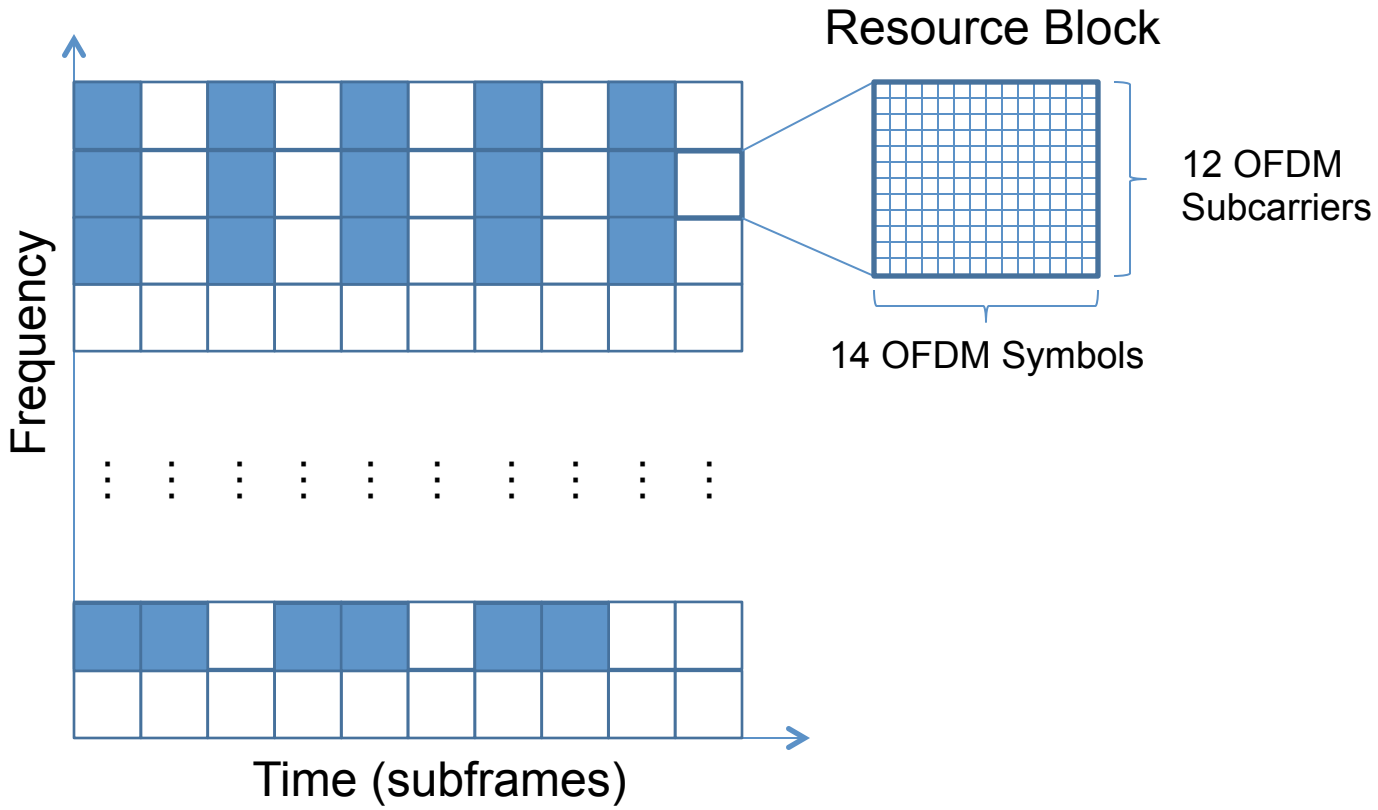
Metrics: Network Load

- Percentage of time-frequency resources utilized in a cell



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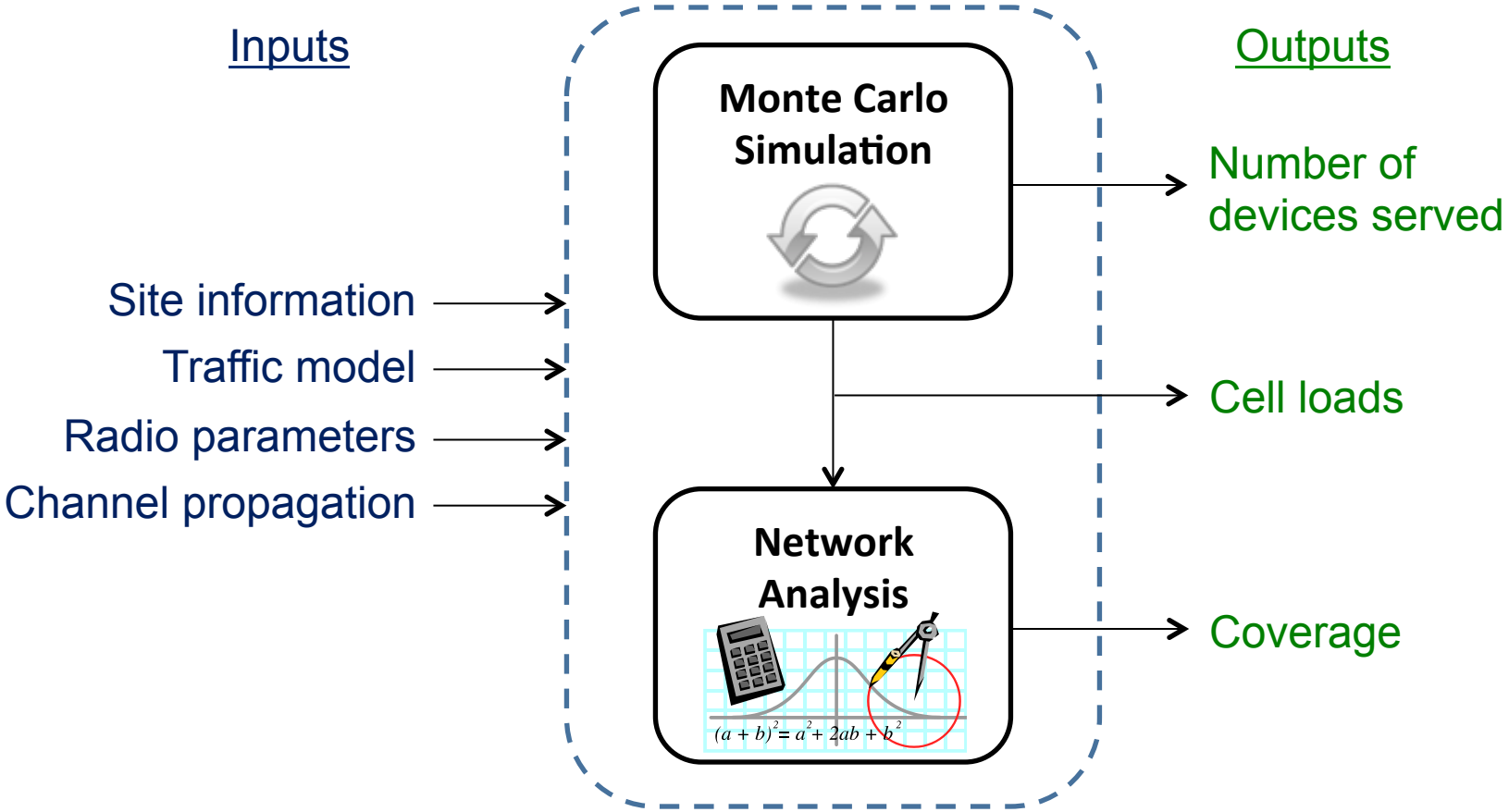
Modeling Approach



Sources of Uncertainty

- Channel propagation model (tuned vs. untuned)
- Time/frequency dynamics of channel and interference

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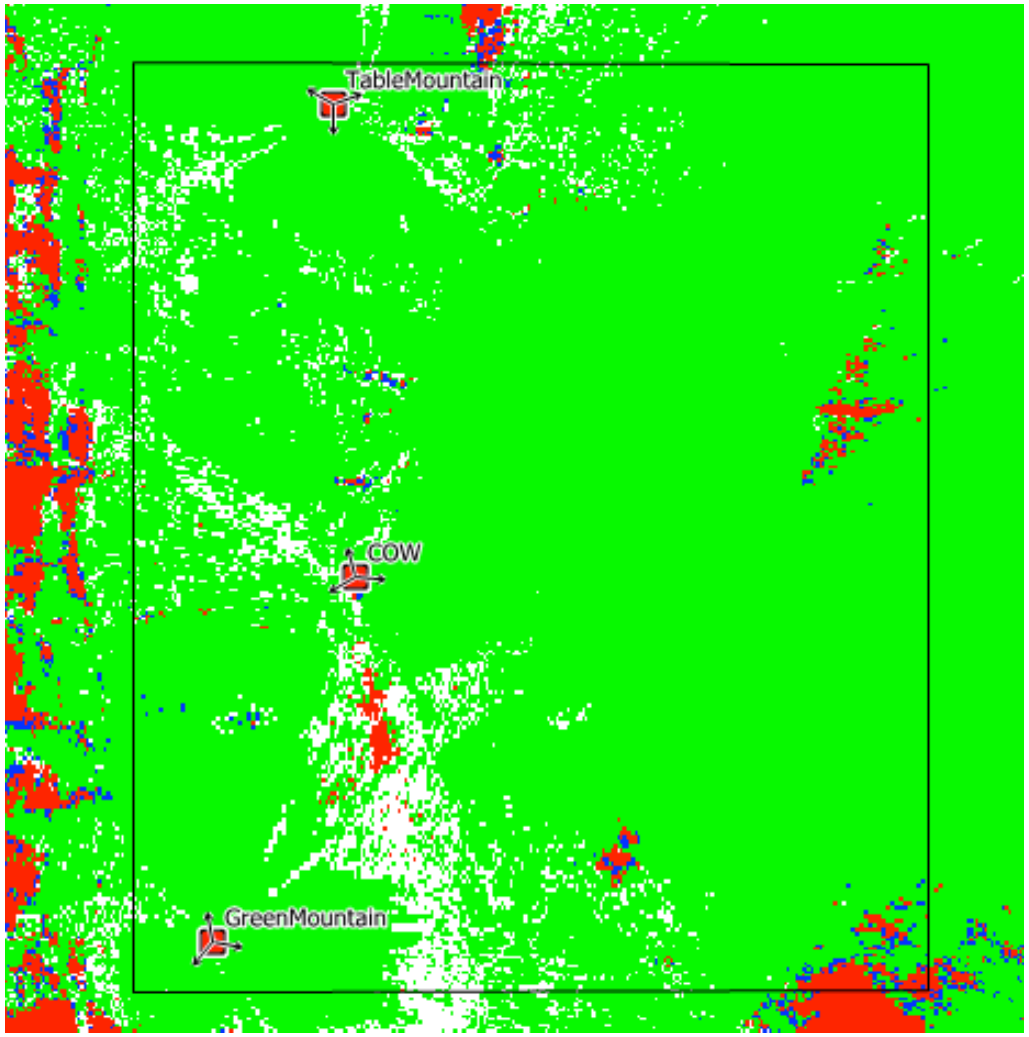
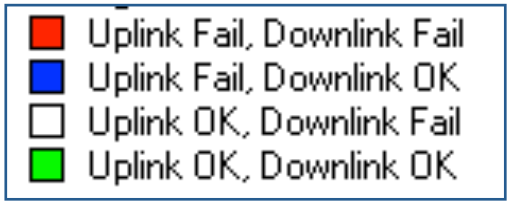
Example: 700 MHz Demonstration Network



RSRP Coverage	96.0%
SINR Coverage	91.6%



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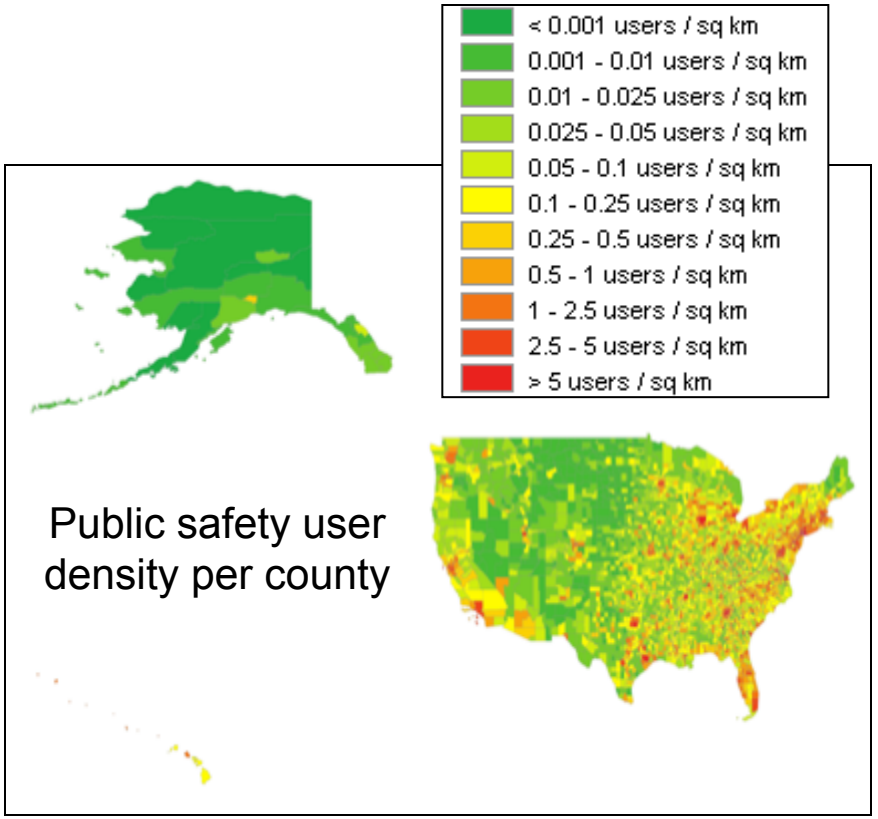
Nationwide Modeling Approach

High resolution terrain data



Combines statistical techniques with detailed performance analyses to address the challenges of modeling a large, diverse area.

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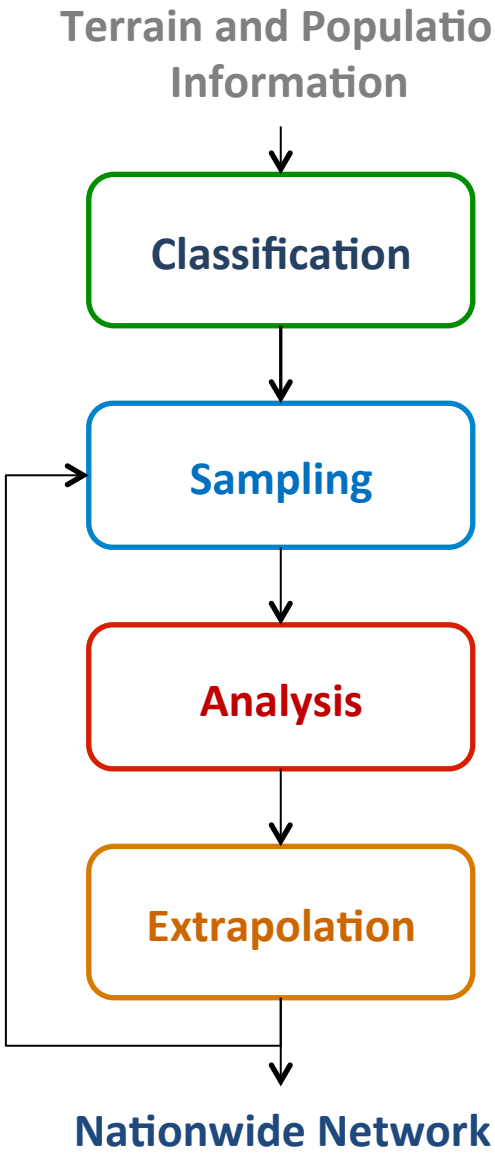
Nationwide Modeling Approach



Use terrain and user distribution to group areas with similar characteristics

Perform random sampling within each group until performance metrics converge

Combine off-the-shelf network planning tools with in-house models; evaluate the resources (sites) required to meet the target coverage and measure the performance of target networks

Scale results to entire nation (coverage, number of sites)

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Nationwide Analysis Tool

Demo

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Areas of Further Study

- Validation of simulation models
- Model improvements
  - Channel propagation
  - Interference coordination
- Mobility and handover

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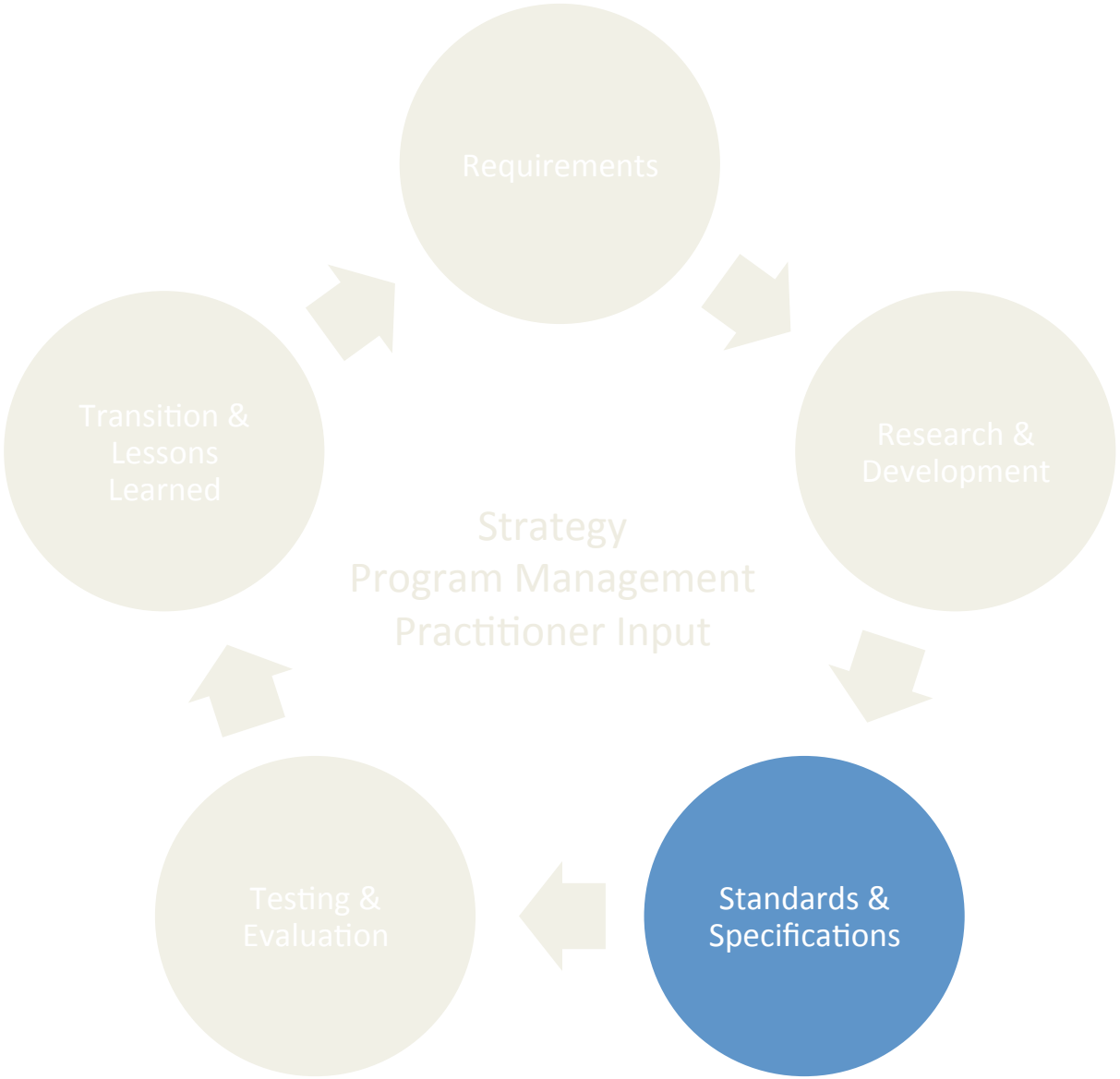
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Standards and Specifications

PSCR has historically provided insight and direction to IT and wireless standards committees that are developing standards for voice, data, image, and video communication specific to public safety. PSCR's work is currently focused in these SDOs:

The **3rd Generation Partnership Project (3GPP)** produces the technical standards and specifications for LTE, uniting numerous telecommunications standards bodies under one group.

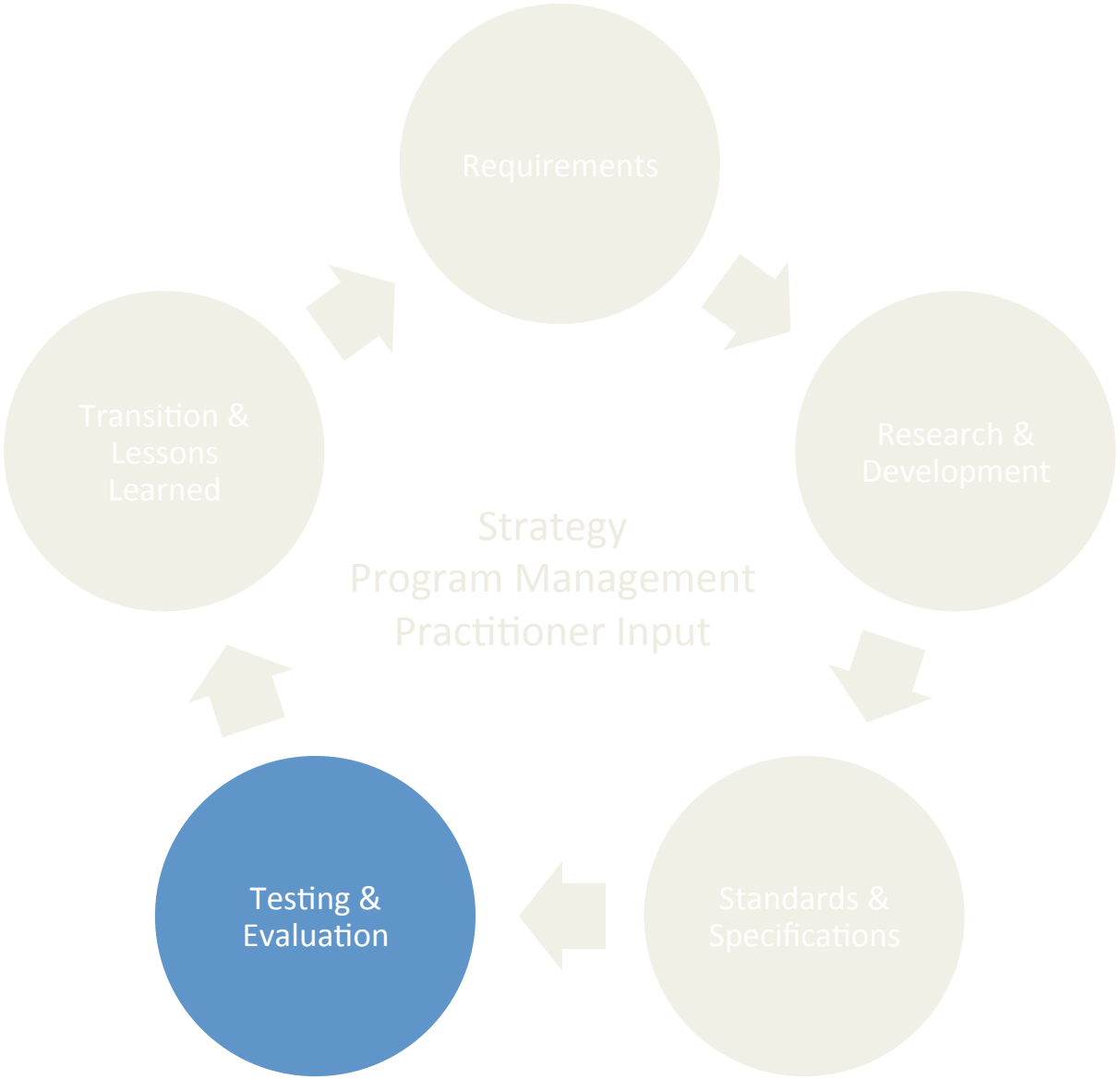
- PSCR is a member of 3GPP and represents public safety's requirements
- PSCR is working in 3GPP to address Direct Mode (Proximity Services) communications and Group Communications Efficiency (GCE_LTE)

The **Alliance for Telecommunications Solutions (ATIS)** is the North American standards body representative in 3GPP.

- PSCR is a member of ATIS and represents public safety's requirements
- PSCR has created an issue statement that would give the ATIS WTSC the ability to work on public safety specific issues
    - Currently working towards nationwide PTT over LTE capability

The **GSM Association (GSMA)** is an association of mobile operators and related companies that support the standardization of the GSM system.

- PSCR is actively seeking membership to GSMA in order to represent public safety's requirements to their Voice over LTE (VoLTE) initiative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T&E: Demonstration Network

The only government or independent lab facility located in the United States to test and demonstrate public safety 700 MHz broadband networks and applications

The Demonstration Network provides:

- A place for manufacturers and carriers to deploy their systems to test them in a multi-vendor environment. This provides integration opportunities.
- A place for public safety to see how these systems will function, specific to their unique needs. Interested agencies can visit the network and get hands-on experience with these systems, as well as run public safety specific test cases that relate directly to their operational environments.
- A place where early builders can ensure that the systems they might procure will in fact work in the eventual nationwide network, assisting agencies in their procurement process.

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Being in Front

If you aren't the lead dog

The view never changes

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eNodeB Base Stations

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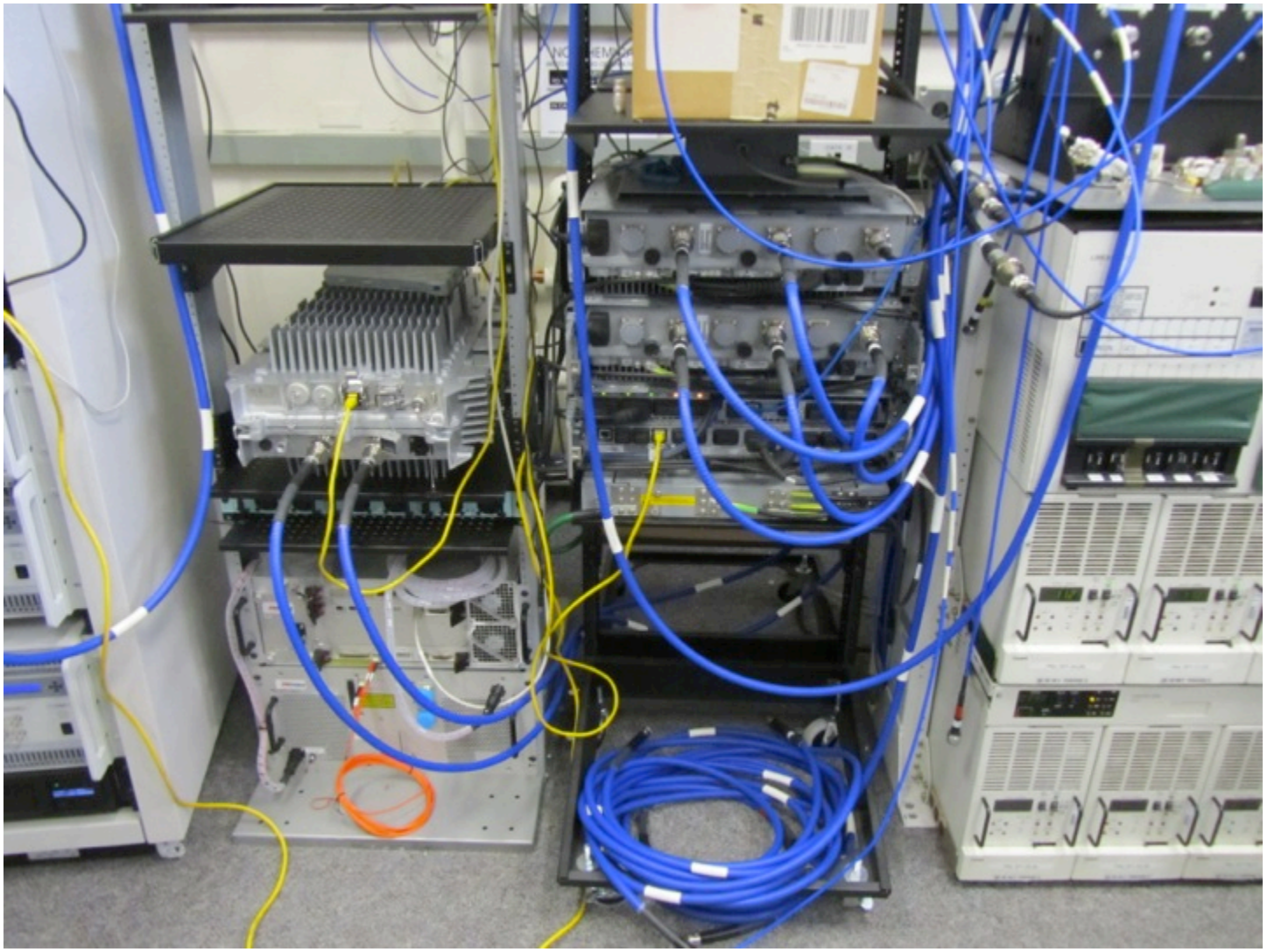
eNodeB Base Stations



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Cell on Wheels

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Eight Foot Antenna

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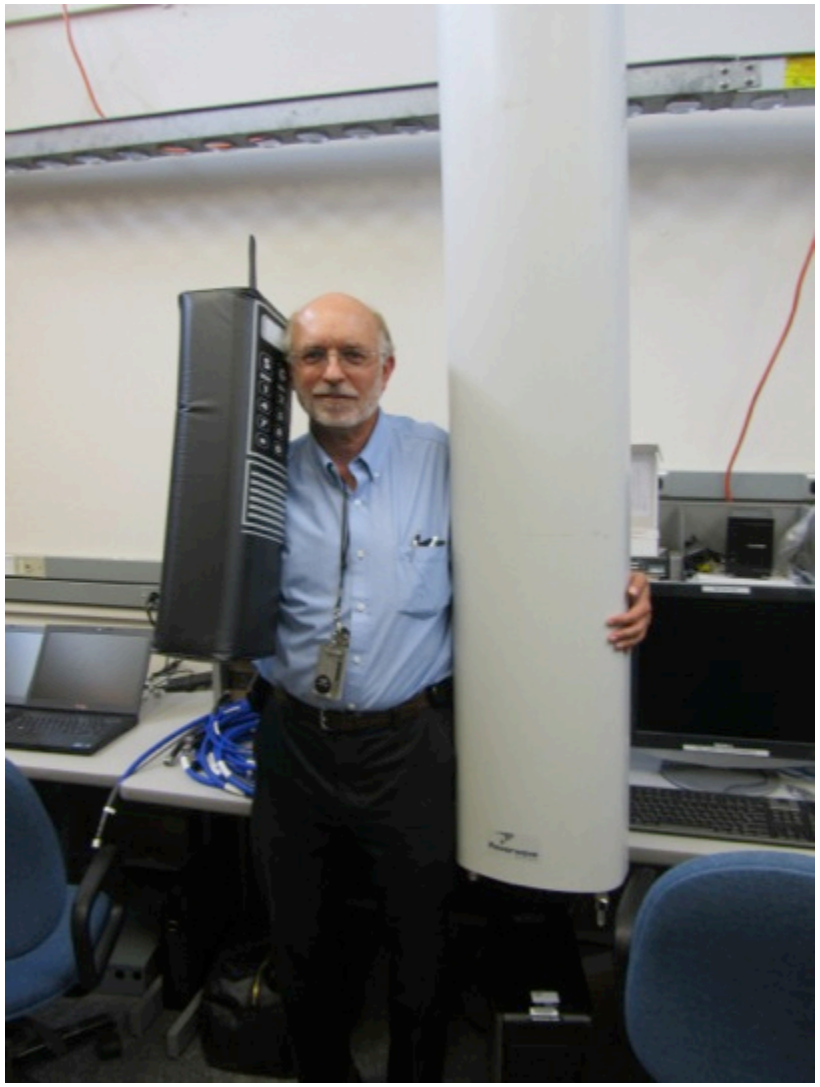
Public Safety LTE Radio?



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The Green Mountain Base Station

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The Green Mountain Base Station

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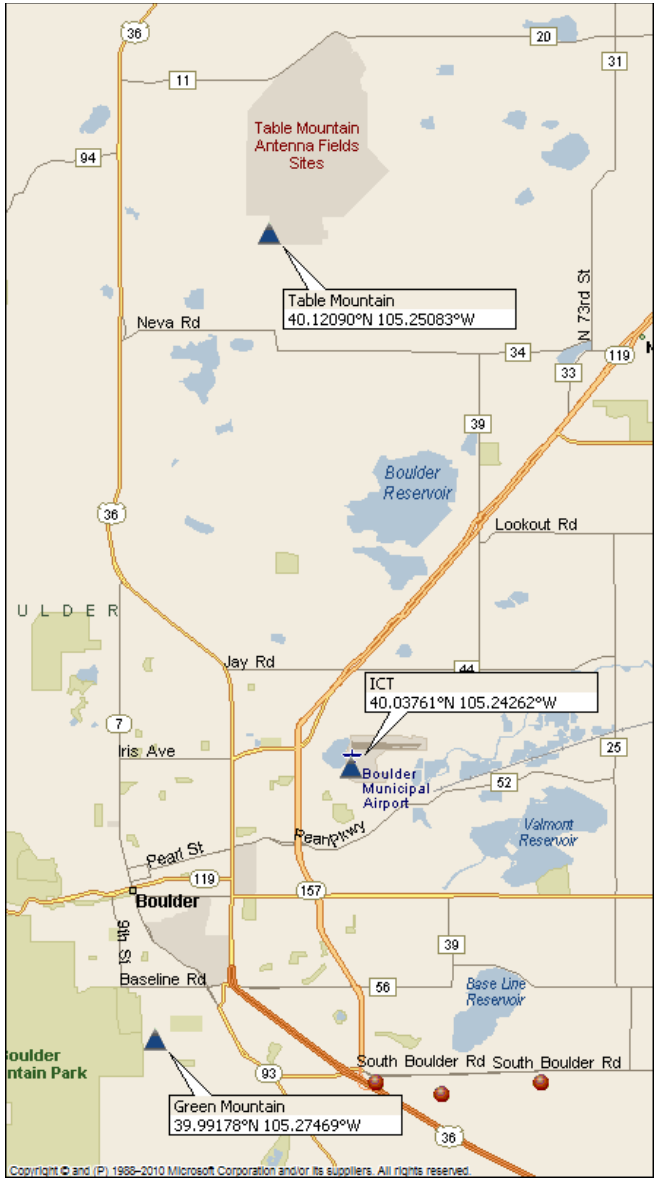
Public Safety Broadband Demo Network



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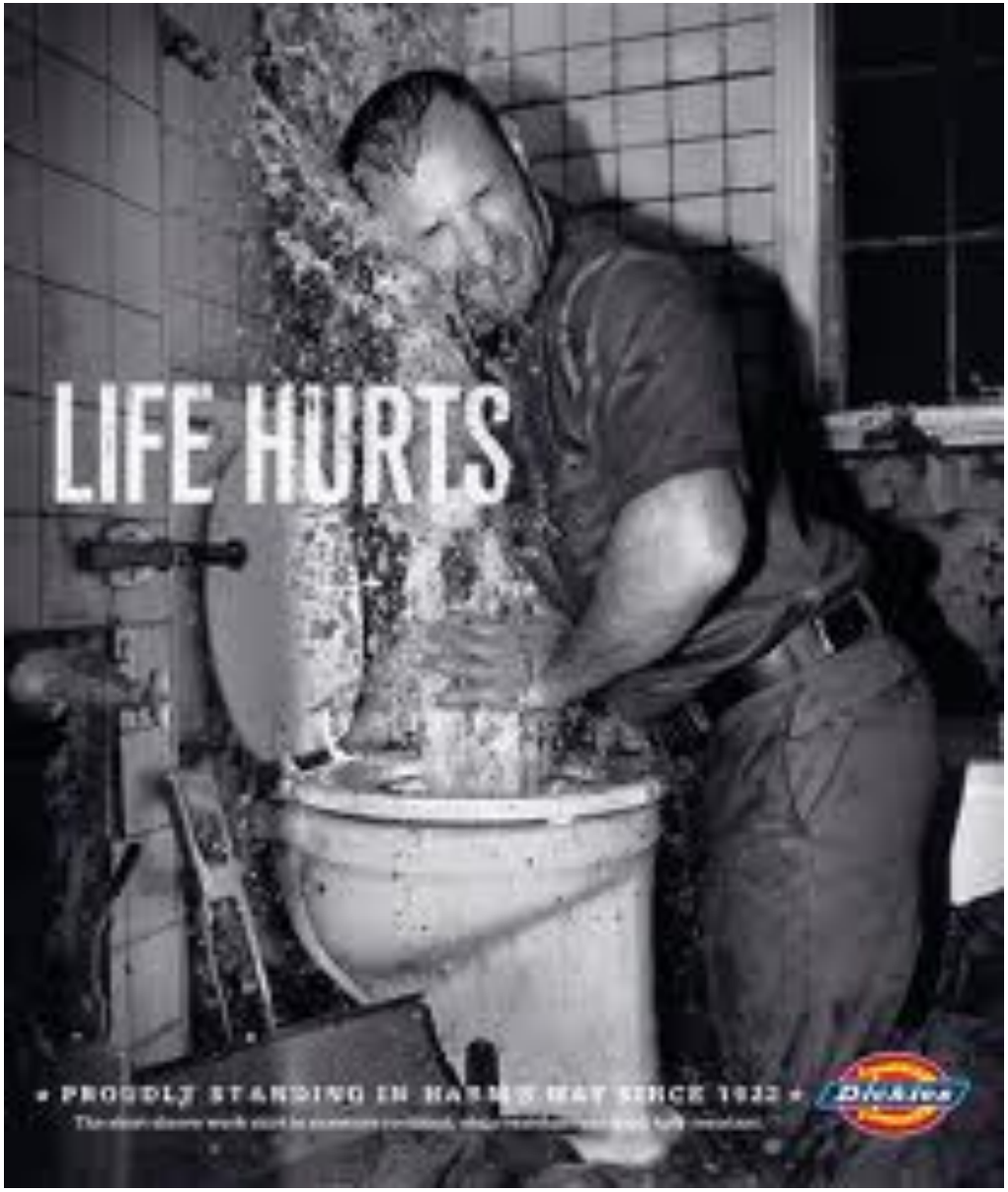
Testing



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Applications Tests

- Web Browser
- File Transfer (Up/Down)
- Email
- VPN
- Voice (Mobile Originate/Terminate)
- Instant Message
- Database

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Vehicular LTE Modem

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Vehicular LTE Modem

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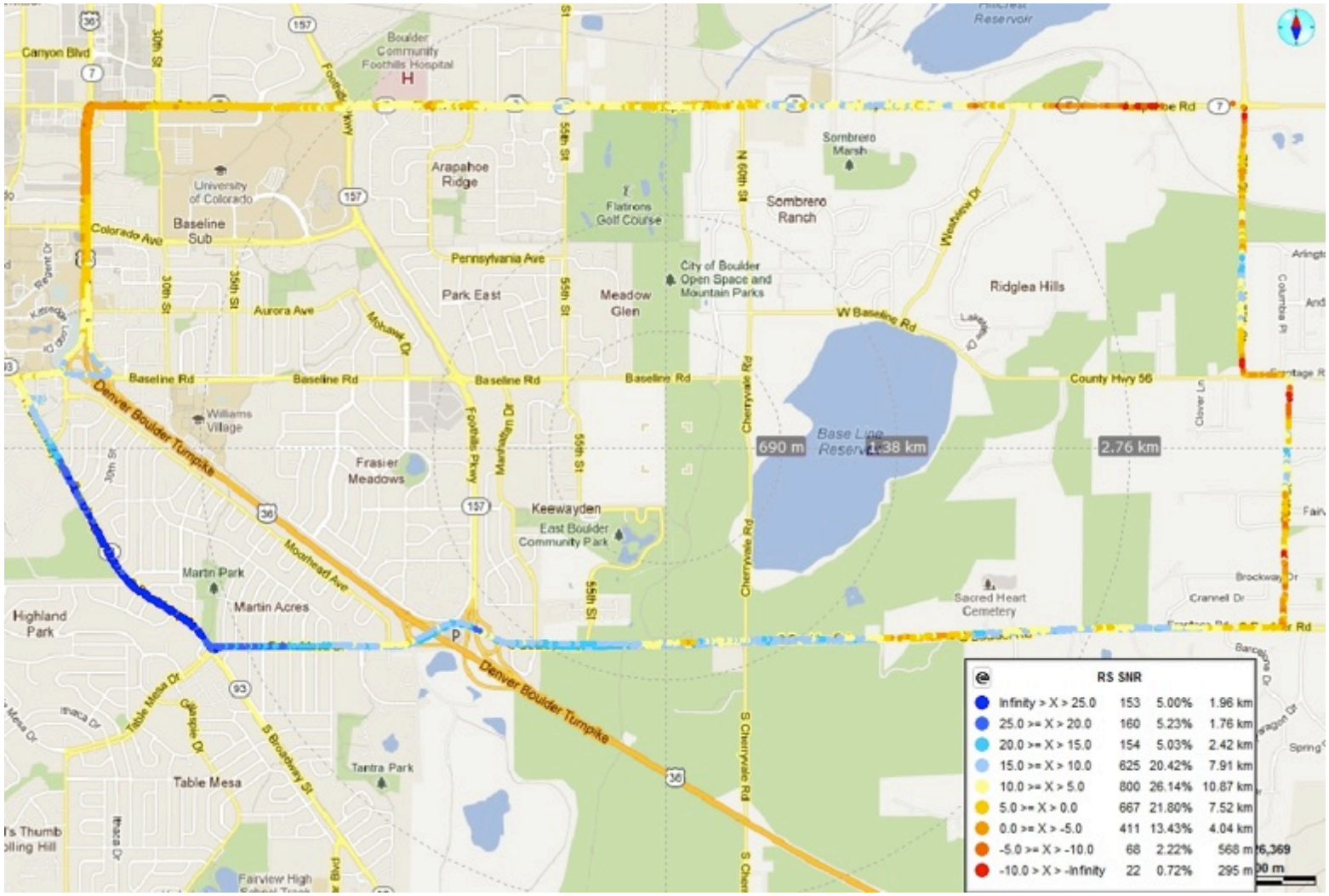
Drive Test Route



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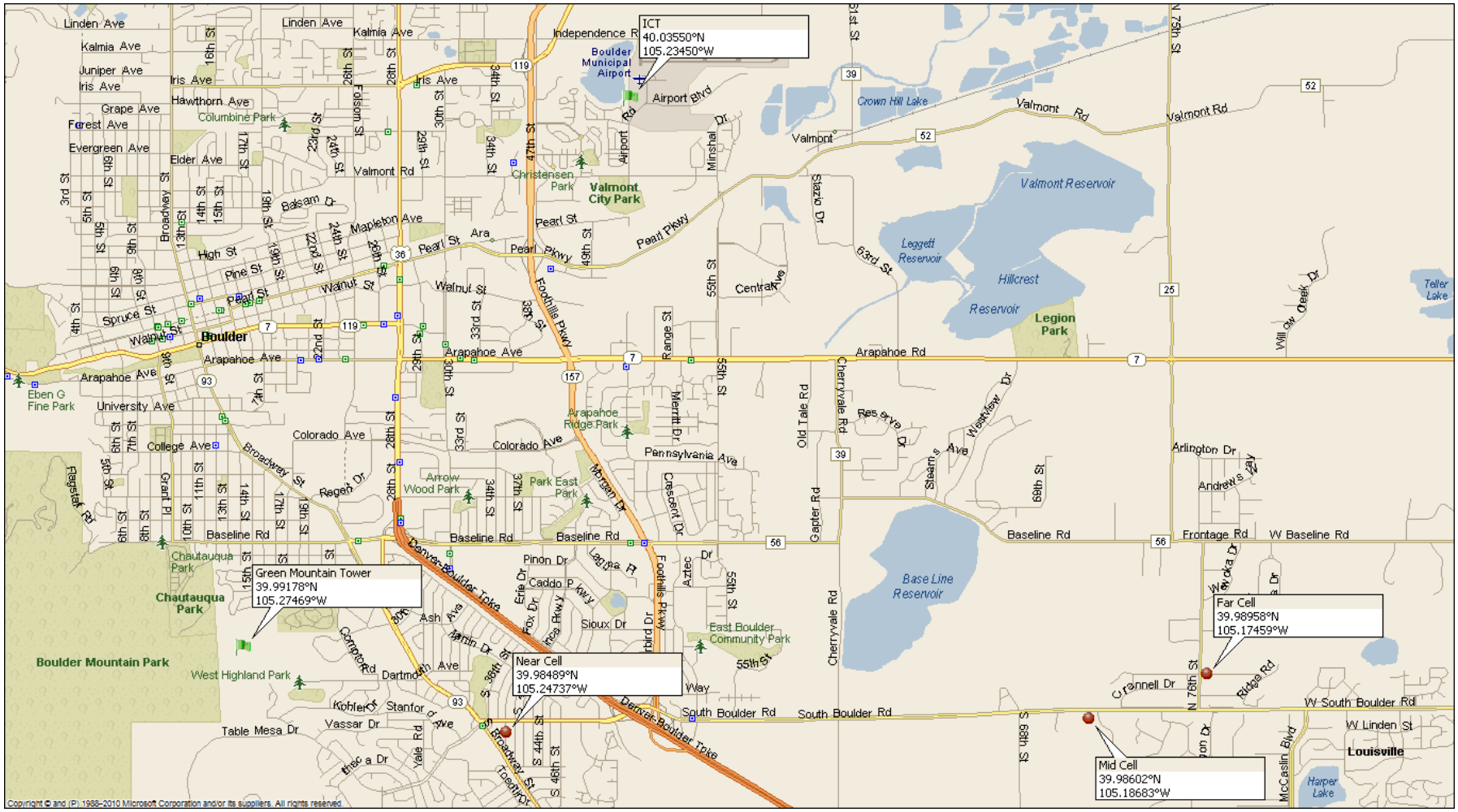
Near, Mid and Far Cell Locations



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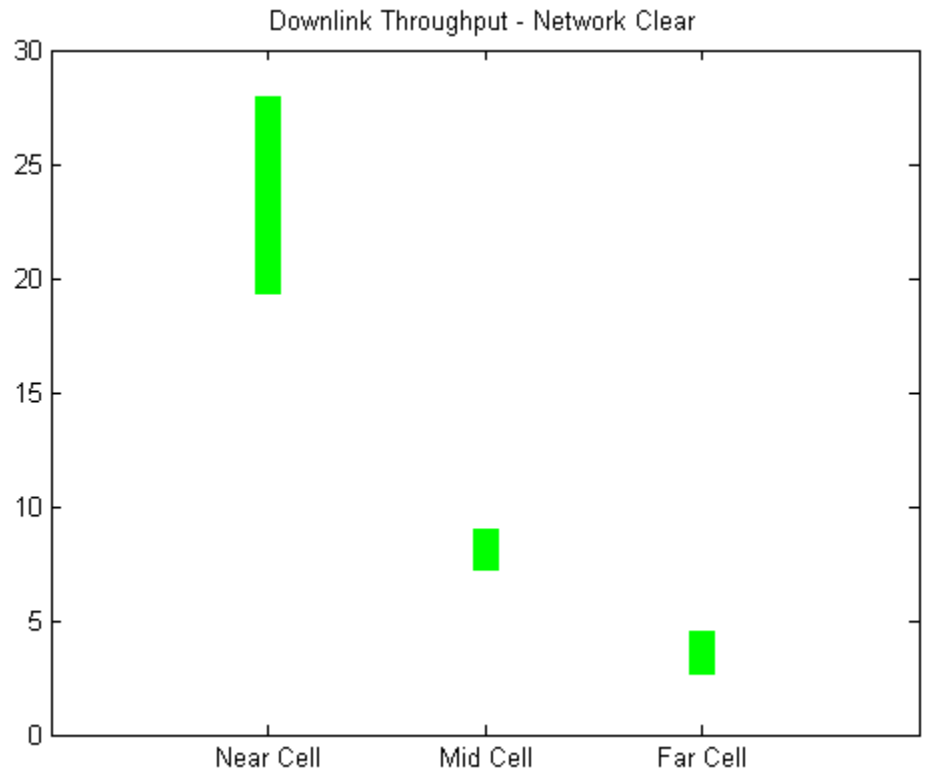
Clear Network Downlink



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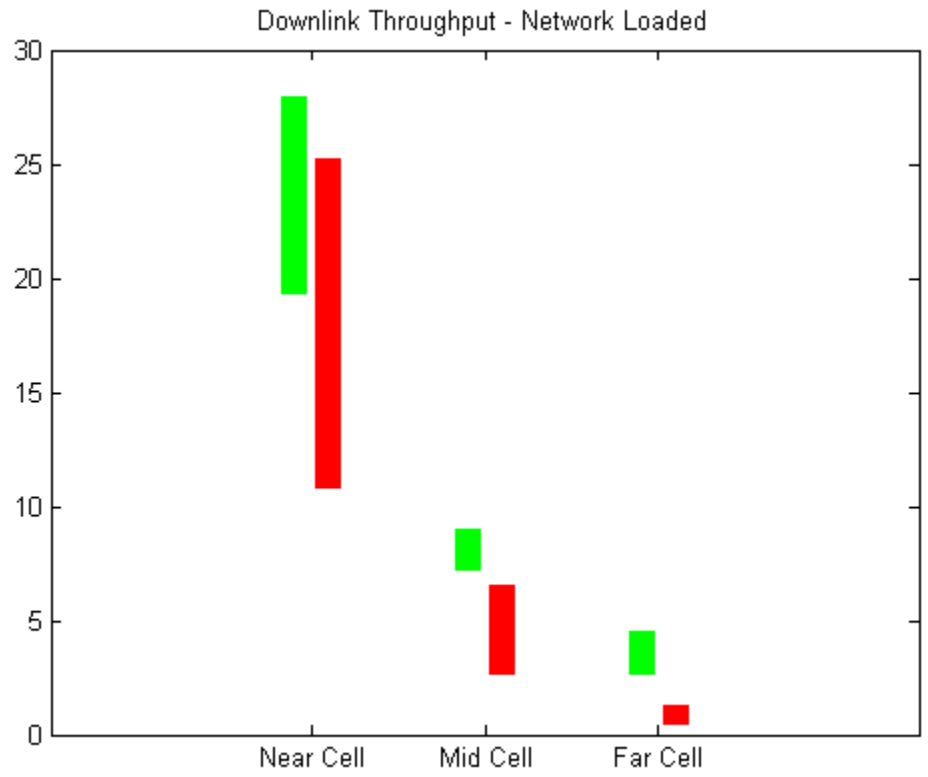
Loaded Network Downlink



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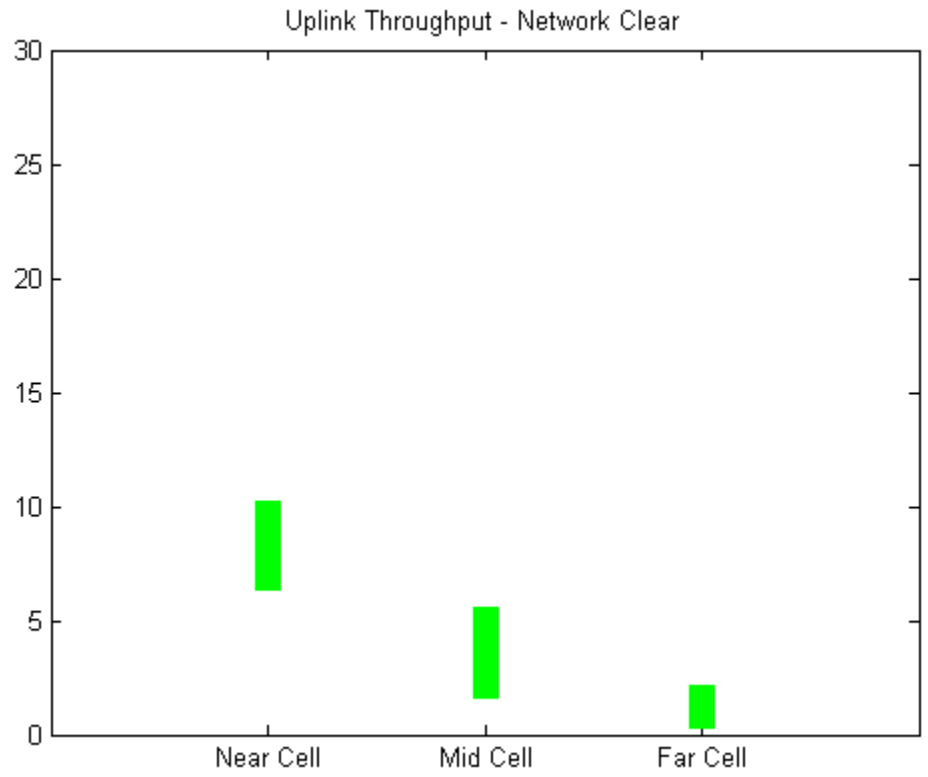
Clear Network Uplink



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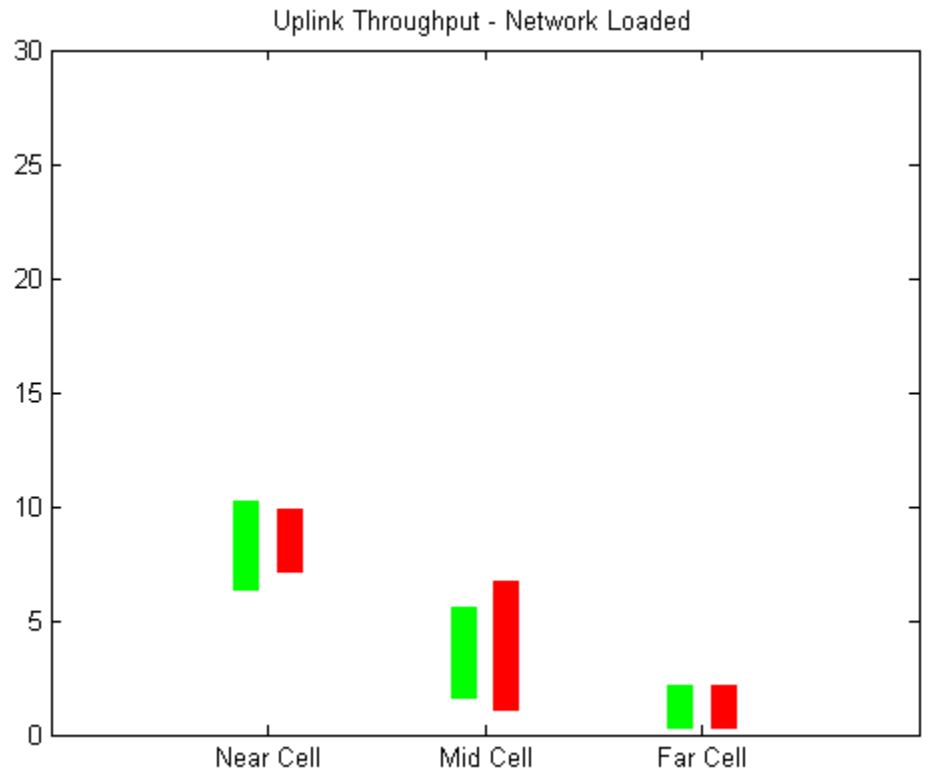
Loaded Network Uplink



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The End

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Public Safety 700MHz Broadband Demonstration Network

Update APCO 2012

What's New In the Demo Network?

- Testing Updates
- Ue and Infrastructure Conformance
- New CRADA Partners
- Lab Upgrades
- Future Developments

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Testing Phases

Phase 1

- Basic functionality testing
  - Physical layer tests to ensure that the submitted equipment will not interfere with other existing 700 MHz LMR, PSCR demonstration systems
  - Messaging/protocol tests
  - Public safety application tests
  - Basic drive test single user performance tests

Phase 2

- Phase 2.1
  - Physical Layer Tests: Examine several characteristics of the eNB that will indicate how this equipment will operate in PS scenarios.
  - Throughput Performance Tests
    - Tests examine throughput in bidirectional, downlink and uplink configurations.
- Phase 2.2
  - Performance Tests
  - Messaging/Protocol Tests
  - Network O&M - Alarm/ Fault Reporting
  - Application/"Status Info Homepage" evaluation

Phase 3

- Network architecture type testing, including evaluation of various PLMN, eNUM and IP implementations
- Interoperability testing that includes testing the EPC and inter-connecting multiple EPCs
  - Basic RAN IOT – UE and eNB based both
- Mobility, Handover & Roaming testing and evaluation (pending UE availability)
  - LTE-to-LTE (public safety-to-public safety)
  - LTE-to-LTE (PS to commercial)
- Stress, performance, messaging/protocol, application tests

PTCRB Status

- The PCS Type Certification Review Board (PTCRB) established as a Certification Forum by North American Operators
  - Creates framework for LTE Ue Certification by developing test cases for operators
  - Tests executed by 3rd party labs i.e. 7Layers Lab, Cetecom, AT4Wireless
- June 2010 PSCR invited to attend PTCRB Operators Meeting and introduce LTE Band 14
  - PSCR based Band 14 tests off existing LTE Band tests
  - March 2012 PSCR determined Band 14 CRs at an acceptable level to start validating devices

Specification	Band	Number of TC in RFT	Number of TC valid	Number of TC valid as %
3GPP TS 36.521-1	FDD 14	52	48	92%
3GPP TS 36.521-3	FDD 14	29	13	45%
3GPP TS 36.523-1	FDD 14	296	229	77%

- **First Band 14 PTCRB Certified Ue approved by PTCRB in July 2012**
  - **Motorola Solutions VML700**

NOTE: PSCR is not a PTCRB lab - no devices or test equipment will be validated or certified at PSCR

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Infrastructure Conformance

- MultiService Forum PSCR submitted a work item at the August 2011 MSF for a S1 MME Conformance Test Plan (a.k.a Backhaul)
  - Initially test S1-MME
    - Over 200 pages of tests (~140 tests)
  - Scheduling IOT event Q4 2012
- PSCR submitting new work item for S6a conformance testing (Primary HSS Interface)
  - Working with ETSI and HSS CRADA partners on co-development (20 tests in development)
- Other global operators and vendors are realizing importance of IOT and Conformance
  - According to Telecom Italia less than 50% of mandatory 3GPP Rel 8 and 9 features have been IOT'd

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CRADA

- CRADA – Cooperative Research And Development Agreement
  - CRADAs are partnering tools allowing federal laboratories to work with US industries, academia and other organizations on cooperative R&D projects. CRADAs provide flexibility in structuring project contributions, intellectual property rights, and in protecting proprietary information and CRADA research results.

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Executed CRADAs

Lab Updates

- Current Configuration
  - 4 RAN vendors deployed
    - 3 of 4 vendors operating at 10 MHz channels
  - 7 EPC vendors deployed
  - 4 Ue Vendors deployed
- Most RAN and EPC vendors have completed upgrades to 3GPP Release 9 this summer – remainder pending by end of year
  - Will allow for future VoLTE, SMS & LCS testing
- Integrated new Ue RF, RRM and Signaling conformance test equipment from Anritsu (RF & RRM)and Anite (Signaling)

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Scheduled Upgrades

- Updating lab equipment for 3GPP Release 9 support
- Upgrade network backbone from native 1Gb to 10GB layer 2 switch matrix
- Integrate Diameter Edge Agent and Diameter Routing Agent vendors into network
- Upgrade microwave backhaul from 80Mbps to 300Mbps
- Integrate three new RAN vendors
- Integrate new Ue devices (i.e. tablet & smartphone)

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Future Developments

- PSCR executing CRADAs with small cell vendors
  - Evaluating "HetNet" small cell trial
  - Still TBD if & when
- Integration of IMS core
  - VoLTE & SMS support
  - IMS video
  - OMA PoC

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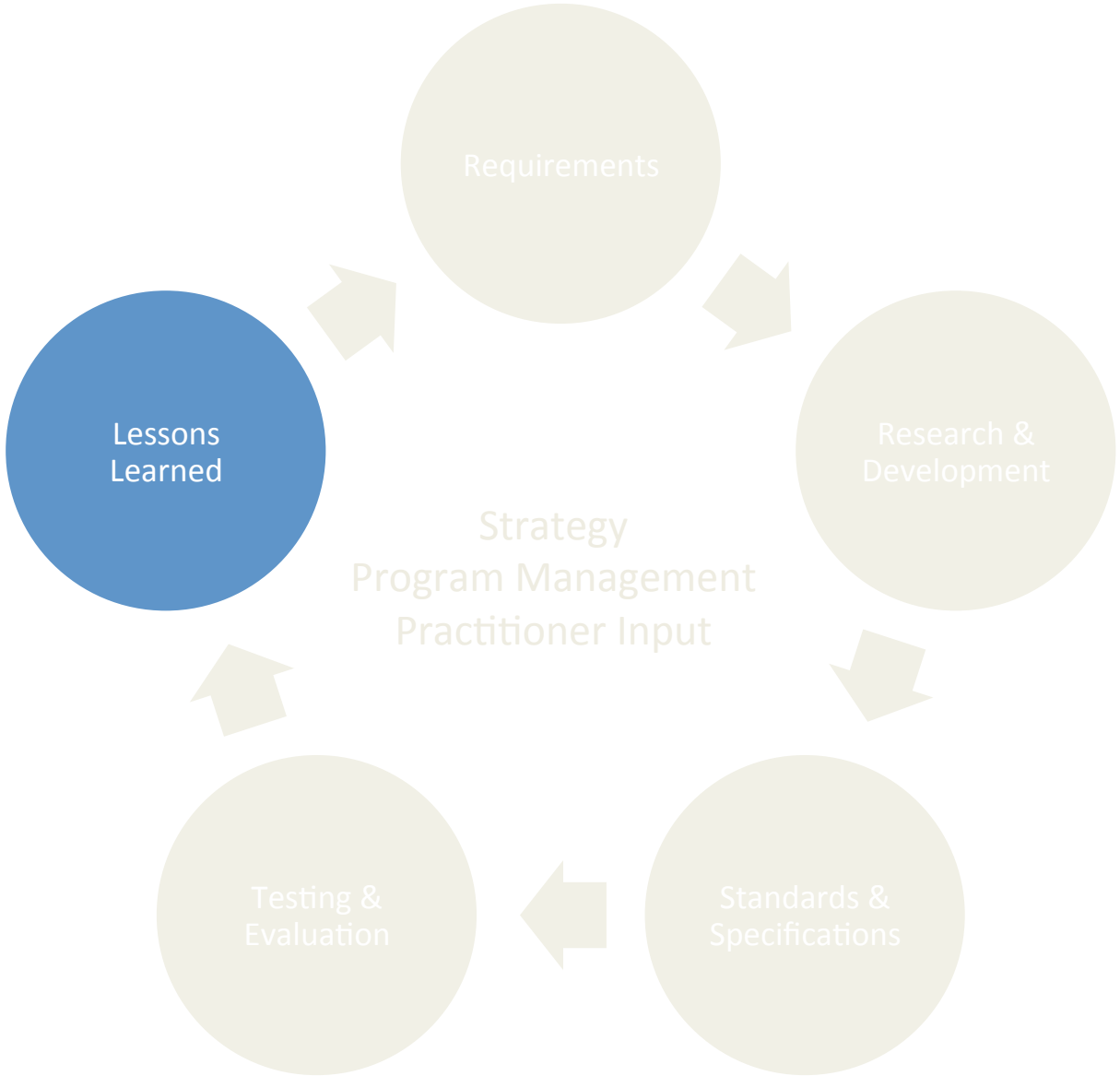
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Lessons Learned: Technical Advice and Reports

PSCR provides technical advice to crucial public safety and Federal partners:

- Office of the Vice President (OVP)
- Federal Communications Commission (FCC)
- Department of Homeland Security (DHS)
- Department of Justice (DOJ)
- National Telecommunications and Information Administration (NTIA)
- State and Local Public Safety Practitioners and Associations
  - Waiver Jurisdictions
  - NPSTC

Reports on Lessons Learned from the Demonstration Network will be published as testing phases are completed

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Moving Forward

Providing objective technical information about the network

- The PSCR Demonstration Network provides a central and independent test bed/ laboratory to help public safety understand 3GPP Release 9, 10, etc.
  - Provides an objective forum for public safety to test and verify new capabilities

Ensuring the network has the crucial long-term capabilities to meet public safety's needs

- Coordinating development of crucial capabilities to make the network successful across multiple requirements efforts and standards bodies:
  - Audio Quality over LTE testing
  - Direct mode in LTE
  - PTT over LTE
  - LMR to LTE

Uniting public safety to ensure the network meets long-term needs

- PSCR is currently interacting with the vast majority of the key stakeholders across these multiple efforts
- The next step is for NIST to pull them into a coordination point that ensures public safety's requirements are being met by the various organizations

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For Additional Information:

http://www.pscr.gov

Andrew Thiessen
athiessen@its.bldrdoc.gov

Rob Stafford
stafford@its.bldrdoc.gov

Emil Olbrich
emil.olbrich@nist.gov

Michael Souryal
michael.souryal@nist.gov

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