Understanding Mobile Broadband for Public Safety

Policy and Technical Update – Morning Session

West Virginia Broadband Workshop

August 30, 2011

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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

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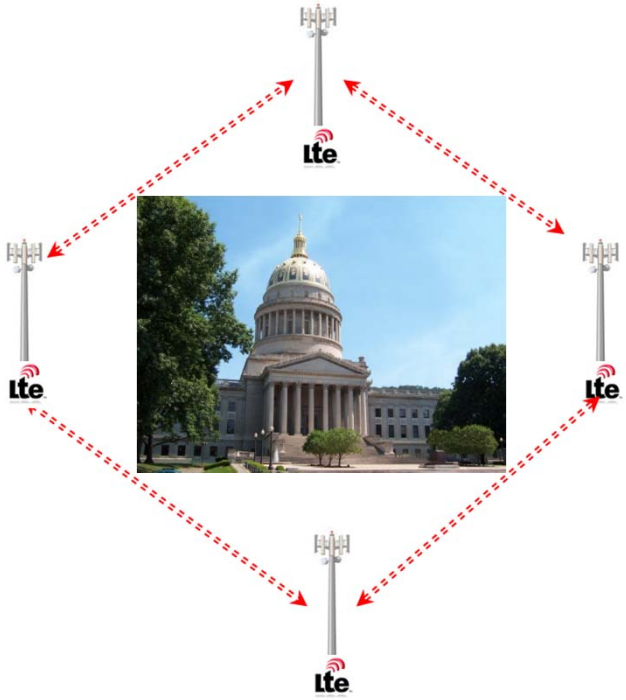
The Broadband Promise

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)

Response to a Public Safety Emergency



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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

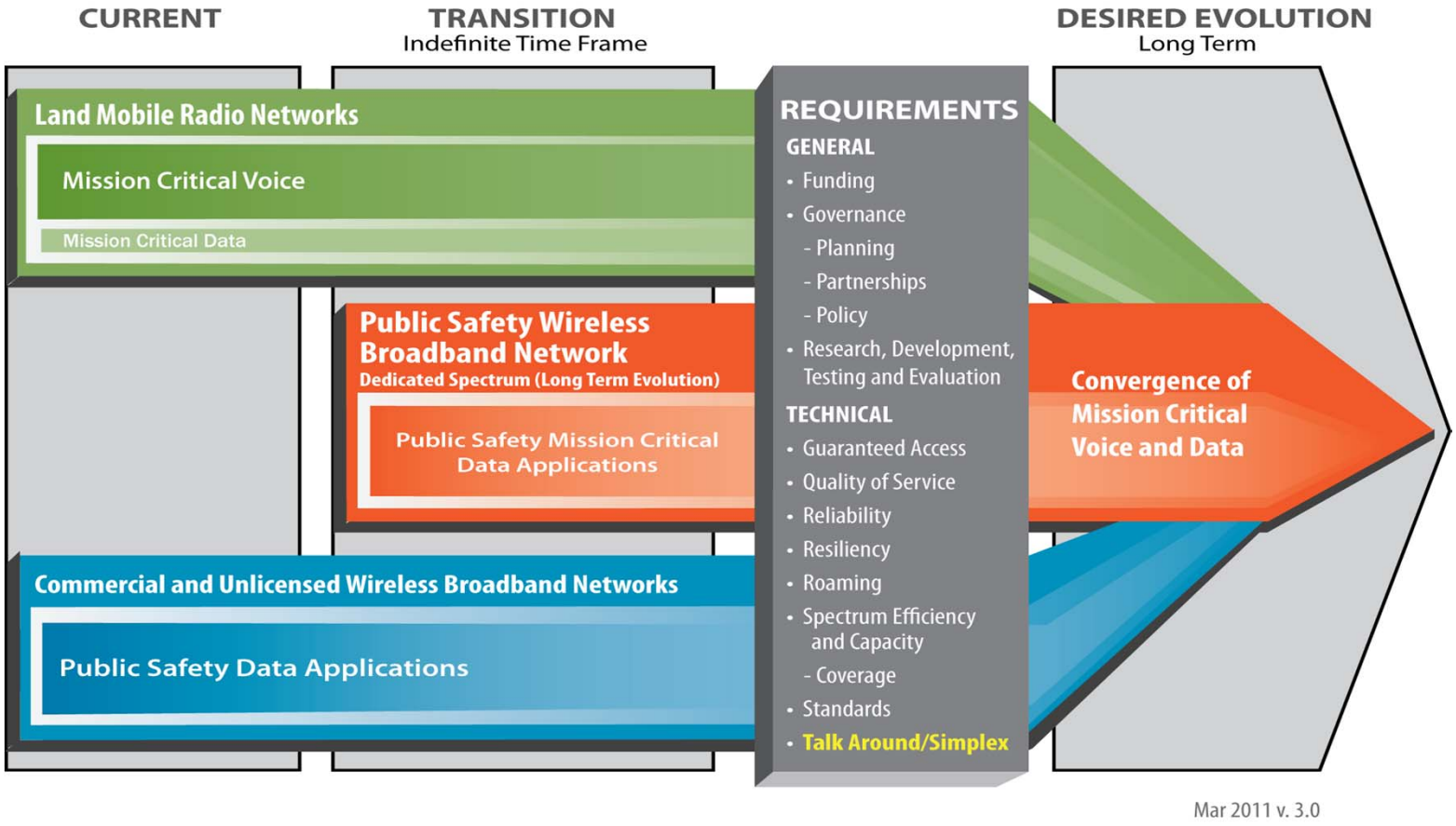
- Spectrum
- Policy
- Governance
- Funding
- National Architecture Approach
- Public Safety Unique Requirements (e.g., mission critical voice)
- Interoperability
- Transition from Existing Mission Critical Networks

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



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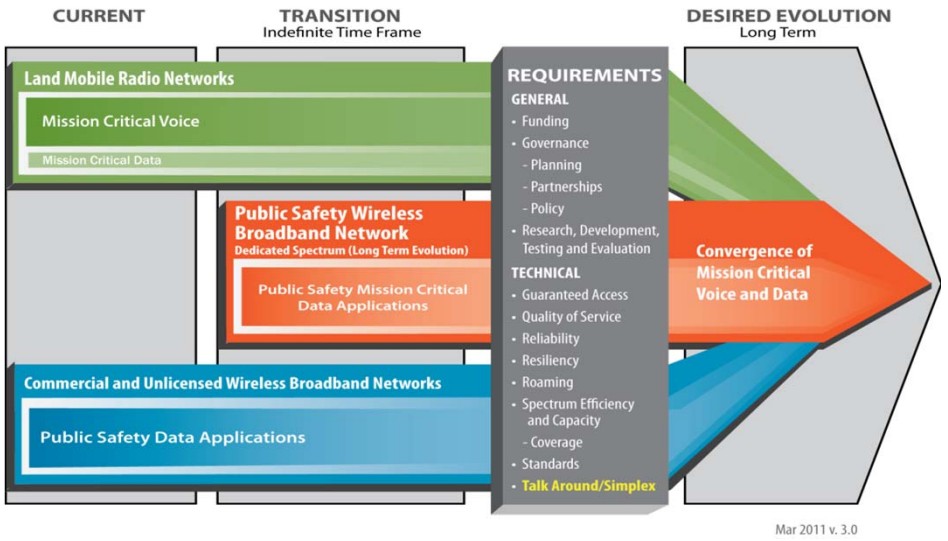
Discussion: Understanding Current State

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

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

3) Data Applications in Use / Desired?



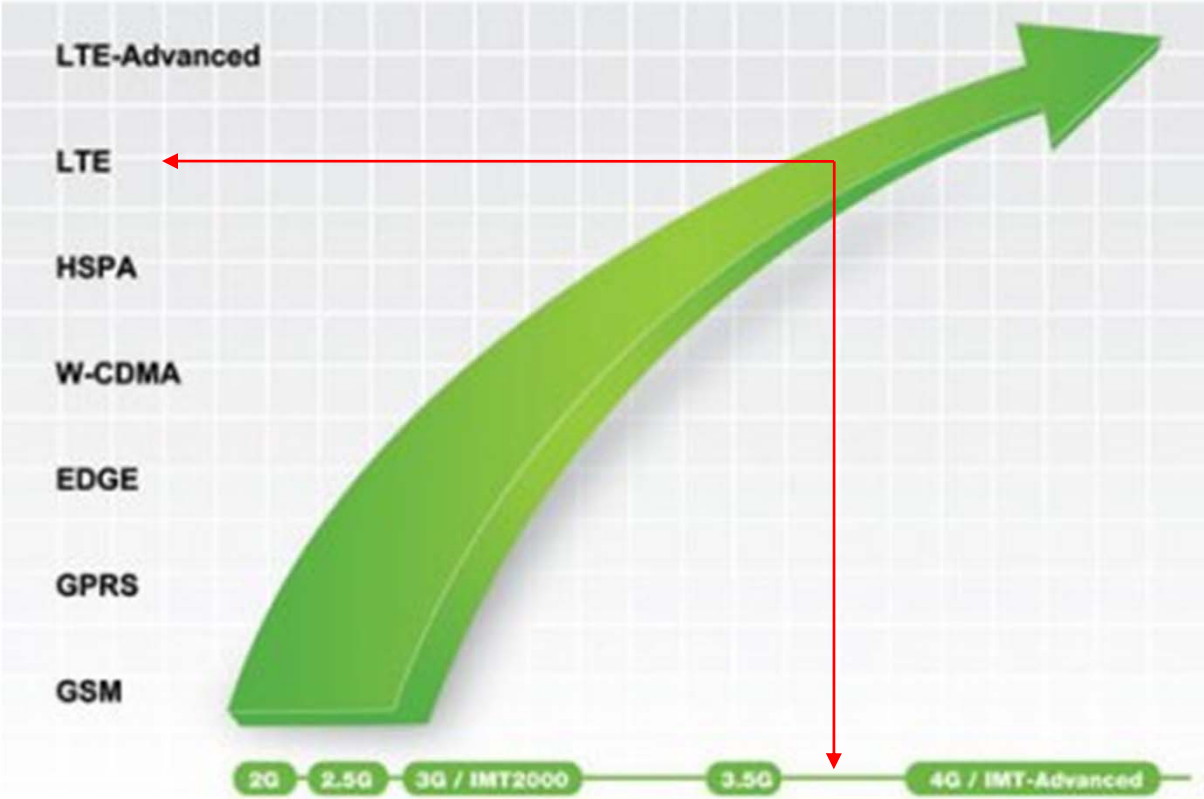
Technology Overview

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

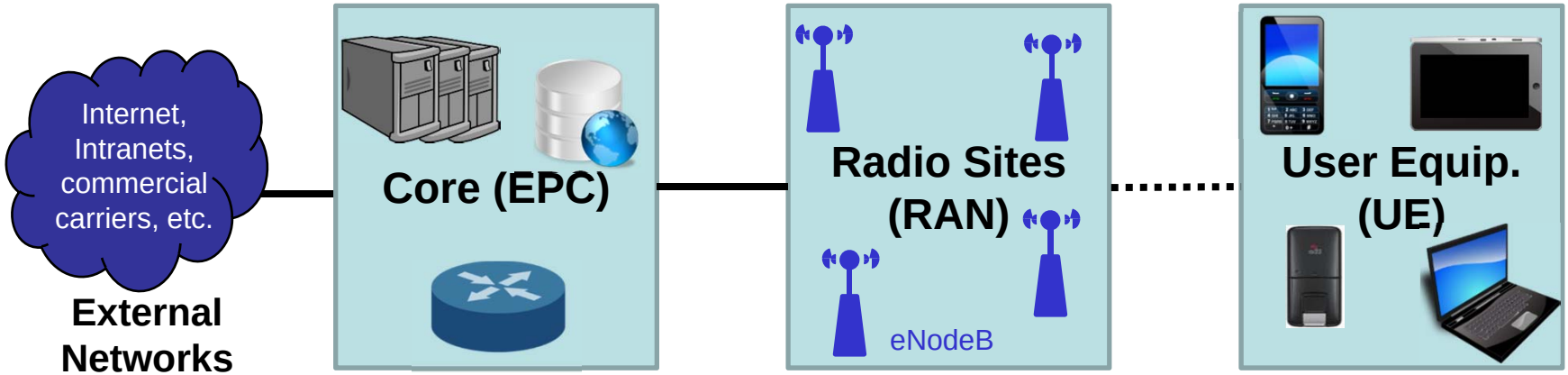
- Overview of LTE basics, new terminology and why they are important
  - LTE Technical Highlights
  - What is an Evolved Packet Core (EPC)?
  - What is the Radio Access Network (RAN)?
  - What is a Band Class?
  - What is User Equipment (UE)?
  - What is a PLMN ID?
- Comparison of legacy networks and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

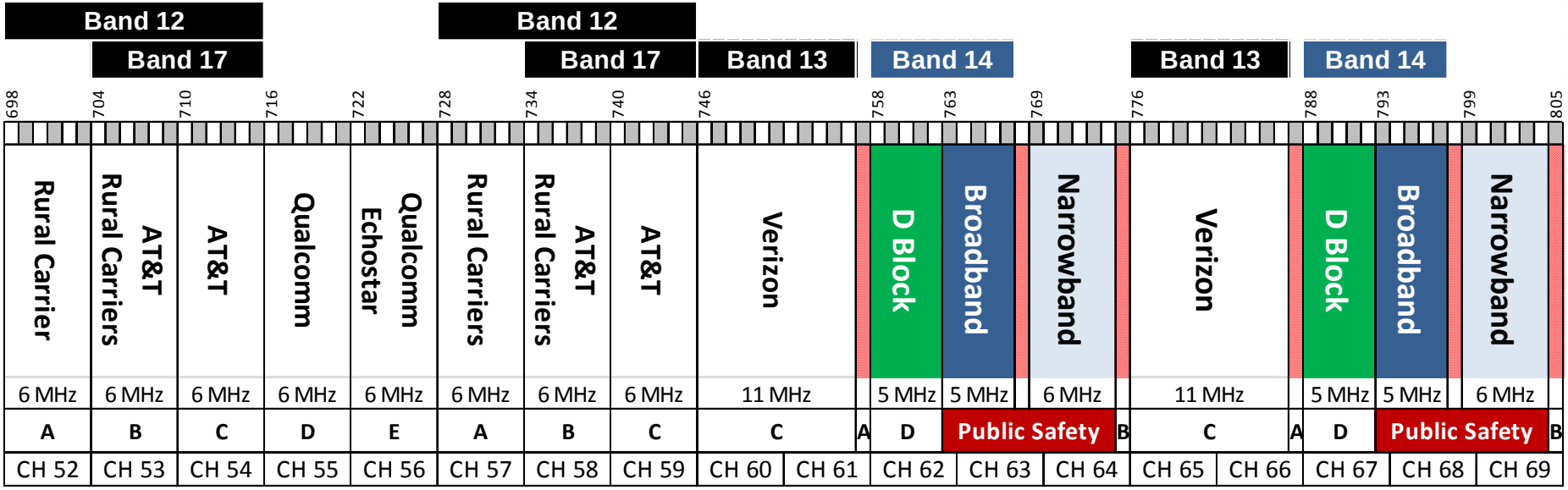
- The EPC network or “Core” contains nodes for the following types of functions:
  - Managing network services
  - Authentication
  - Roaming and mobility
  - Policy enforcement, such as Quality of Service levels
  - Routing
  - Network Interfaces to Internet, private networks and other network operators
  - 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



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Guard Band – *Note no guard between **D Block** and (PS) **Broadband**

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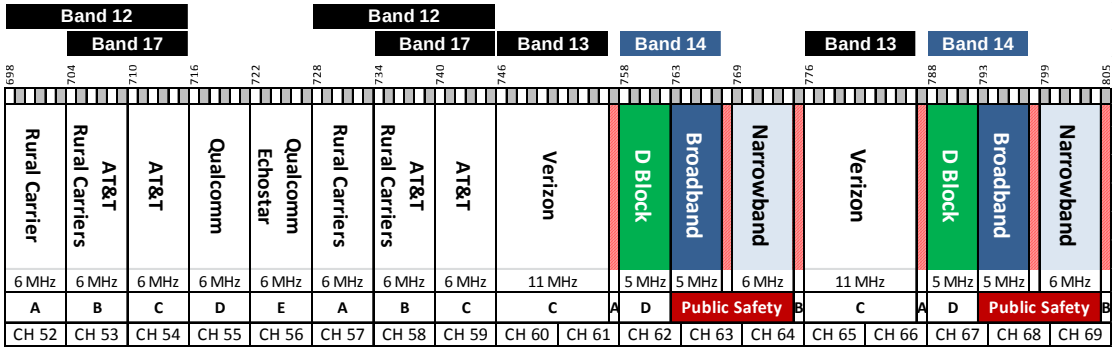
Why is this Important?

- 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



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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

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

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)

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

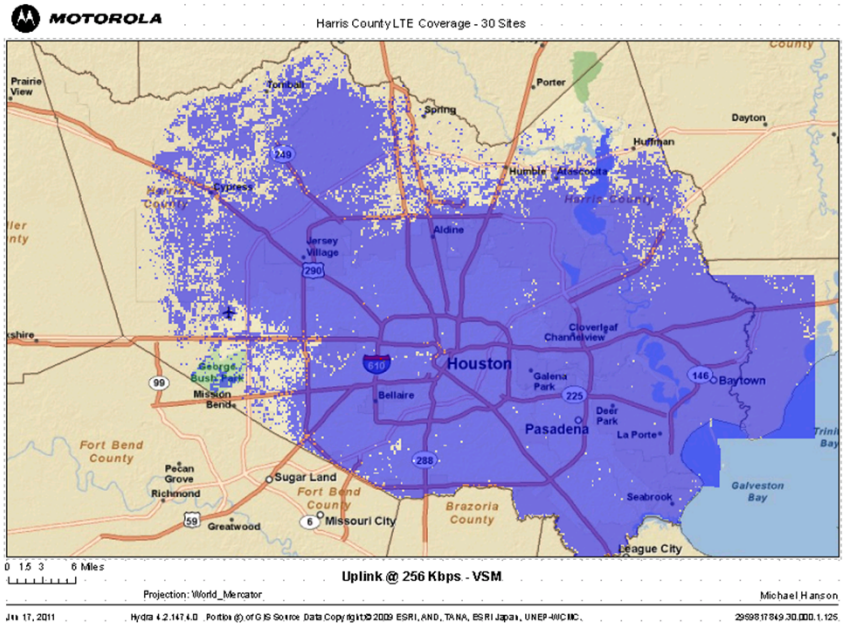
Initial LTE designs indicate coverage per RF site will be substantially less than P25

Direct comparisons are needed – same location & UE configuration

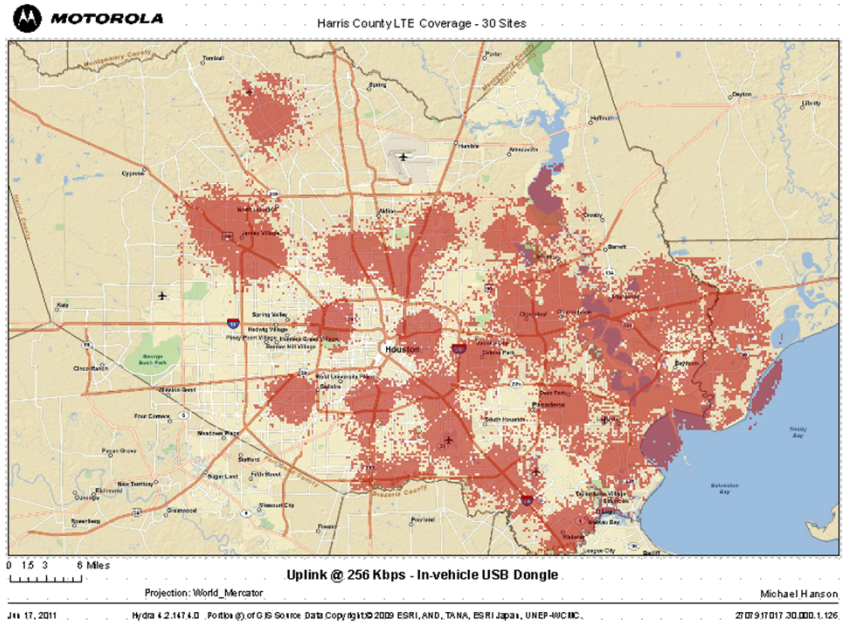
LTE Coverage – UE Comparison

Source: Harris County Interoperability Showing

Vehicular modem with antennas on exterior - Uplink



USB dongle inside vehicle – Uplink = UE dongle to eNB



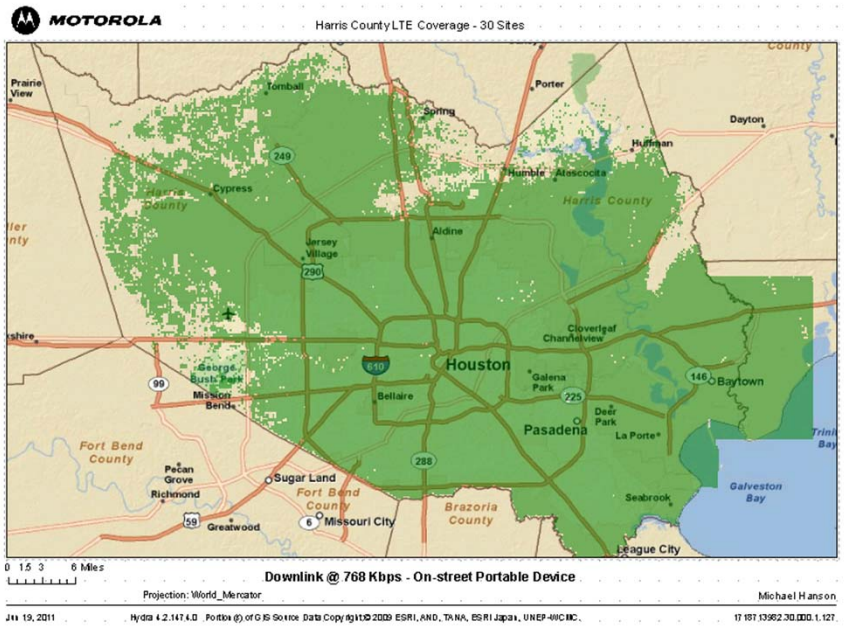
Just as in legacy LMR type and position of UE will have a large effect on coverage

Coverage shown is for 30 sites – current plan is 16

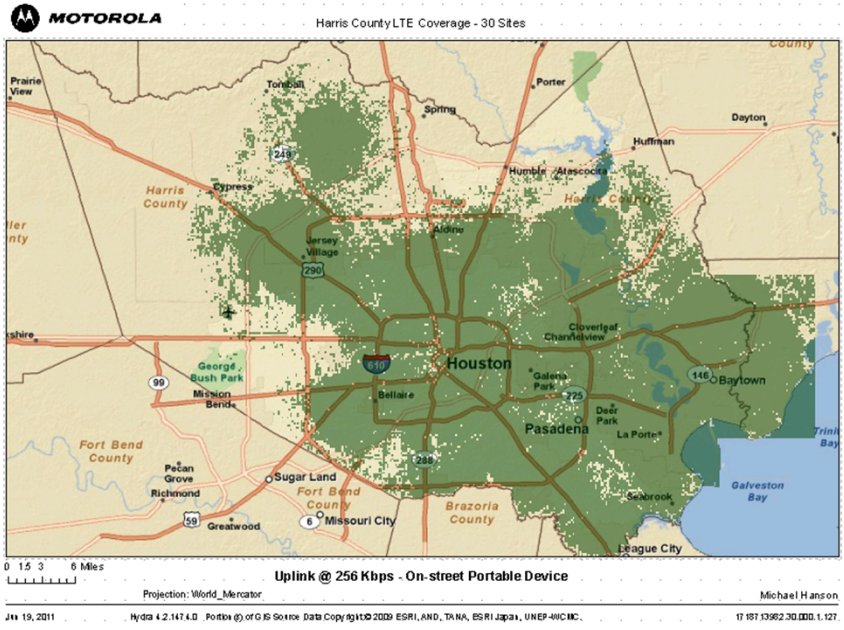
LTE Coverage – Uplink/Downlink

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 (Sykpe, 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.

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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

Voice Category	Status	
Duplex VoIP	Demonstrated – not standardized	
Duplex LTE Voice Standard	VoLTE is leading option; available soon?	
Non-mission critical PTT	Standard and proprietary options being developed	
Mission critical PTT	Description available; submit for standardization; many barriers	
Direct mode	Request has been made to standardize. Includes data also	

History and Background on Broadband Policy

Public Safety & 700 MHz Spectrum

The First Steps (1997-2001)

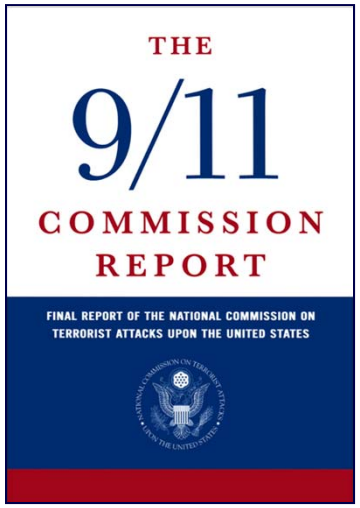
- In 1997 Congress passed Balanced Budget Act allocating 24 MHz of 700 MHz spectrum to public safety
- In 2001 the NCC and FCC established Rules for the 24 MHz and divided it into 12 MHz of narrowband and 12 MHz of wideband channels
  - In 2007, the FCC adjusted the public safety 700 MHz spectrum plan 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

Post 9/11/2001 - (2001-2006)

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

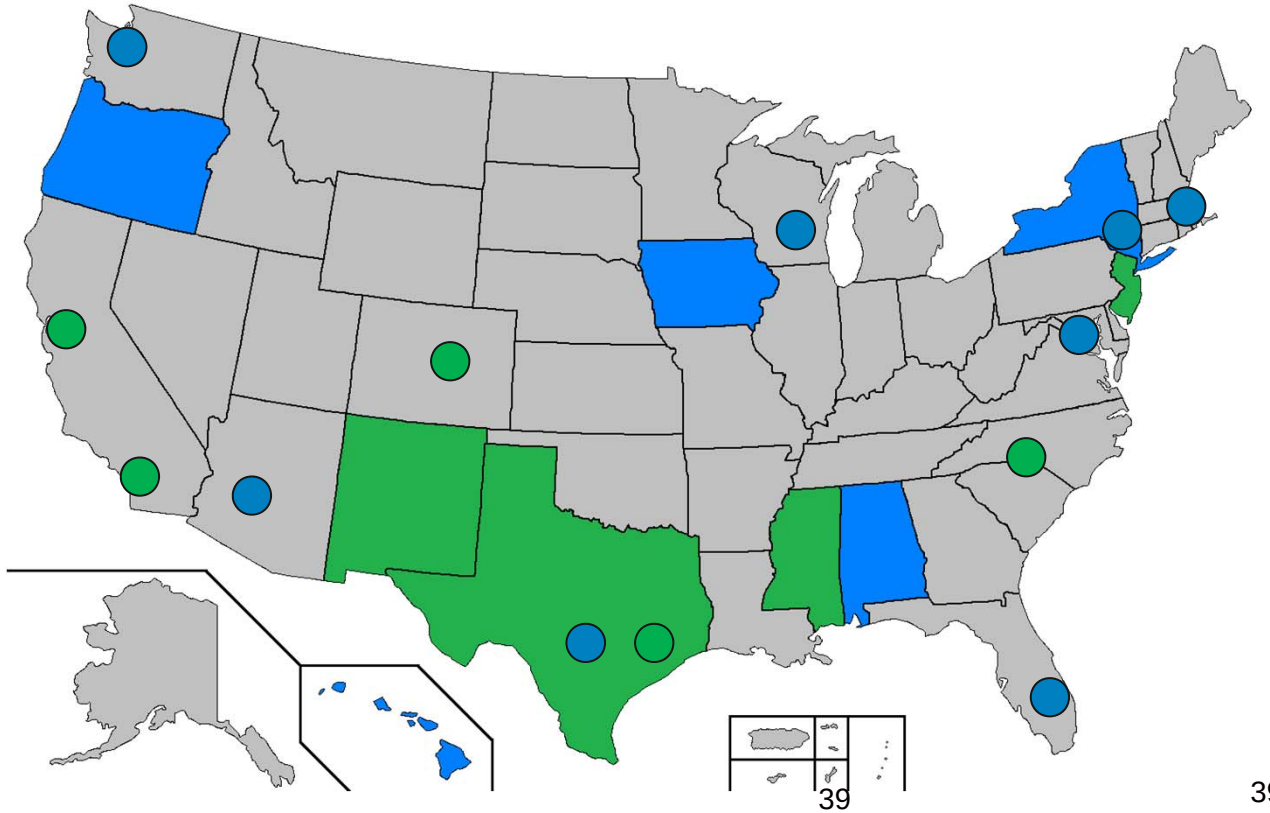
Current Implementation Efforts

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")



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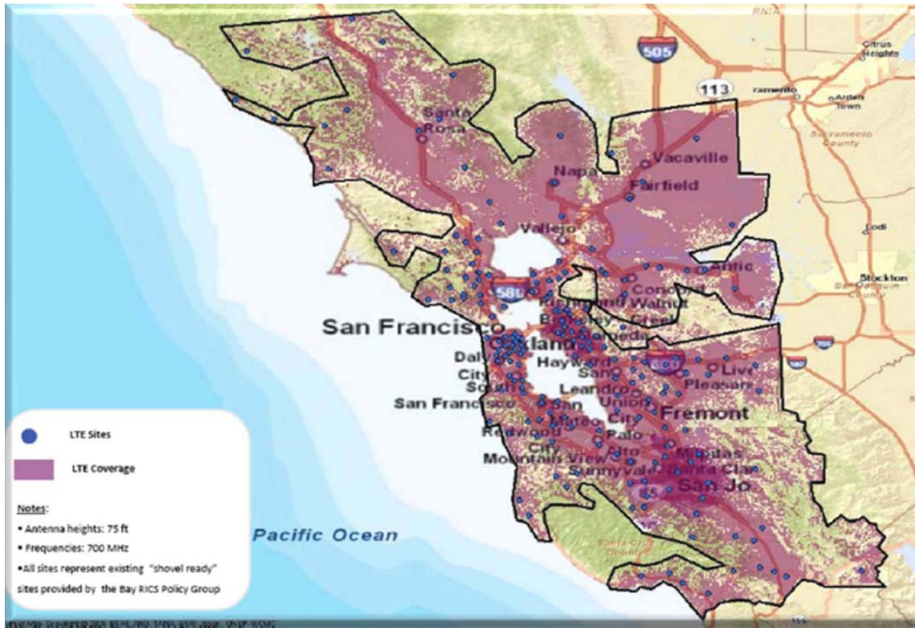
Early Builder Highlights/Updates

- 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.

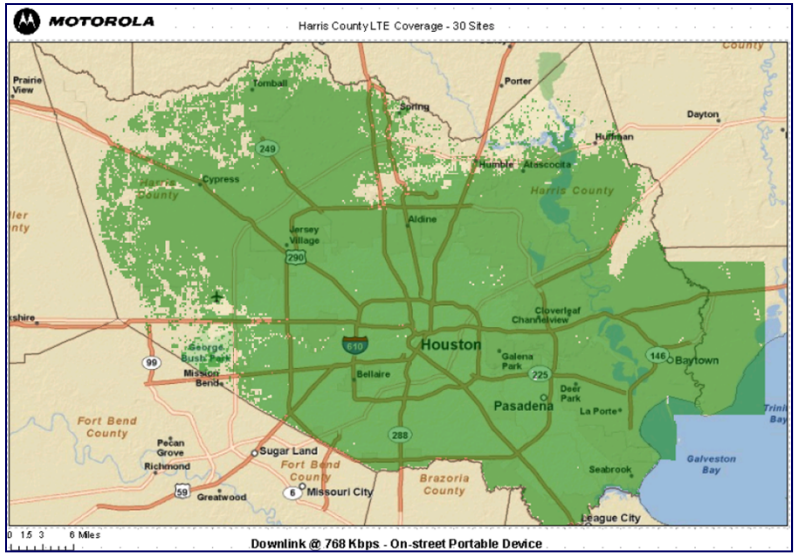
- Mississippi (MSWIN)
  - June 2011 – contract award to Motorola Solutions
  - Currently implementing concurrently with a new statewide P25 system
    - All broadband equipment will be deployed at the same radio sites as P25
  - In process of upgrading backhaul capacity to support broadband requirements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



Source: Texas Interoperability Showing

**Information obtained from publicly available Quarterly Reports submitted to FCC*

Status of Waiver Recipient Early Builders

	Adams	Charlotte	BayWEB	Mississippi	New Jersey	Los Angeles	Harris
Grant Type	BTOP	BTOP	BTOP	BTOP	BTOP	BTOP	Port Grant
Grant Amount	$12.1 M	$16.7 M	$50 M	$70 M	$39 M	$154.6 M	$10 M
RFP	√	√	√	√	√		√
Awarded	√		√	√			√
Deploy	Fall 2011		In Process	Beginning			In Process
Build Out	Fall 2011 – Dec. 2012		In Process				In Process
Testing			In Process				
In Service	Mar. 2013				2013		Jun. 2012

*Information obtained from publicly available Quarterly Reports submitted to FCC

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