



Public Safety Communications Research Program

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Presentation Materials

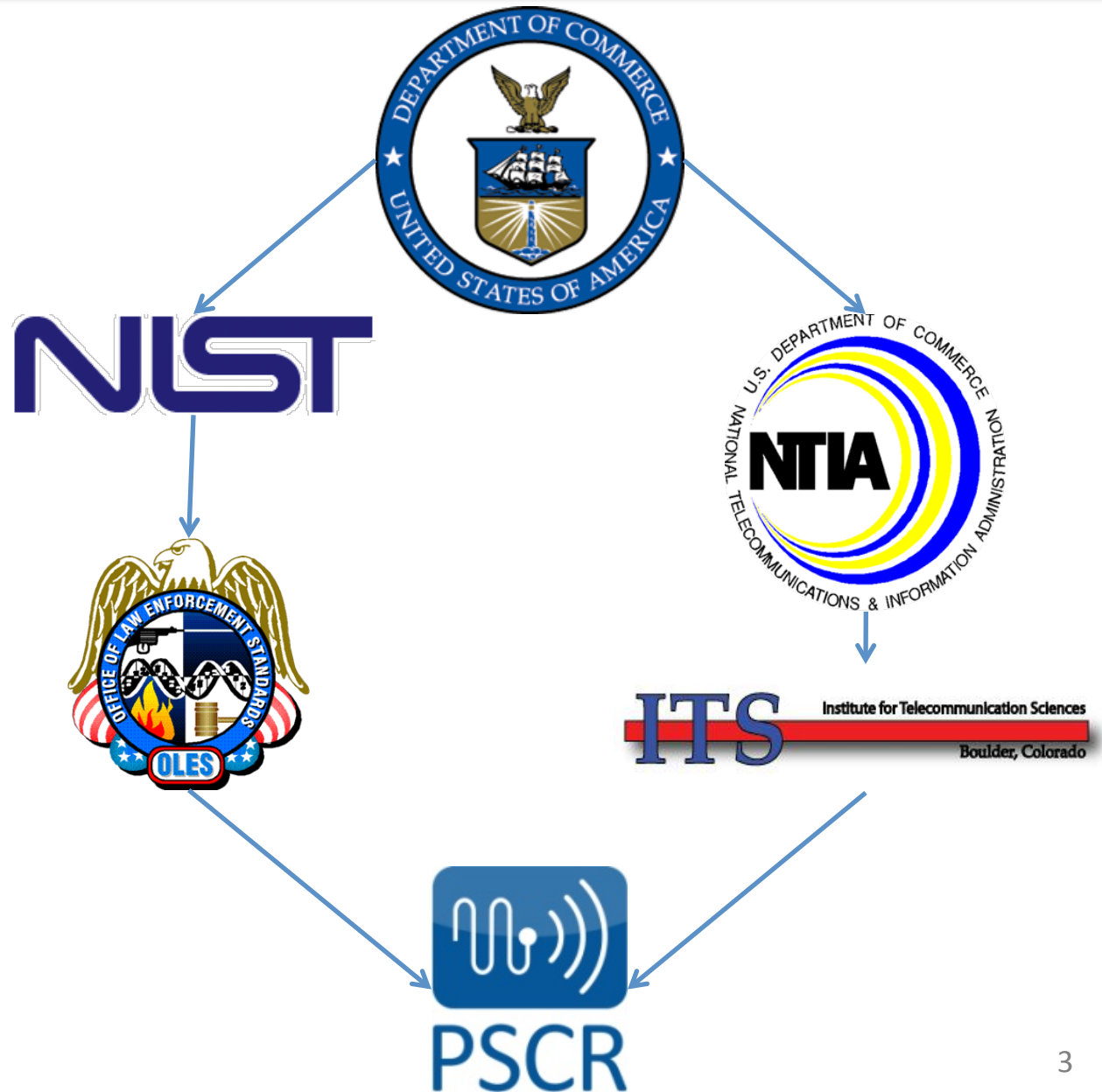
- All presentations can be downloaded from <http://pscr.gov/agenda.php>
- Send questions and/or comments at any time during the meeting to zoomhz@its.bldrdoc.gov

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)



PSCR Program Sponsors



Homeland Security

Department of Homeland Security



Office for Interoperability and Compatibility
(DHS/OIC)



Department of Justice



Community Oriented Policing Services

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.

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	RF Propagation Studies	

PS Broadband Demonstration Network Staff

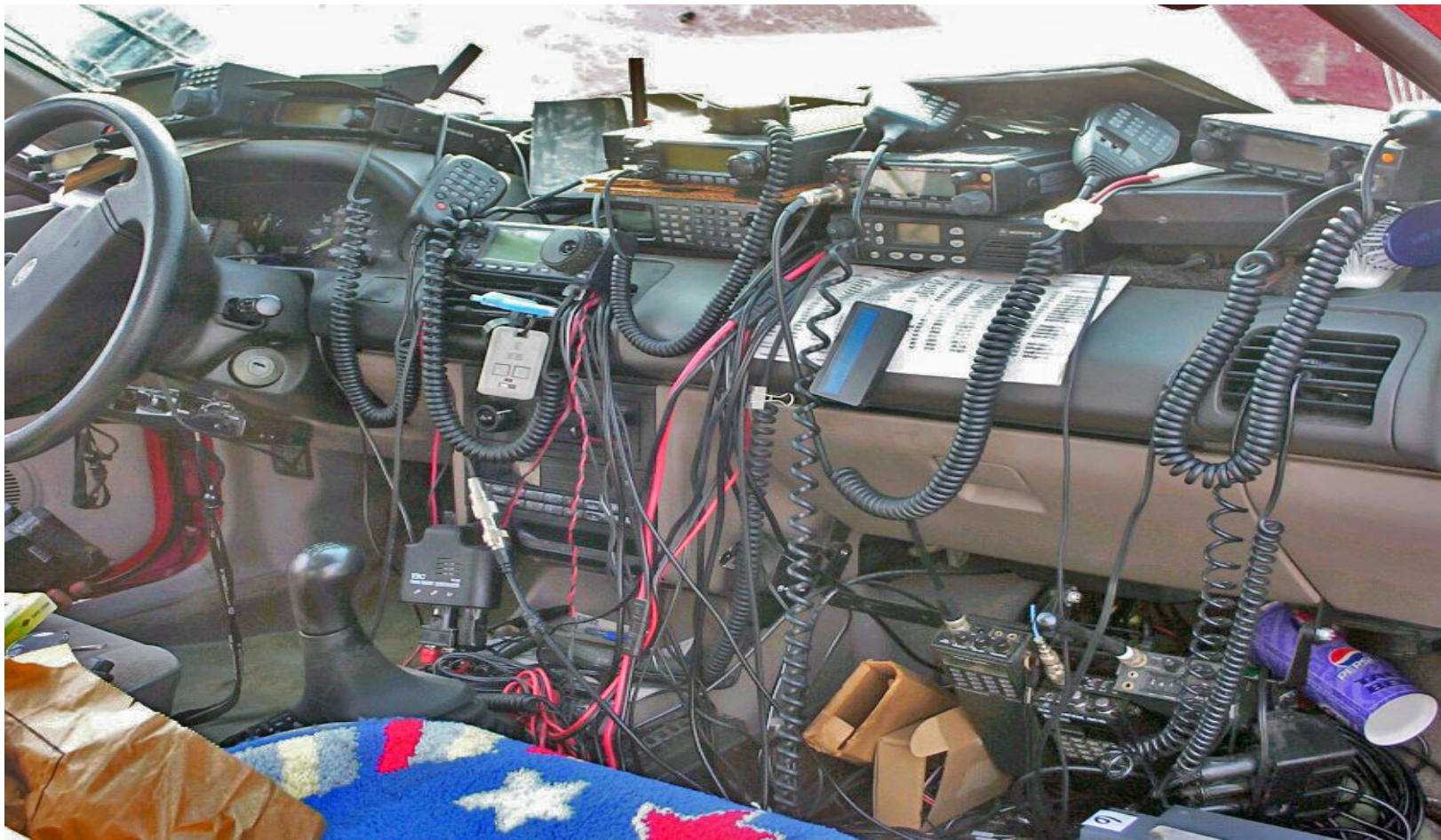
Truly a TEAM effort:

- DJ Atkinson
- Kameron Behnam
- Chris Behm
- Ron Carey
- Jon Cook
- John Ewan
- Camillo Gentile
- Nada Golmie
- Sam Gomez
- Emil Olbrich
- Chris Redding
- Corey Reynolds
- Richard Rouil
- Michael Souryal
- Rob Stafford
- Andy Thiessen
- Ken Tilley
- Bruce Ward

Special Thanks:

Darcy Anton, Kathy Mayeda, Corey Reynolds

Public Safety Interoperability



Logistics

- Need help? Conference staff is available at all times in the **Registration Coat Room** (outside the Centennial Ballroom).
- Breaks. Refreshments will be served during morning and afternoon breaks in the **Centennial Foyer** and the **Interlocken Foyer**.
- Lunches. Lunch will be served buffet style in the **Centennial Foyer** and the **Atrium**. Tables are spread out between the **Centennial Ballroom**, the **Private Dining Room**, and the **Atrium**.
- Wireless Internet. Connect to **AVT Event Technologies**.
 - **Username:** PSCRint32012
 - **Password:** PSCRint32012

Public Safety Broadband Demonstration Network Overview

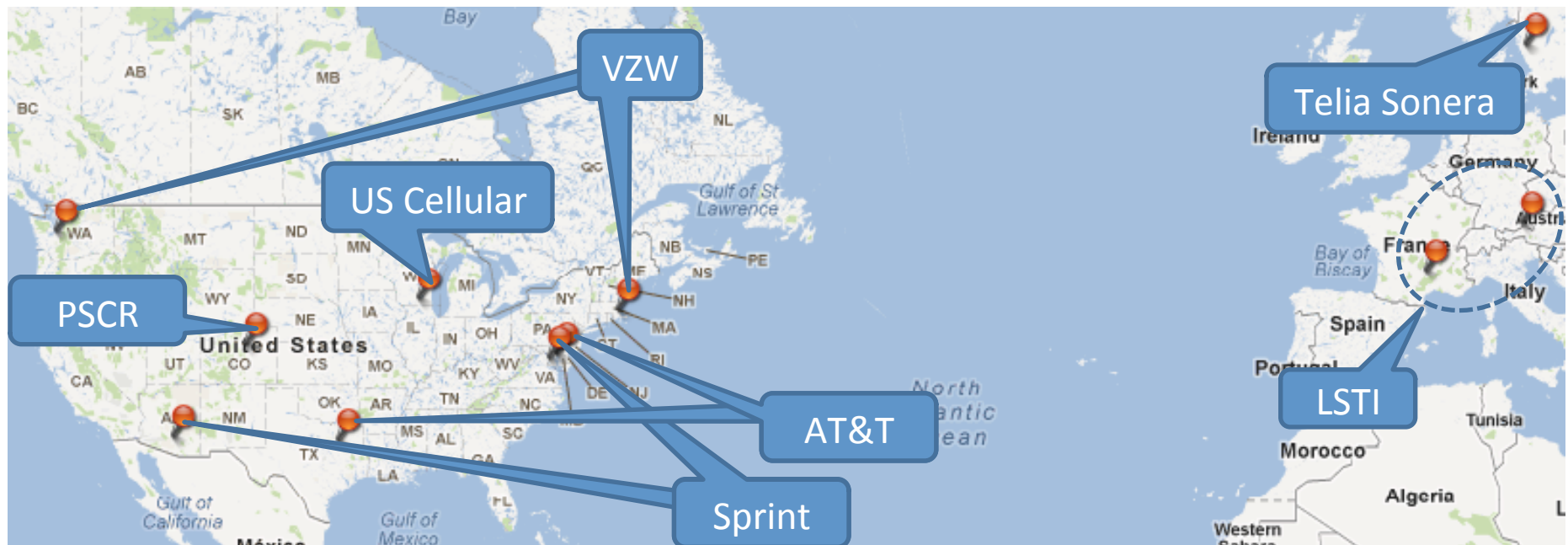


Public Safety Communications Research

Emil Olbrich
NIST OLES

Why a demo network?

Commercial service provider establish demo/trial networks to test and evaluate new technologies... such as LTE



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 NIST, or are recommended by NIST, or that they are necessarily the best materials, instruments, software or suppliers for the purposes described.

Genesis of PSCR Demo Network

- **Spring 2010 PSCR kicks off 700 MHz LTE 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 vendor-neutral 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.

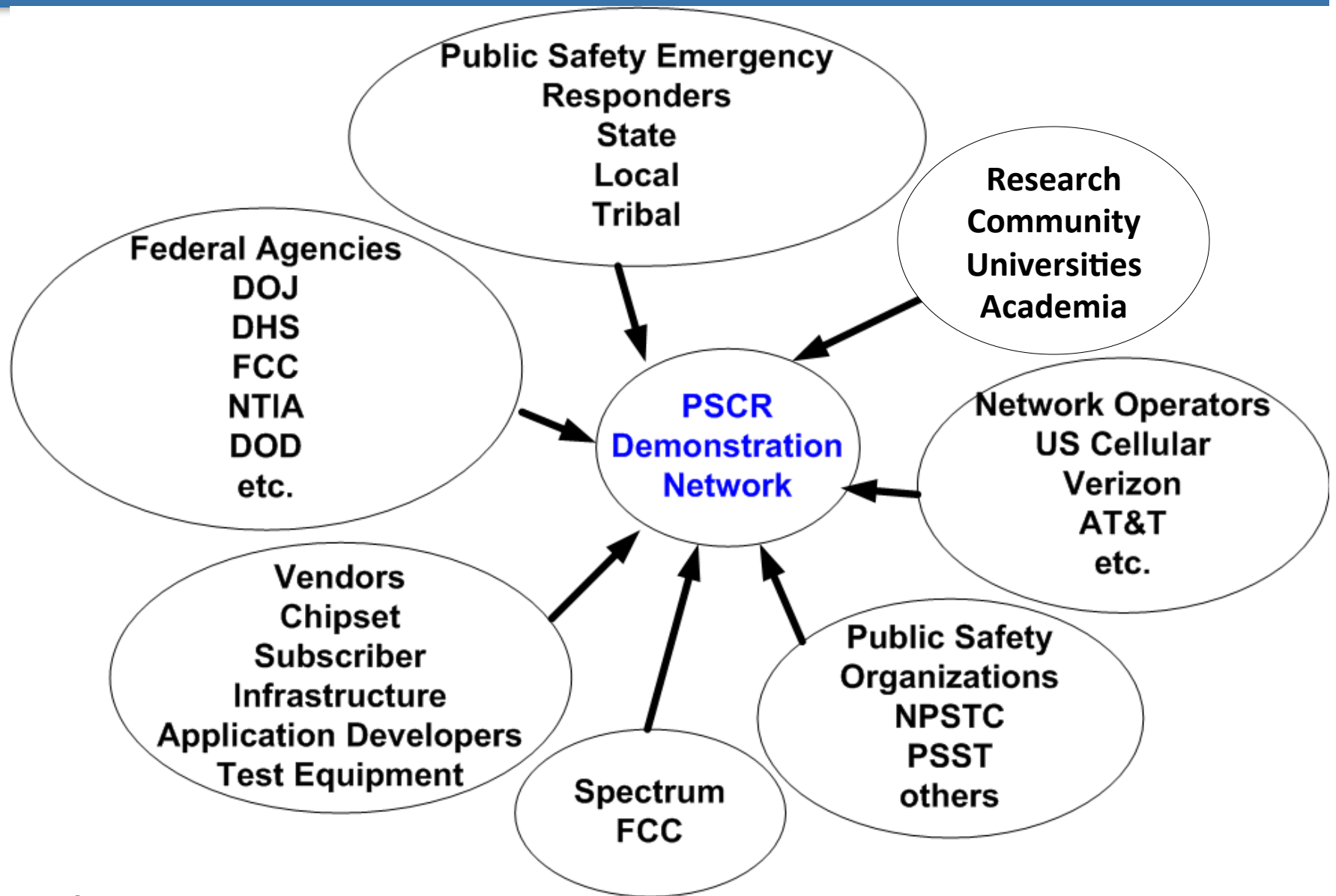
PSCR Demo Network Project Plan

- **Obtain, Procure and generate interest from broadband vendors to develop a 700 MHz broadband equipment ecosystem - including Band Class 14 (D Block & Public Safety Block), Long Term Evolution (LTE)**
 - Stimulate early development for public safety systems
 - Support the commercial 3GPP standards process with public safety requirements
- **Demonstrate broadband air-interface and core network capabilities**
 - Proof of concept, Improve quality for future systems, Create new technology and requirement benchmarks
 - Evaluate broadcast capabilities for wide area, simultaneous data delivery
- **Interoperability with existing cellular, broadband and LMR technology**
 - Roaming functionality with LTE and non-LTE systems
 - How QoS, billing, priority, pre-emption and applications work when roaming
- **Validation of key public safety functionalities and requirements**

How do we accomplish the plan?

- R&D **nationwide interoperability** through a unified approach to network design and implementation
 - Testing (conformance, performance and evaluation)
 - Multi-site/vendor Over-The-Air network – allows consistent testing between vendors
 - All eNodeBs co-located and share common antenna system
 - EPCs local and remote
 - Dedicated RF & Interoperability test labs
 - Develop guidelines/Industry Requirements for network architecture, RF, IP, PLMN, IMSI, eNUM, Security, Application... etc
 - Advanced feature testing – QCI, ARP, eMBMS, FFR, Channel Bonding, IPX/Roaming

Demo Project Stakeholders



NOTE: This is a partial stakeholder list

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.
 - 50+ submissions – more in process
 - Project Phased Approach relates to phased CRADA execution
 - Judgment of NIST on whether or not to execute CRADA based on project needs

Executed CRADAs



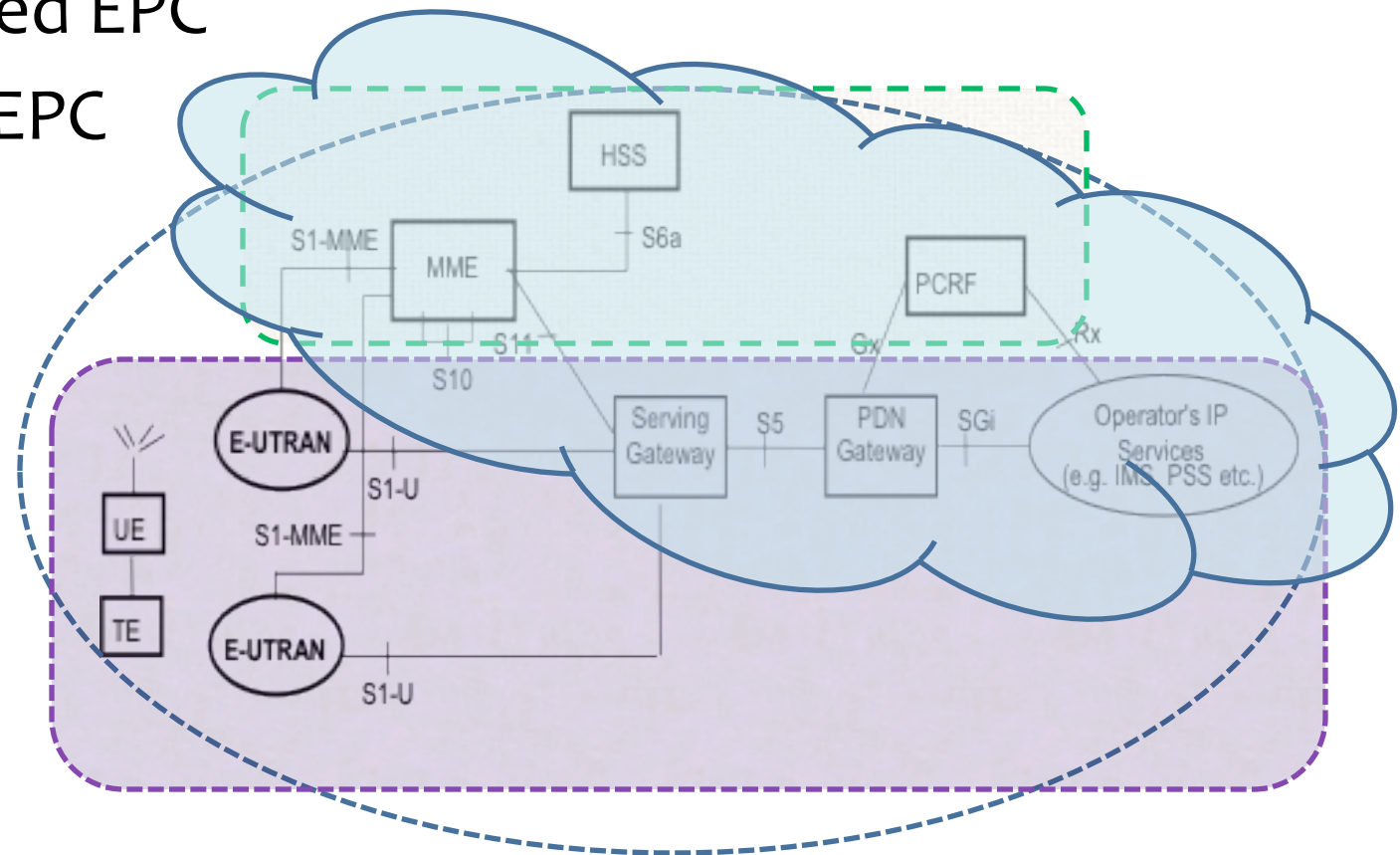
Demo Locations

- The initial laboratory and demonstration network will utilize the PSCR facilities located in Boulder, CO.
 - PSCR Boulder labs will be used for EPC testing and lab RF testing
 - Local Application servers
 - RF, signaling test equipment
 - Multiple drive test
 - RF Load testing
 - End-to-End test capability – RF to individual EPC interfaces
 - Multiple EPCs on site in various configurations – distributed and full core
 - UICC programming capability

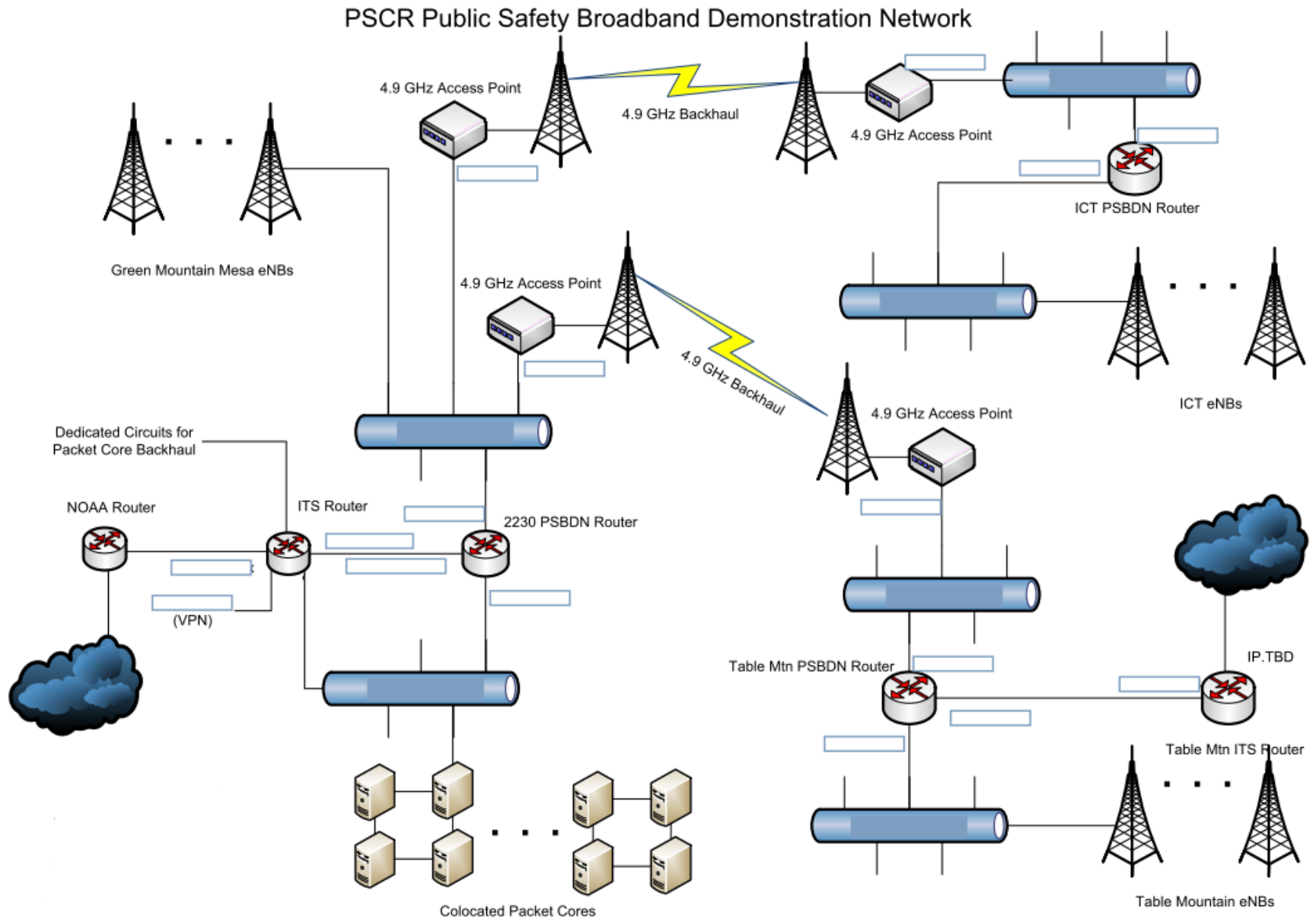


Multiple EPC Configurations

- Full EPC (local)
- Distributed EPC
- Remote EPC



IP System Architecture



Field Sites

Multi-site Over The Air (OTA) test site located in Boulder, CO

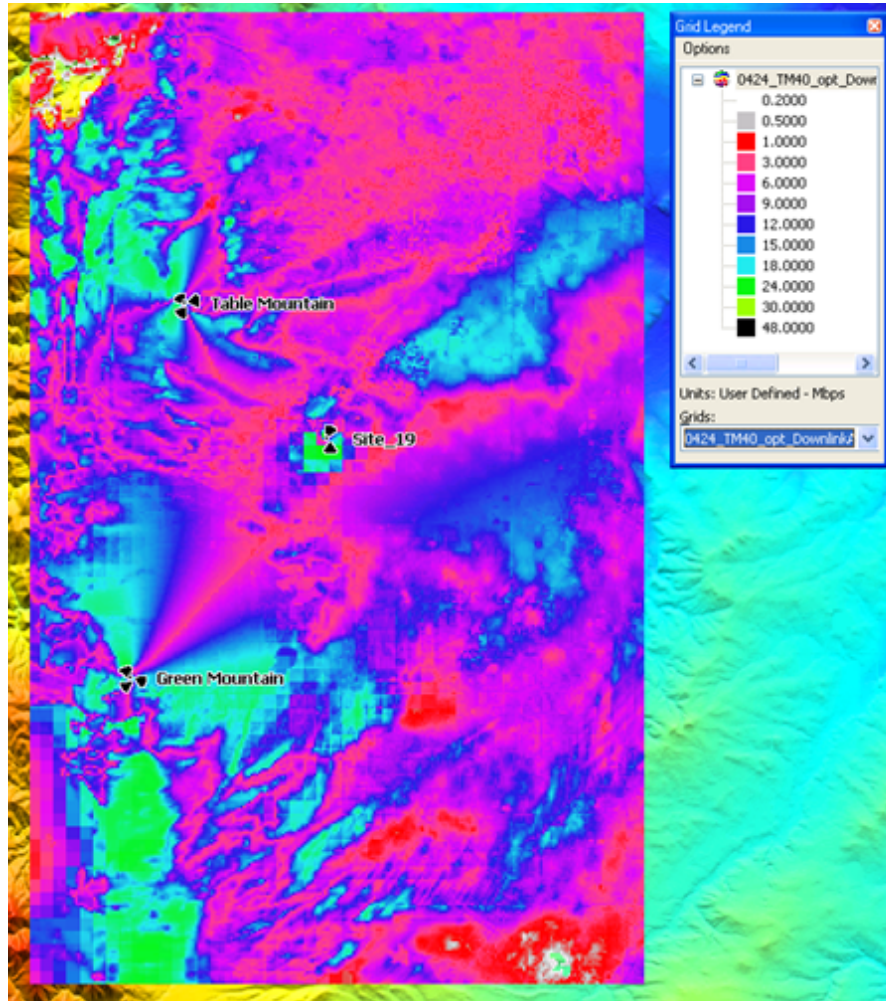
- Department of Commerce Boulder Laboratories Table Mountain Radio Test
 - 1 of 2 RF quiet zones in the US allows us to do specific RF related testing
 - Good for rural coverage and throughput tests
- Green Mesa (located behind DoC Campus)
- Two portable sites
 - Cell On Wheels (COW)
 - Cell On Light Truck (COLT – a.k.a ICT)
- Backhaul connections via fiber and microwave (4.9 GHz and unlicensed)
- Each eNodeB co-located at each site
- Utilize same RF transmission & backhaul facilities
- Test in variety of RF conditions (rural & suburban), antennas



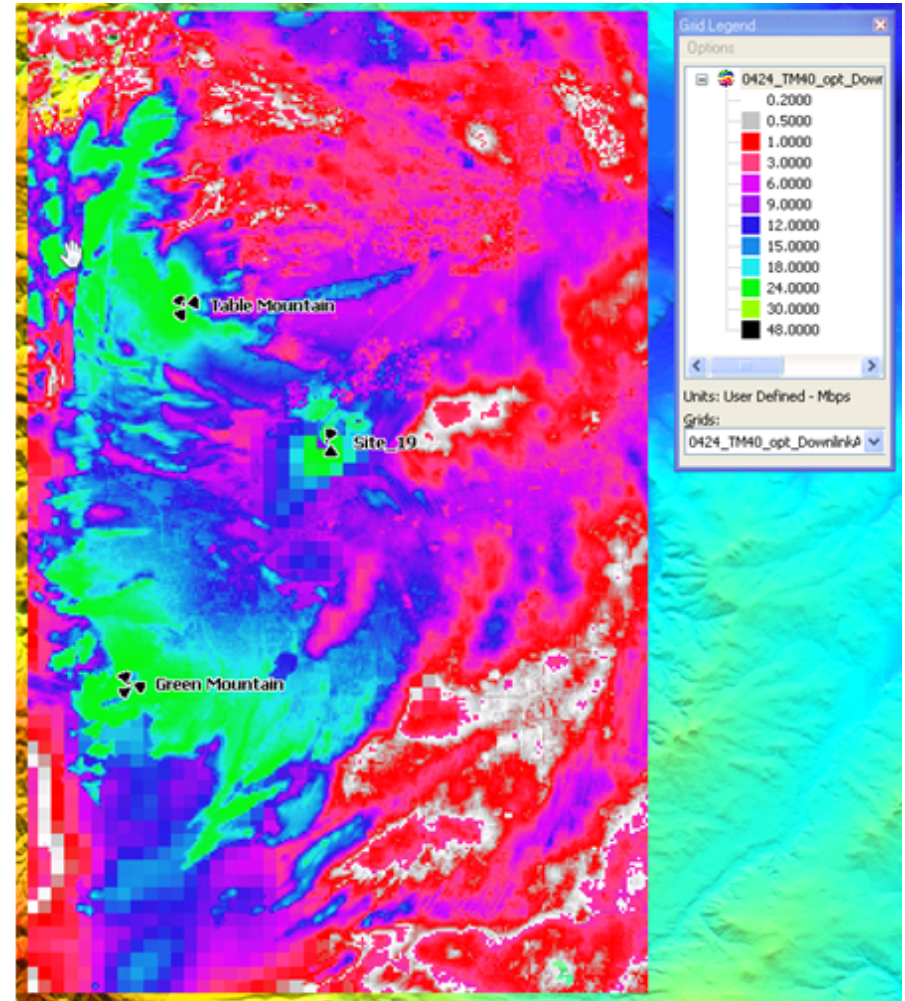
NOTE: Each site enabled with RET and multiple vendors antennas



Simulations



Area DL > 768 kbps: 98.0%



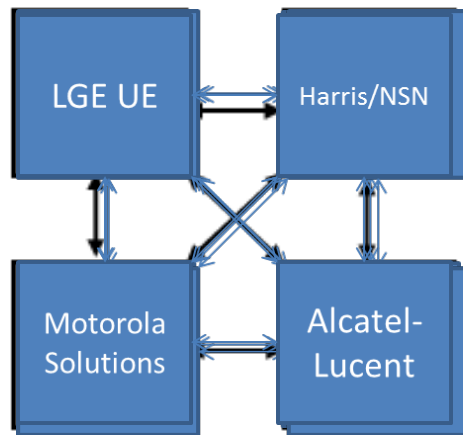
Area UL > 256 kbps: 91.7%

Testing & Simulations

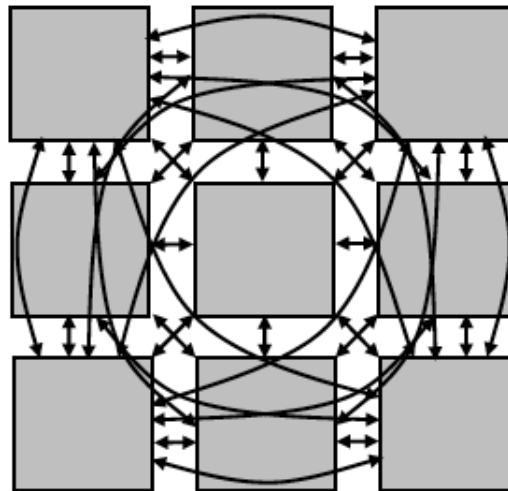
Updates

Managing complexity is an exponential problem

Its not that systems can't work it is primarily that as complexity rises there are just so many operational combinations to design and test for



If 4 elements in a system are capable of interacting either in a linear or complex fashion there are six bi-directional scenarios to design and test for



But for a system with 9 elements, there are 36 bi-directional scenarios to consider

For n elements there are $n^2 - n$ possible interactions.
E.g. for 50 elements we have 2450 interactions...

Conclusion:
Interaction must be minimized since we cannot design or test quality into unnecessarily complex systems

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

Testing Status

- Phase 1, Phase 2.1 & Phase 2.2 tests published & available on www.pscr.gov
- Phase 1 Testing completed with all available RAN vendors
 - Test plan stable at v1.22 - **10 MHz testing TBD**
 - Completed Phase 1 testing with Alcatel-Lucent, MSI and Harris/NSN
- Phase 2.1 testing complete with Alcatel-Lucent
- Phase 2.2 TBD
- Phase 3 TBD

EPC IOT

-  NETWORK VENDORS IOT FORUM &  MultiService Forum both examined for potential use as EPC test forums
 - Non-vendors are not allowed to participate in NVIOT.
 - Currently pursuing MSF due to direct liaisons into 3GPP, ATIS, GSMA & ITU
 - Existing EPC IOT test plan to build off of
 - Basic Interoperability: e.g. MME Pooling.
 - Roaming and Interconnect
 - Non-LTE Access to EPC
 - Handover/Relocation
 - Self Organizing Networks/Automatic Neighbor Relation
 - 2nd LTE Plug fest for VoLTE executed
 - Comprehensive testing of multiple EPC interfaces (23 so far)
 - Many CRADA vendors already participating in MSF

MSF EPC IOT Process

PSCR

- PSCR identifies and/or defines PS conformance tests and EPC IOT
- New Work Item introduced into MSF

MSF

- Hosts IOT and plug fests
- MSF publishes test plans and results to members

Test Lab

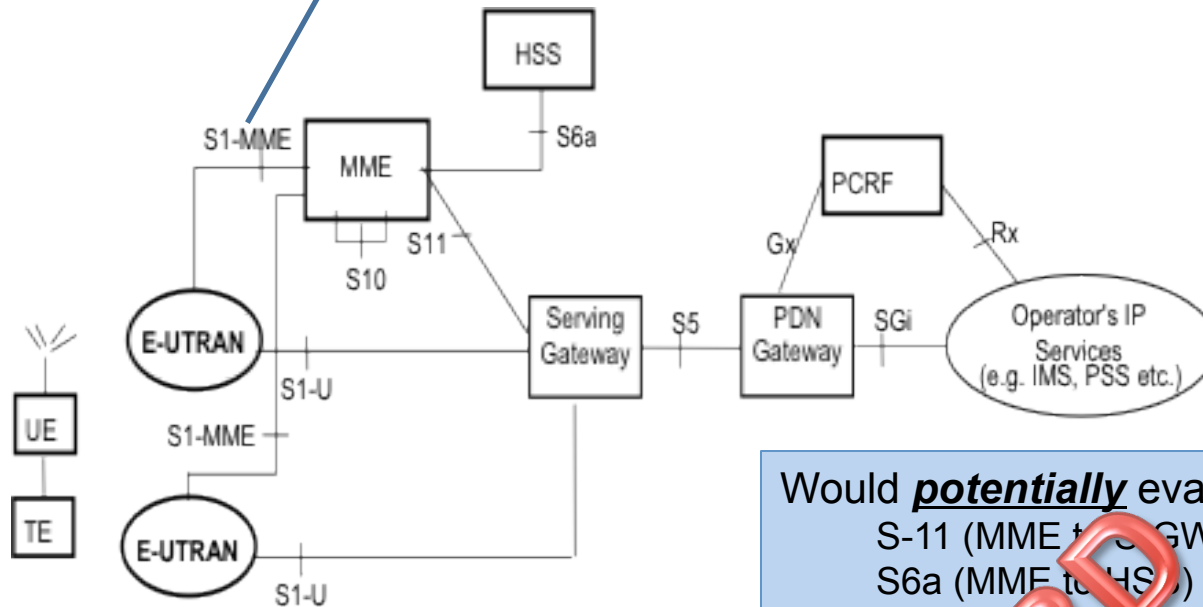
- Executed multi-vendor tests per MSF process
- Crucial to plug fests

Infrastructure Conformance

- PSCR submitted a new work item in March 2011 to the Multi-Service Forum entitled: MSF LTE EPC Certification Program
 - PSCR re-submitted a modified work item at the August 2011 MSF that removed certification aspect - S1 MME Conformance Test Plan
 - Contribution msf2011.191.00 – just went through straw ballot & comment resolution (80+ comments).
 - Updated to msf2012.039.00
 - Initially test S1-MME
 - Over 200 pages of tests (~140 tests)
 - Scheduling IOT event Q3 2012

S1-MME Tests

Single LTE Interface ~
140 Unique Test Cases



Would **potentially** evaluate :

- S-11 (MME to S-GW)
- S6a (MME to HSS)
- S5 (S-GW to P-GW)
- Gx (P-GW to PCRF)
- Rx (PCRF to P-CSCF)
- S-10 (MME to MME)...etc

PSCR Standards & Testing

- Lead and participate in public safety requirements development
- Generate interest from broadband vendors to develop a 700 MHz broadband equipment ecosystem
 - Band Class 14 (D Block & Public Safety Block), Long Term Evolution (LTE)
 - Stimulate early development for public safety systems (e.g. Waiver Orders)
 - Support & participate in the commercial standards and testing process with public safety requirements e.g.
 - Publish test results (non-attributable) to inform stakeholders



Study Item Groups

- PSCR has defined specific Study Items for the Broadband Demonstration Network. These Study Items are areas of technical need identified within the PSCR Demonstration Network project that require input from our stakeholders.
- The following Study Items will be led by the PSCR Project Team:
 - UE Testing – UE Sharing Program in progress
 - **Network Identifiers – Published PSCR 700 MHz Demonstration Network Identifier Guidelines – *a.k.a.* PLMN IDs**
 - Roaming & Clearing – in progress
 - UICC - TBD
- To join the groups go to www.pscr.gov and sign up for the groups and for sharepoint/web portal access

UE Testing

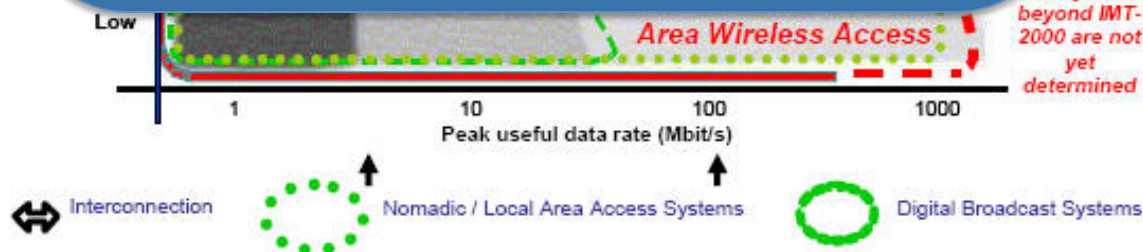
- PSCR looking to move most UE testing to PCS Type Certified Review Board certified labs
- Working with PTCRB on PVG submittal for Band 14 validation

“Come hear the updates after lunch at the UE session”

Path to 4G

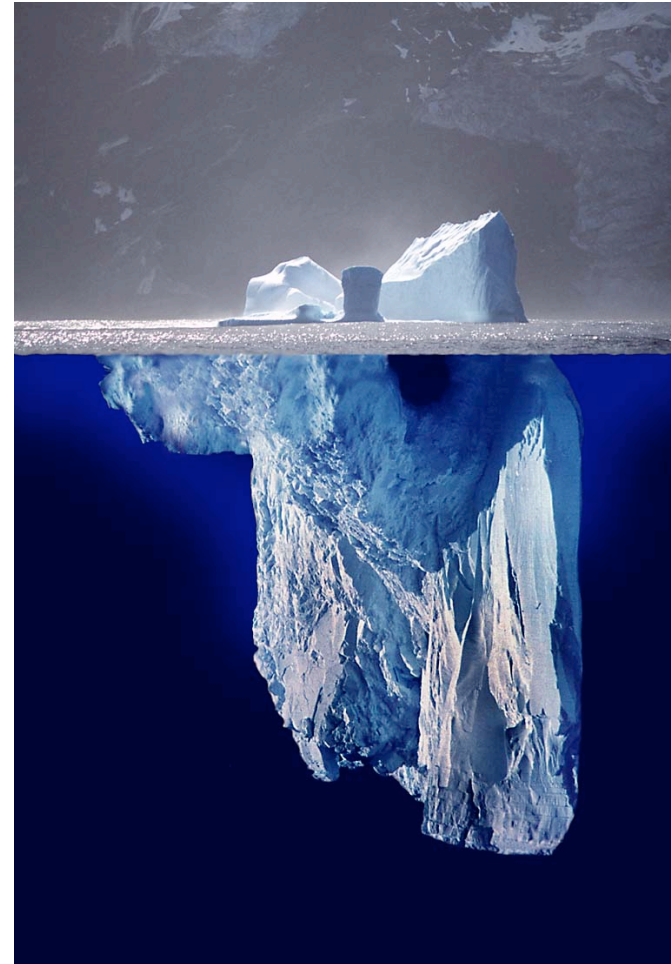
Jan 18, 2012 the ITU Radiocommunication Assembly determined that LTE-Advanced would be the official designee of IMT-Advanced or 4G

- High mobility and seamless roaming
- Works in IMT bands
- Scalable bandwidths to 40 MHz
- Trunkable bandwidths 100 MHz
- 100 Mbps high mobility, 1 Gbps low mobility



Final Thoughts

- We have only scratched the surface on what we understand about LTE
- The technology is advancing quickly and dynamically – PSCR is well placed to evaluate the best solutions to public safety.





PSCR

For Additional Information:

<http://www.pscr.gov>

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