Understanding Mobile Broadband for Public Safety

Policy and Technical Update – Morning Session

West Virginia Broadband Workshop

August 30, 2011
Public Safety Broadband Policy and Planning

MORNING AGENDA (9:00 – 12:00)
- Overview: The Promise (and Current State) of Broadband (w/ discussion)
- Technology Overview
- Discussion
- History and Background of Broadband Policy
- Current Implementation Efforts

AFTERNOON AGENDA (1:00 – 4:00)
- Overview of Current Broadband Legislation
- Stakeholder Information and Engagement
- Discussion
- LTE vs. Legacy Voice Comparison (targeted for technical audience)
The Promise *(and Current State)* of Public Safety Broadband
The Broadband Promise

Potential for Public Safety Response

Public Safety needs technology similar to commercial networks to enable advanced applications, improving response capabilities

- Fire Department downloads building plans to hand held devices (Data)
- Police helicopter provides video downlink to Incident Commander (Video)
- EMS transmits patient information (including video) to hospitals (Data / Video)
- Incident COML establishes interoperable talkgroups for State and local responders (Voice)
- Responders arrive from surrounding jurisdictions and are seamlessly integrated (Roaming)
- Network continues to work even as cellular is overwhelmed by civilian traffic (Public Safety grade network)
The Proposed Solution

*Broadband on a National Public Safety Network*

- Create next generation nationwide public safety wireless network
- Adopt fourth generation (“4G”) cellular technology to leverage fast pace of commercial development
- Leverage commercial equipment economies of scale while maintaining public safety unique requirements
- Provide high data rates (“broadband”) to enable advanced applications
- Use industry standards to enable interoperability for public safety
What Can Broadband Provide?

- A broadband network can enable many new capabilities that may not have been available on previous networks:
  - Streaming video / surveillance
  - Large file transfer / download
  - License plate reader
  - Facial recognition
  - Field fingerprinting
  - Field reporting
  - GIS/Mapping tools
  - Database queries
Challenges

Key Areas to Address to Achieve the End Solution

- Spectrum
- Policy
- Governance
- Funding
- National Architecture Approach
- Public Safety Unique Requirements (e.g., mission critical voice)
- Interoperability
- Transition from Existing Mission Critical Networks
Some Broadband Myths

- **“Broadband will eliminate the need for land mobile radio communications…”**
  - Despite recent advancements, VoLTE solutions do not yet meet public safety needs for mission critical voice (i.e. “talk-around”)

- **“A nationwide broadband network will make all public safety agencies interoperable…”**
  - Like LMR, technology is only one lane on the Interoperability Continuum
  - Agencies will still need to address interoperability at the application level

- **“Broadband data access will be seamless across the country…”**
  - Roaming will still be limited to public safety broadband coverage areas
  - Multi-band (band class) and multi-mode (backwards compatibility) devices with prior agreements will be required to roam onto commercial networks

- **“Data rates will be near 100 Mbps (4G)…”**
  - Data rates advertised are the peak rate under ideal conditions and for max bandwidth
  - Data rates depend on signal quality, user density, channel bandwidth and advanced antenna enhancements
Planning for Convergence

LMR Remains Critical for the Foreseeable Future

CURRENT

Land Mobile Radio Networks
- Mission Critical Voice
- Mission Critical Data

TRANSITION

Indefinite Time Frame

Public Safety Wireless Broadband Network
Dedicated Spectrum (Long Term Evolution)
- Public Safety Mission Critical Data Applications

Commercial and Unlicensed Wireless Broadband Networks
- Public Safety Data Applications

DESIRED EVOLUTION

Long Term

REQUIREMENTS

GENERAL
- Funding
- Governance
- Planning
- Partnerships
- Policy
- Research, Development, Testing and Evaluation

TECHNICAL
- Guaranteed Access
- Quality of Service
- Reliability
- Resiliency
- Roaming
- Spectrum Efficiency and Capacity
- Coverage
- Standards
- Talk Around/Simplex

Convergence of Mission Critical Voice and Data

Mar 2011 v. 3.0
Discussion: Understanding Current State

1) Public Safety Mobile Data (CAD/RMS)?

2) Use of Commercial Devices (Mobile Phones/Aircards)?

3) Data Applications in Use / Desired?
Technology Overview
Long Term Evolution (LTE)

- In the waiver order, the FCC required the use of Long Term Evolution (LTE) as a radio access network and associated network core technology
  - A single technology was mandated to ensure nationwide interoperability and roaming
  - LTE had the support of the Public Safety Spectrum Trust and was recommended in the NPSTC Broadband Task Force Report

- LTE is a global standard adopted by several major carriers

- LTE is developed by the 3GPP organization, the same group that has developed several previous cellular standards
Evolution of Cellular Standards

- Standards have evolved and are continuing to evolve
  - LTE today is revision 8 – not quite 4G but will evolve to 4G.

Source: 3GPP
Outline

- Overview of LTE basics, new terminology and why they are important
  - LTE Technical Highlights
  - What is an Evolved Packet Core (EPC)?
  - What is the Radio Access Network (RAN)?
  - What is a Band Class?
  - What is User Equipment (UE)?
  - What is a PLMN ID?

- Comparison of legacy networks and LTE
LTE Technical Highlights

- Considered to be one of two 3G+/4G standards (the other is Wi-Max)
- Cellular standard that was designed for data first and not voice
  - Inclusion of LTE standardized voice is a work in progress
- **All-IP** (Internet Protocol) architecture designed for low latency
- Potential for **economies of scale** by leveraging commercial market
- Inter-network **mobility and interoperability** with commercial carriers
- **Flexible** channel bandwidths of 1.4, 3, 5, 10, 15 and 20 MHz
- **High user data rates** to support new applications
- **Security and authentication** mechanisms
- **Priority and Quality of Service** mechanisms
- **Modern antenna techniques** to support improved performance
Basic LTE Subsystems

- At a very high level, the system can be divided into 3 subsystems:
  1. Evolved Packet Core (EPC) or “Core”
  2. Radio Access Network (RAN) or “Radio Sites”
  3. User Equipment (UE) or “User Device”

*Between the various subsystems the standards identify interfaces, some of which are specifically identified in the FCC Orders as required in waiver recipient deployments*
Core Overview

The EPC network or “Core” contains nodes for the following types of functions:

- Managing network services
- Authentication
- Roaming and mobility
- Policy enforcement, such as Quality of Service levels
- Routing
- Network Interfaces to Internet, private networks and other network operators
- Accounting and charging
Radio Access Network (RAN) Overview

- Also referred to as E-UTRAN which stands for Evolved UMTS Terrestrial Radio Access Network
  - UMTS acronym stands for Universal Mobile Telephone System, a 3rd Generation cellular system preceding LTE

- The RAN consists of radio sites that provide radio access and coordinate management of resources across the radio sites

- Radio sites includes equipment (eNodeB) responsible for uplink and downlink connectivity to User Equipment (UE)
### 700 MHz Band Allocation

- Frequencies, TV channels, auction blocks (letters), 3GPP bands
- Public Safety’s Broadband allocation is “**Band 14**”
- Major carriers operate in Bands 13 and 17 as well as other bands outside of 700 MHz

<table>
<thead>
<tr>
<th>Band 12</th>
<th>Band 17</th>
<th>Band 13</th>
<th>Band 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural Carrier</td>
<td>AT&amp;T</td>
<td>Qualcomm</td>
<td>Echostar</td>
</tr>
<tr>
<td>6 MHz</td>
<td>6 MHz</td>
<td>6 MHz</td>
<td>6 MHz</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>CH 52</td>
<td>CH 53</td>
<td>CH 54</td>
<td>CH 55</td>
</tr>
</tbody>
</table>

**Guard Band** – *Note no guard between D Block and (PS) Broadband*
Why is this Important?

- Most commercial equipment is targeted for a specific band class and thus not designed to operate in Band 14
  - Can’t purchase an LTE phone at your local cellular store and expect it to work
- Some public safety equipment may not support bands other than Band 14 and may not support legacy protocols
- This would reduce the ability of public safety equipment to support roaming onto commercial networks
  - Example: Motorola has partnered with Verizon to address this
- Equipment supporting the public safety band will be produced in lower volumes and thus more expensive than common commercial equipment
User Equipment (UE)

- Companies targeting public safety are just beginning to release products

- Common form factors for commercial equipment
  - USB & PCI modems, embedded modules, mobile modems, and mobile routers

- Handhelds for Band 14 are not expected to be available initially

- By FCC Orders, all equipment deployed by waiver recipients must be tested by the Public Safety Communications Research (PSCR)

- Most commercial LTE equipment is multi-mode, relying on legacy voice and data networks for voice, SMS and non-LTE coverage areas
PLMN ID or HNI

- Public Land Mobile Network (PLMN) Identifier (ID) (also called Home Network ID) is used to uniquely identify the network
  - Roaming is triggered if PLMN ID of a UE ≠ PLMN ID of targeted EPC

- The PLMN ID is assigned by the ATIS International Mobile Subscriber Identity Oversight Council

- Public safety associations and industry have coalesced around a single PLMN ID for the public safety system i.e. no roaming

- Harris County, Texas is first to request – delayed by process

- There are many IDs used in LTE: user, eNodeB, access point
  - PLMN ID is the basis for all other IDs
  - PSCR has formed a study group to determine a method to allocate IDs
## Comparison of Legacy and LTE

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Legacy Systems</th>
<th>P.S. LTE System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio Interoperability</td>
<td>Not intrinsic – limited</td>
<td>Intrinsic - excellent</td>
</tr>
<tr>
<td>Applications</td>
<td>Voice with some data</td>
<td>Data – no voice presently</td>
</tr>
<tr>
<td>Application interoperability</td>
<td>Voice is good</td>
<td>To be determined</td>
</tr>
<tr>
<td>RF coverage per site</td>
<td>More</td>
<td>Less</td>
</tr>
<tr>
<td>Throughput (bits/second)</td>
<td>Low and static over area</td>
<td>High and variable</td>
</tr>
<tr>
<td>Frequency allocation</td>
<td>Unique freq. from FCC</td>
<td>Same freq. at all sites</td>
</tr>
<tr>
<td>Infrastructure required</td>
<td>No, direct mode pervasive</td>
<td>Yes, direct mode request</td>
</tr>
<tr>
<td>Priority/Quality of service</td>
<td>Priority levels</td>
<td>Priority plus QoS</td>
</tr>
<tr>
<td>One-to-many sessions</td>
<td>Intrinsic - voice only</td>
<td>Special case - voice &amp; data</td>
</tr>
<tr>
<td>Backhaul (RF site to core)</td>
<td>Low data rates</td>
<td>Very high (&gt; 30 Mb/s)</td>
</tr>
<tr>
<td>Duplex telephone calls</td>
<td>No</td>
<td>Possible</td>
</tr>
</tbody>
</table>
RF Coverage Area

- LTE will cover less area than legacy LMR systems in the same frequency band for several reasons:
  - Lower RF power (40 Watts from base, 0.2W from UE)
  - The higher data rate of LTE requires a higher received signal power since the energy of the signal is spread over more bits.
  - Internal antenna on handheld may be less efficient than external
  - No data loss for some applications requires stronger signal
- How much less area is dependent on many factors:
  - High throughput at edge of coverage requires stronger signal
  - Requirement of both high average data rates and high usage in all cells will increase noise levels and cause high modulation modes, and thus require higher signal levels
## Comparison of Coverage per RF Site (700/800 MHz)

<table>
<thead>
<tr>
<th>System</th>
<th>Type</th>
<th># of Sites</th>
<th>Area (square miles)</th>
<th>Area/site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkansas</td>
<td>P25</td>
<td>72</td>
<td>53,179 (State)</td>
<td>627</td>
</tr>
<tr>
<td>Louisiana</td>
<td>P25</td>
<td>100</td>
<td>43,561 (State)</td>
<td>414</td>
</tr>
<tr>
<td>Michigan</td>
<td>P25</td>
<td>231</td>
<td>58,804 (State)</td>
<td>239</td>
</tr>
<tr>
<td>San Diego</td>
<td>SmartNet</td>
<td>36</td>
<td>4,526 (County)</td>
<td>126</td>
</tr>
<tr>
<td>Adams</td>
<td>LTE</td>
<td>15</td>
<td>1,198 (County)</td>
<td>80</td>
</tr>
<tr>
<td>BayWEB</td>
<td>LTE</td>
<td>193</td>
<td>7,370 (10 Counties)</td>
<td>38</td>
</tr>
<tr>
<td>LA County</td>
<td>LTE</td>
<td>300</td>
<td>4,063 (County)</td>
<td>14</td>
</tr>
</tbody>
</table>

Initial LTE designs indicate coverage per RF site will be substantially less than P25.
Direct comparisons are needed – same location & UE configuration.
LTE Coverage – UE Comparison

Source: Harris County Interoperability Showing

Vehicular modem with antennas on exterior - Uplink

USB dongle inside vehicle – Uplink = UE dongle to eNB

Just as in legacy LMR type and position of UE will have a large effect on coverage

Coverage shown is for 30 sites – current plan is 16
LTE Coverage – Uplink/Downlink

Source: Harris County Interoperability Showing

Portable on street –
Downlink at 768 kb/s

Portable on street –
Uplink at 256 kb/s

Low RF power of UE (0.2W) will limit uplink coverage relative to downlink

Coverage shown is for 30 sites – current plan is 16
In-Building RF Coverage

- In building coverage is not required by FCC for waiver recipients.
- Legacy LMR uses bidirectional amplifiers and distributed antenna systems (DAS) to boost signal into RF-opaque buildings.
- LTE could use these same techniques but it also could use femto-cells (Home eNodeB in LTE) or picocells.
- These cells are small, low RF power, devices that provide coverage to a small area. Picocells cover a larger area and serve more users.
- These cells are usually connected to the backhaul network through a wired IP connection so generally no RF antennas are required on the outside of the building.
- These cells are easier to install than DAS. They are almost plug&play.
- These cells increase not only coverage but throughput.
Voice Communication over LTE

- LTE doesn’t directly support any voice communications presently but there are several efforts in progress:
  - Duplex Voice over IP (Telephone calling)
    - IP Multimedia Subsystem (IMS) - eventual goal
    - VoIP over LTE (VoLTE) is being developed as a subset of IMS
    - Could be based on telephone #’s or IP addresses
    - Several demonstrations have been conducted (Skype, Google Voice)
  - Push-to-talk (PTT) Non-mission-critical
    - Not all the features public safety requires & slow access
    - Examples: Motorola PTT (Verizon) & Kodiak RTX (AT&T) & IDEN (Sprint/Nextel & SouthernLINC), BeOn from Harris
    - Demonstrations have been conducted with LTE PTT communicating with P25 PTT using the ISSI to connect the two systems.

Telephony and non-mission-critical PTT voice could be implemented soon on a public safety LTE system.
Mission-Critical Voice

- NPSTC has produced a description of mission-critical voice for LTE
- Some of the salient requirements of the functional description follow:
  - “Immediate” communications with low call setup times
  - Direct (no infrastructure required) communication mode
  - PTT, half duplex, group or individual call
  - Duplex telephony
  - Emergency call with ruthless preemption & audio takeover
  - Audio quality such that no repetition is needed, speaker recognition, speaker stress level in voice, background sounds can be heard with sufficient clarity
- NPSTC description is being reviewed by VoIP working group
- Intend to send description to standards body for incorporation in LTE
- A request for standardization of direct mode has been submitted to the standards body (3GPP)
## Voice Summary

<table>
<thead>
<tr>
<th>Voice Category</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duplex VoIP</td>
<td>Demonstrated – not standardized</td>
</tr>
<tr>
<td>Duplex LTE Voice Standard</td>
<td>VoLTE is leading option; available soon?</td>
</tr>
<tr>
<td>Non-mission critical PTT</td>
<td>Standard and proprietary options being developed</td>
</tr>
<tr>
<td>Mission critical PTT</td>
<td>Description available; submit for standardization; many barriers</td>
</tr>
<tr>
<td>Direct mode</td>
<td>Request has been made to standardize. Includes data also</td>
</tr>
</tbody>
</table>
History and Background on Broadband Policy
Public Safety & 700 MHz Spectrum

The First Steps (1997-2001)

- In 1997 Congress passed Balanced Budget Act allocating 24 MHz of 700 MHz spectrum to public safety

- In 2001 the NCC and FCC established Rules for the 24 MHz and divided it into 12 MHz of narrowband and 12 MHz of wideband channels
  - In 2007, the FCC adjusted the public safety 700 MHz spectrum plan and converted the wideband data allocation to broadband

- FCC would eventually divide adjacent 700 MHz spectrum into five blocks (A, B, C, D, and E) for auctions to commercial service providers.

- These decisions required spectrum to be vacated by analog television services before it could be reallocated.
A Growing Urgency


Digital Television Transition and Public Safety Act, February 2006:

- Established Feb. 17, 2009 for broadcasters to transition to digital technology.
- Established auction date for reclaimed spectrum no later than Jan. 28, 2008
- Used $1B in expected proceeds to fund PSIC Grant Program

“Recommendation: Congress should support pending legislation which provides for the expedited and increased assignment of radio spectrum for public safety purposes....”
Public Safety Spectrum Trust

Planned Public/Private Partnership (2006-2007)

- In 2007 the FCC named the Public Safety Spectrum Trust (PSST) as the entity to serve as Public Safety Broadband Licensee
  - FCC stipulated that D Block winner work with PSST to build a nationwide public safety broadband network
- Intended benefits of Public/Private partnership with PSST:
  - Co-location of public safety equipment on base sites and towers
  - Economies of scale for user devices based on commercial volume
  - Rapid network build-out driven by commercial marketplace
  - Nationwide network
Emergence of Waiver Jurisdictions

D-Block Auction & Shift from National to Regional Efforts (2008-2010)

- Mar. 2008, auction’s reserve price for the D Block was not met; D Block was not licensed
  - FCC proceeding remains open and no auction is scheduled
- Aug. 2009, 12 petitions to the FCC to waive rules to allow deployment of public safety broadband networks
- After the FCC’s request for comment, 10 more petitions submitted
- May 2010, the FCC released a waiver order granting 21 of 22 waivers
- Additional waiver requests were subsequently received
- In May 2011, the FCC approved one additional waiver to bring the total waiver recipients to 22
Administration Support

• Jan, 2011 President announced his **Wireless Innovation & Infrastructure Initiative** in the State of the Union Address, which included:

  • Reallocating the 700 MHz D-Block for the National Public Safety Broadband Network
  • Extending mobile broadband into underserved rural markets
  • Establishing $3B in a Wireless Innovation (WIN) Fund to support research and development ($500M earmarked for public safety), test beds, and experimentation

• In June 2011, the Administration (Vice President Biden, Secretary Napolitano and others) reiterated their support
Current Implementation Efforts
Current Waiver Recipients

- Adams County, CO
- Alabama
- Boston, MA
- Charlotte, NC
- Chesapeake, VA
- District of Columbia
- Hawaii
- Iowa
- Los Angeles County
- Mesa, AZ
- Mississippi
- New Jersey
- New Mexico
- New York City
- New York State
- Northern California

- Oregon
- Pembroke Pines, FL
- San Antonio, TX
- Seattle, WA
- Wisconsin Consortium
- Texas (Harris County)*

Waiver Recipients
Waiver and Grant Recipients ("Early Builders")
Early Builder Highlights/Updates

- Adams County, CO
  - Contract awarded in July 2011 to Raytheon (integrator) and IP Wireless (infrastructure equipment)
  - Fall 2011 - Test capability (small scale)
  - Spring 2013 – Estimated to be fully operational

- Charlotte, NC (Includes Mecklenburg County)
  - April 2011 – Released RFP
  - June 2011 – proposal submission deadline
  - Proposal reviews currently in progress

- New Mexico
  - Awarded $38.6 million BTOP grant
  - Quarterly reports are confidential

*Information obtained from publicly available Quarterly Reports submitted to FCC*
Early Builder Highlights/Updates, cont.

- Northern California (BayWEB)
  - Build, Own, Operate and Maintain (BOOM) agreement with Motorola Solutions
  - Hired independent testing of 4 site test network; results to be published in early August
  - 193 planned sites
  - System boundary spans throughout boundaries of 10 Bay Area counties

Source: APCO Broadband Summit presentation

*Information obtained from publicly available Quarterly Reports submitted to FCC*
Early Builder Highlights/Updates, cont.

- Mississippi (MSWIN)
  - June 2011 – contract award to Motorola Solutions
  - Currently implementing concurrently with a new statewide P25 system
    - All broadband equipment will be deployed at the same radio sites as P25
  - In process of upgrading backhaul capacity to support broadband requirements
  - 134 planned RF sites

- New Jersey (as of April)
  - Planning to release RFP
  - Planning to use 77 sites which already exist
  - Planned completion targeted for 2013

*Information obtained from publicly available Quarterly Reports submitted to FCC*
Early Builder Highlights/Updates, cont.

- Los Angeles County (LASafety-Net)
  - Total estimated cost is $245 million
  - Nearly 300 sites planned
  - Update: First RFP process had problems; restarting RFP process

- Harris County, TX (BIG-Net)
  - Filed FCC required Interoperability Showing
    - Sections on System Architecture, Roaming, Applications, Coverage, etc.
  - Phase 1.0: 6 sites for testing by Jul. 31st
  - Phase 1.1: 1 mobile site added by Aug. 19th
  - Phase 1.2: 16 sites operational by Jun. 2012

*Information obtained from publicly available Quarterly Reports submitted to FCC*
# Status of Waiver Recipient Early Builders

<table>
<thead>
<tr>
<th></th>
<th>Adams</th>
<th>Charlotte</th>
<th>BayWEB</th>
<th>Mississippi</th>
<th>New Jersey</th>
<th>Los Angeles</th>
<th>Harris</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grant Type</strong></td>
<td>BTOP</td>
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<td>BTOP</td>
<td>BTOP</td>
<td>Port Grant</td>
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<tr>
<td><strong>Grant Amount</strong></td>
<td>$12.1 M</td>
<td>$16.7 M</td>
<td>$50 M</td>
<td>$70 M</td>
<td>$39 M</td>
<td>$154.6 M</td>
<td>$10 M</td>
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<tr>
<td><strong>RFP</strong></td>
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<tr>
<td><strong>Awarded</strong></td>
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<td>√</td>
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<tr>
<td><strong>Deploy</strong></td>
<td>Fall 2011</td>
<td>In Process</td>
<td>Beginning</td>
<td>In Process</td>
<td>In Process</td>
<td>In Process</td>
<td></td>
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<tr>
<td><strong>Testing</strong></td>
<td></td>
<td></td>
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