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Emerging Technology Forum

Broadband 101: Getting Up to Speed

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Agenda

- Public Safety Broadband: Next Gen Communications
- LTE and LMR: The Differences
- LMR and LTE: A New Communications Language
- LTE Basics
- Applications and Services
- How, When, and How Much?
- Conclusions
- Q and A

Public Safety Broadband Network

- Nationwide, fully interoperable network
  - Based on commercial 4th-generation technology (LTE)
  - In same portion of spectrum (700 MHz) as AT&T and Verizon's new LTE networks
- Designed to AUGMENT and not replace existing mission-critical voice networks
- Voice MAY be possible in the future

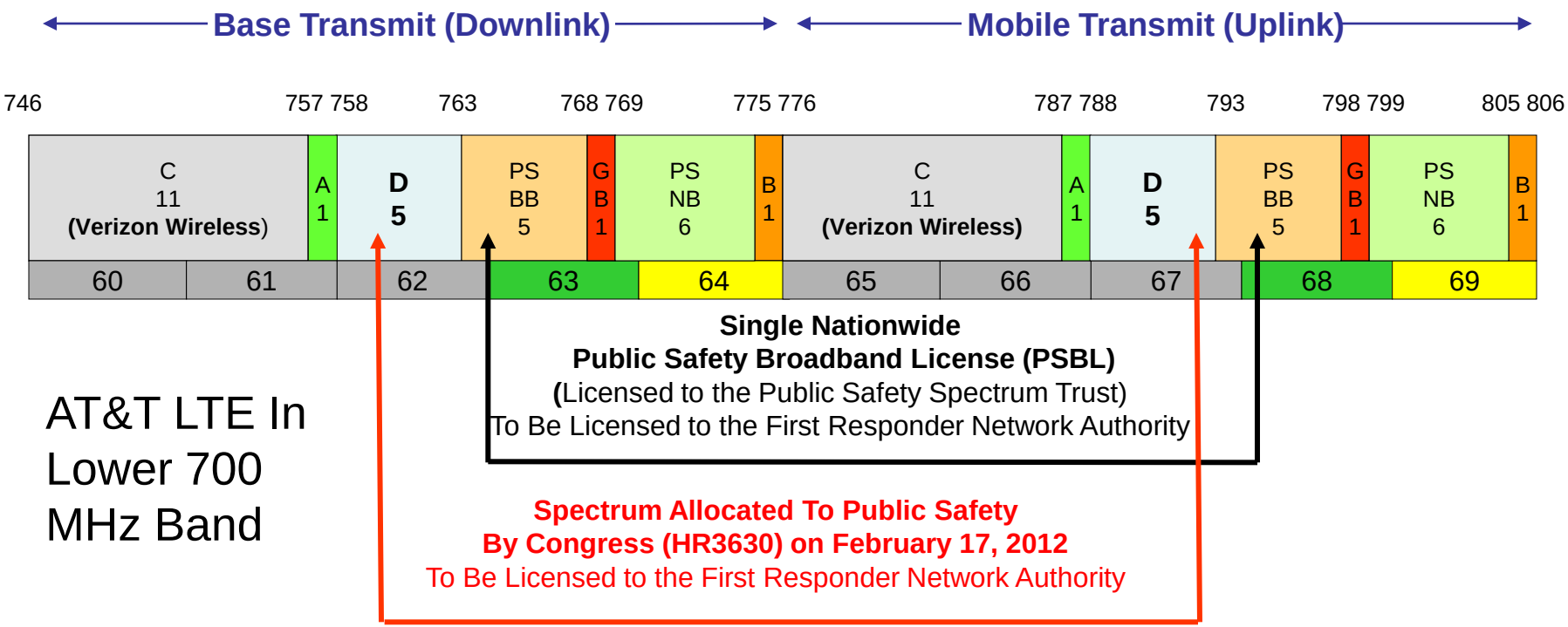
H.R. 3630 Title VI

- Passed Congress February 17, 2012
- Signed in to law by President Obama February 22, 2012
- Quick Summary…
  - Requires FCC to allocate D Block spectrum to public safety
  - Establishes First Responder Network Authority (FirstNet) to govern the PSBN
  - Provides $7 billion in funding to build out nationwide public safety broadband network
  - Provides $135 million for state and local implementation grants
  - Provides up to $300 million for research and development grants
  - Provides $115 million for 9-1-1 and NG 9-1-1 grants
  - Requires public safety to give back T-Band (470-512 MHz) in 9 years—used heavily for NB voice in 13 major metro areas

PSBN: 20 MHz of Broadband Spectrum

Public Safety 700 MHz:

20 MHz of Broadband Spectrum, and 12 MHz of Narrowband spectrum



AT&T LTE In Lower 700 MHz Band

Existing Waivers and Leases

May 12, 2010: FCC issued conditional waivers to 21 early waiver petitioners

States (8): Alabama, Hawaii, Iowa, Mississippi, New Jersey, New Mexico, New York, Oregon

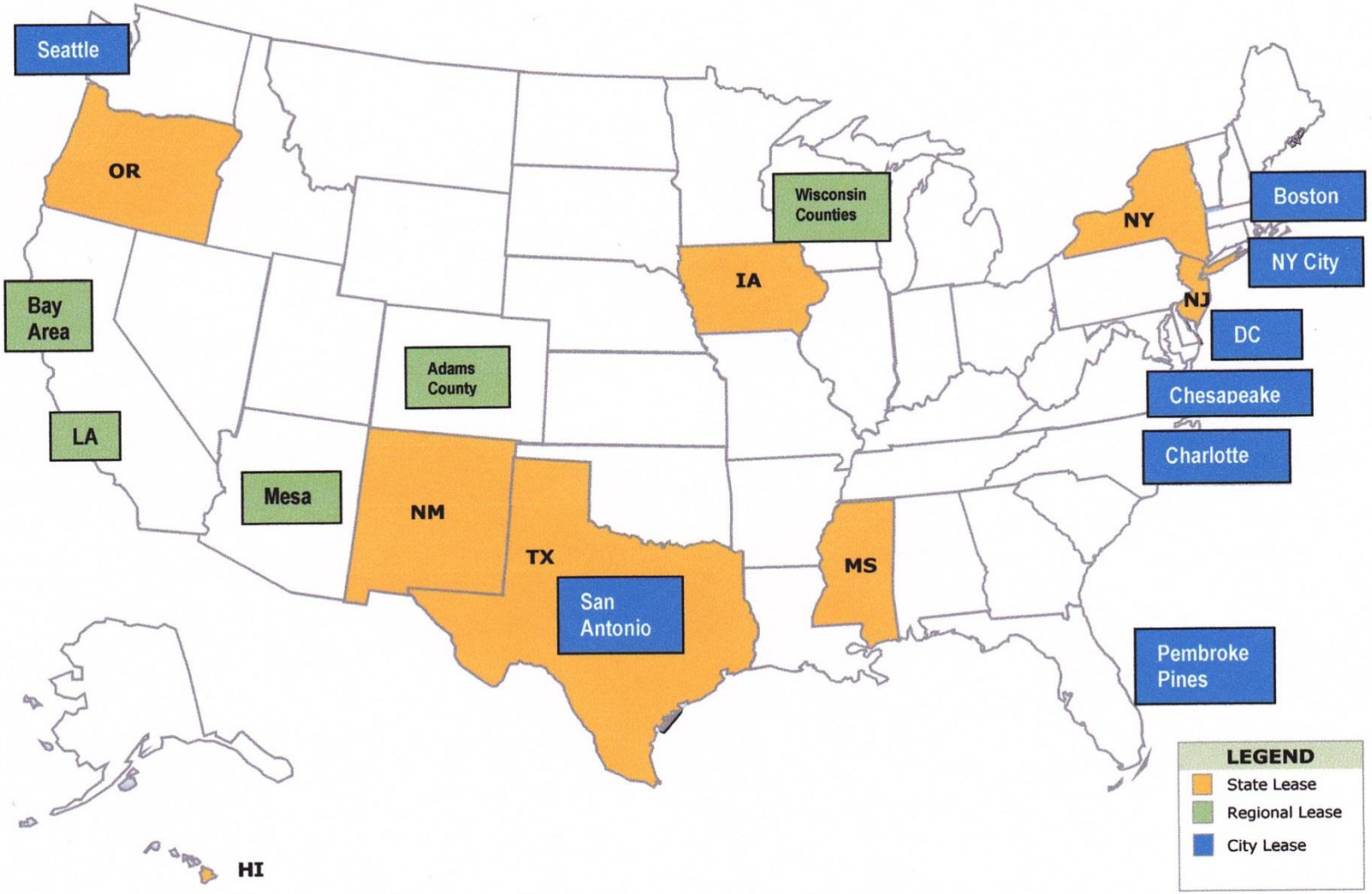
Counties/Regions (5): Adams County-Denver Airport (CO), Bay Area (CA), Mesa-TOPAZ (AZ), San Antonio (TX), Wisconsin Counties (WI)

Cities (8): Boston (MA), Charlotte (NC), Chesapeake (VA), Washington (DC), Los Angeles (CA), New York City (NY), Pembroke Pines (FL), Seattle (WA)

September 9, 2010: FCC approved 20 PSST spectrum leases for above entities with exception of Alabama, which was not ready to move forward

May 12, 2011 –FCC issued a conditional waiver to the State of Texas

Waiver Entities



S-1 Hawaii (HI)
S-2 Iowa (IA)
S-3 Mississippi (MS) .....$70.0 million BTOP Grant
S-4 New Jersey (NJ) ..... $39.6 million BTOP Grant
S-5 New Mexico (NM) ..... $38.7 million BTOP Grant
S-6 New York State (
S-7 Oregon (OR)
S-8 Texas (TX)
R-1 Adams County-Denver Airport (CO) ….. $12.1 million BTOP Grant
R-2 Bay Area (CA) ..... $50.0 million BTOP Grant (Motorola)
R-3 Los Angeles (CA) ..... $154.6 million BTOP Grant
R-4 Mesa-TOPAZ (AZ)
R-5 Wisconsin Counties (WI)
C-1 Boston (MA)
C-2 Charlotte (NC) ..... $16.7 million BTOP Grant
C-3 Chesapeake (VA)
C-4 District of Columbia (DC)
C-5 New York City (NY)
C-6 Pembroke Pines (FL)
C-7 San Antonio (TX)
C-8 Seattle (WA)

S – States……8
R – Regions……5
C – Cities……. 8
21

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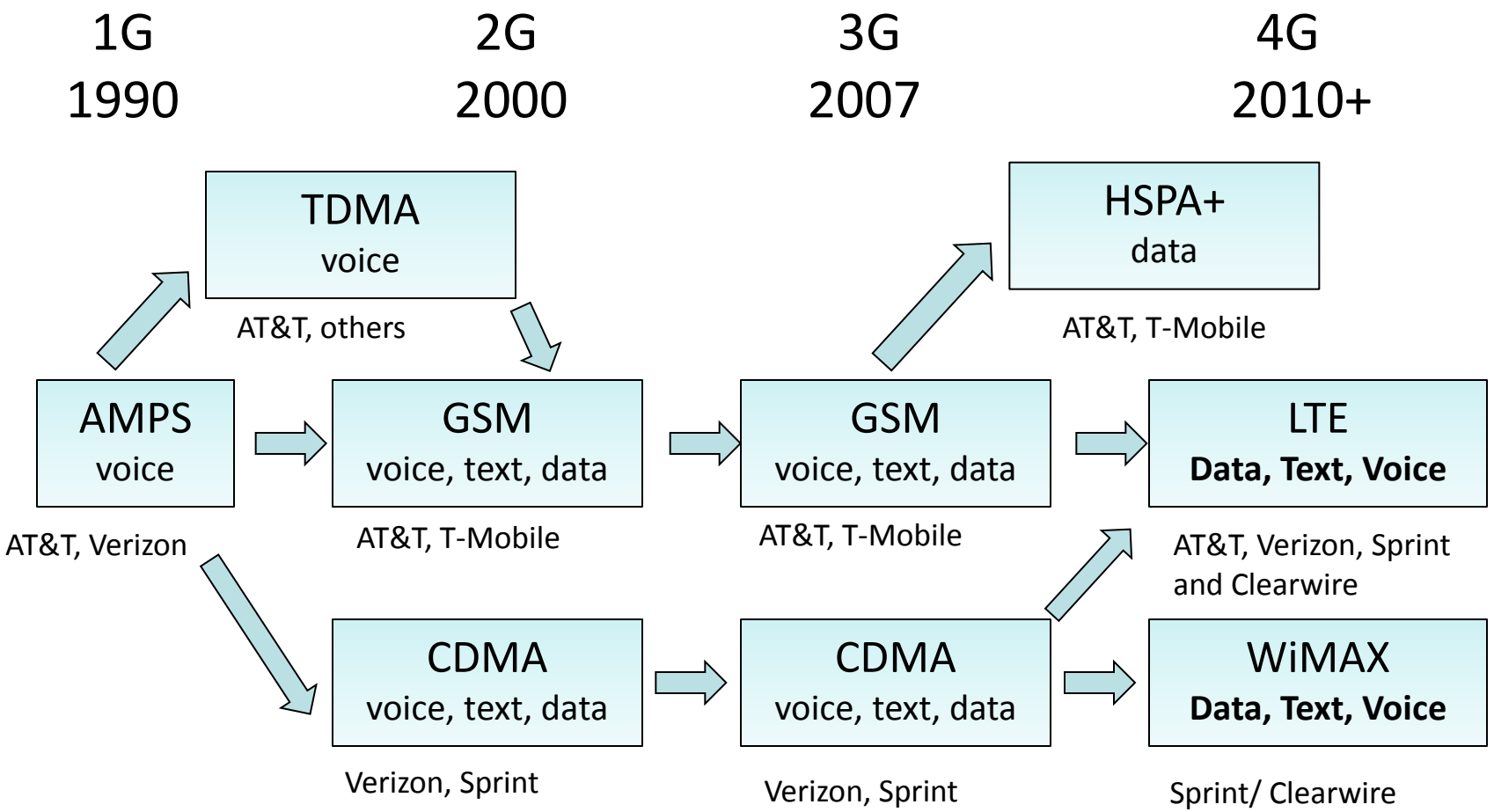
What Is This Network and What Is LTE?

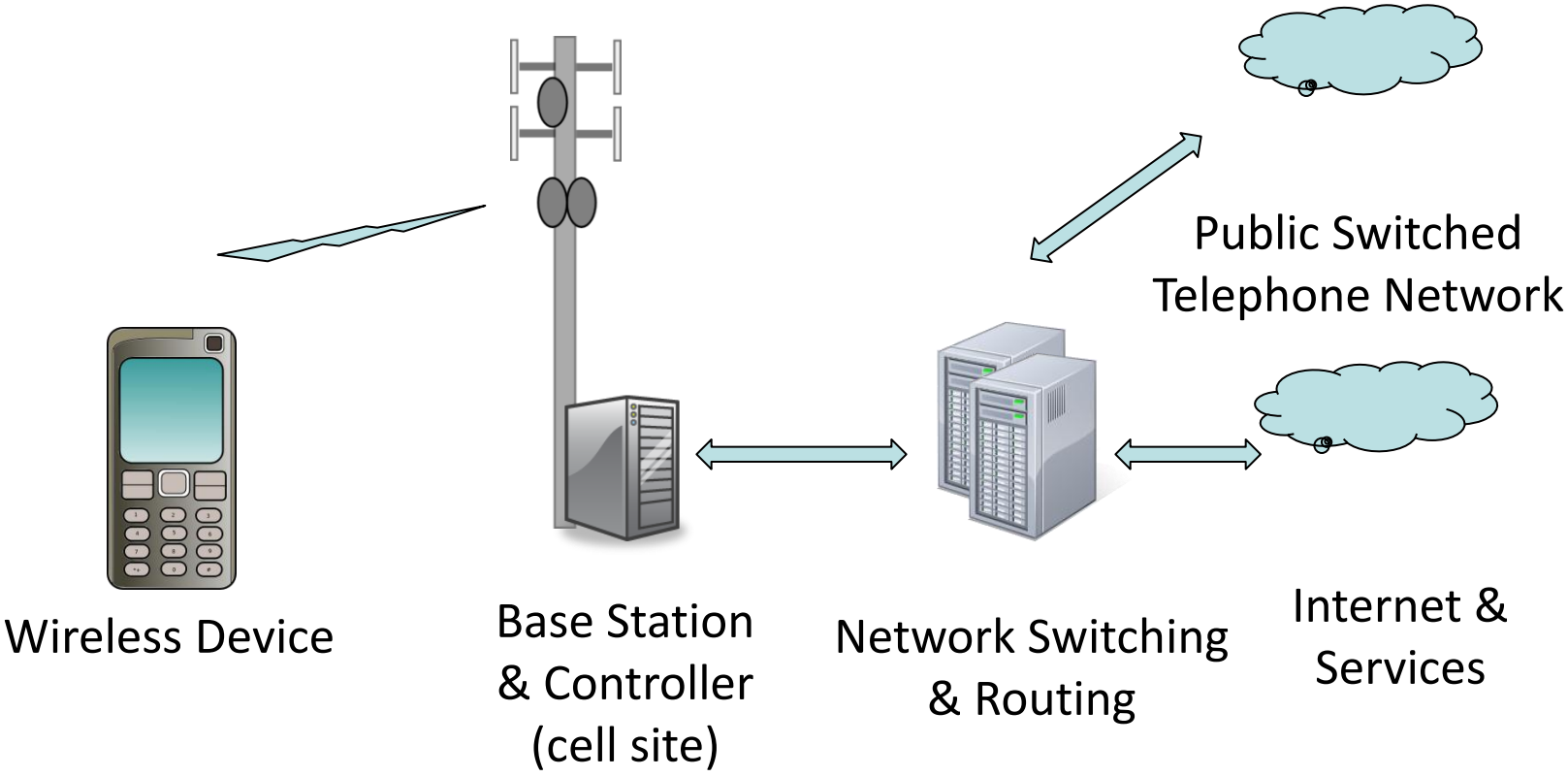
What Is LTE?

- **LTE stands for Long Term Evolution**
  - Standard developed by 3GPP organization
  - Networks and vendors tired of 1G, 2G, 2.5G, 4G names so LTE is really 4G technology
  - Unlike 1, 2, and 3G that were designed for voice first with data added, LTE was designed for broadband data services first and foremost
  - All-IP network
  - LTE refers to the airlink, which is based on OFMDA
    - Orthogonal Frequency-Division Multiple Access
    - Technology developed for high-speed data
  - LTE is an all-IP-based system
    - IP over the airlink and through the back end of the system
    - Low latency—fast data, quick response
  - And you really don't need to know any of this!

Roadmap: First Generation to LTE

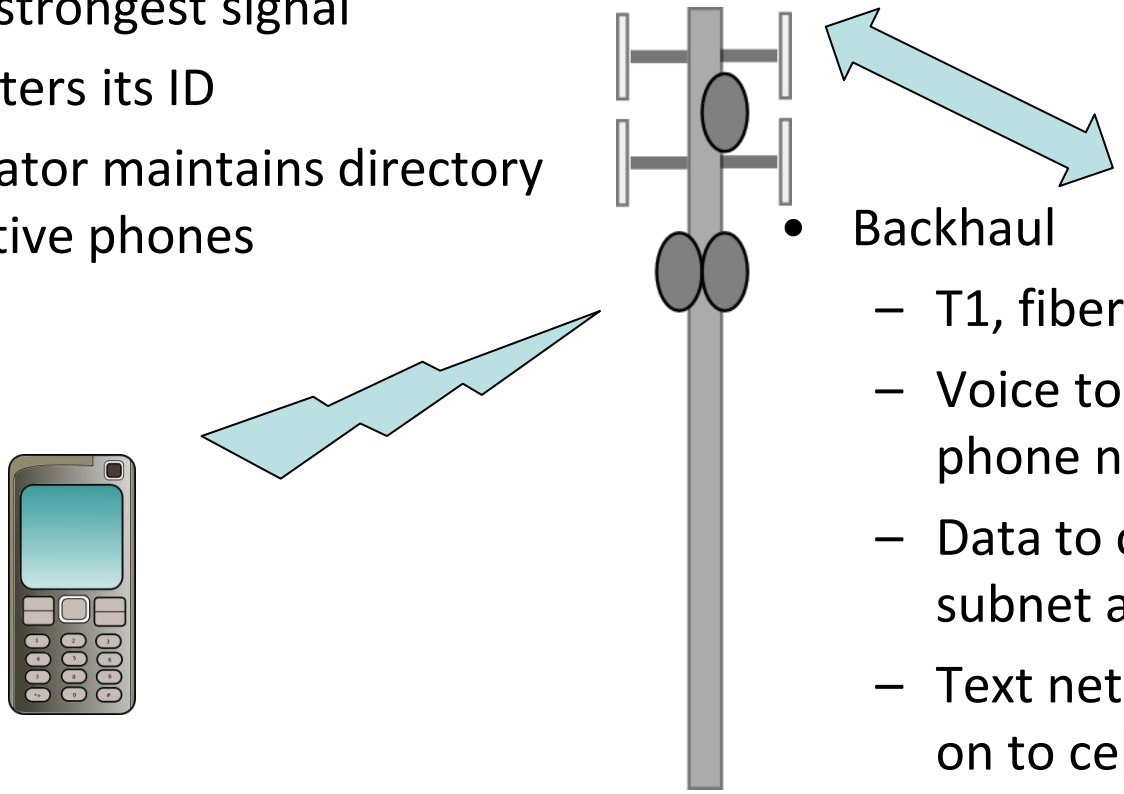


How It Works: Network Overview



How It Works: Backhaul

- Phone connects to cell tower with strongest signal
- Registers its ID
- Operator maintains directory of active phones



- Backhaul
  - T1, fiber, microwave
  - Voice to operator's phone network
  - Data to operator's subnet and Internet
  - Text network and then on to cell phone on any network

Broadband vs. LMR System Design

The Differences

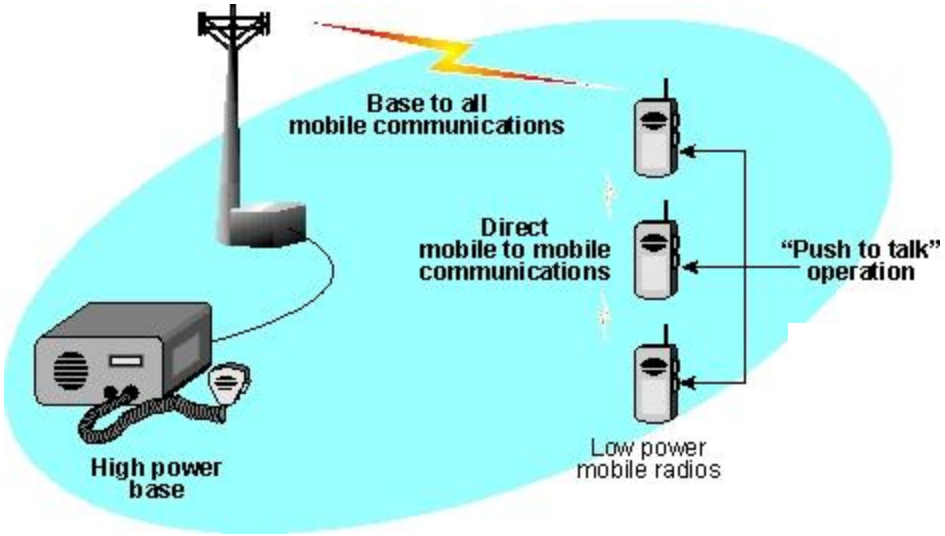
LTE Broadband System Design

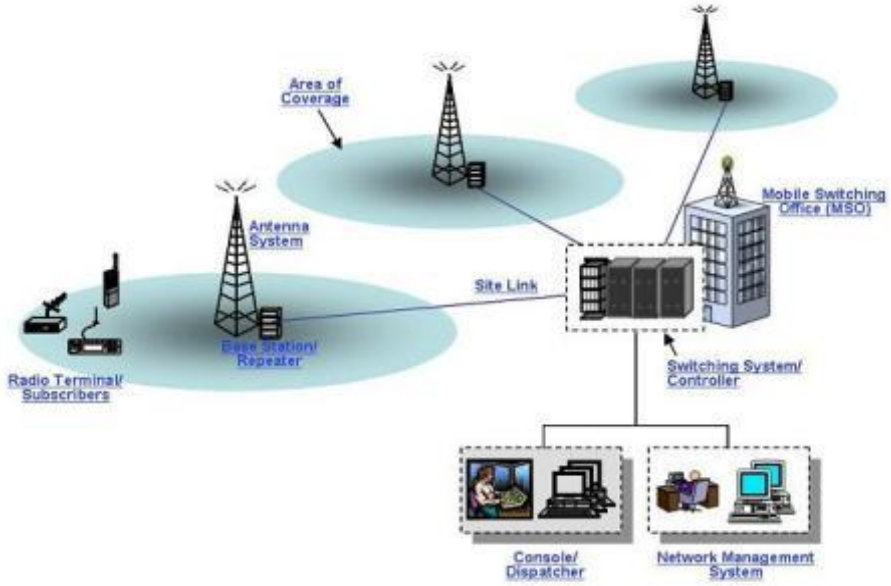
- LMR Systems Base
  - High-level sites
  - High-power transmit
  - Transmit as needed
  - Coverage 20-40 miles
  - Omni antenna
- LMR Mobile/HT
  - High power (5-100W)
  - External antennas
  - Talk-around simplex
- LTE Broadband Cell
  - Low-level sites
  - Low-power transmit
  - Transmits 24/7
  - Coverage 1-3 miles
  - Sectored antennas
- LTE Devices
  - Low power (250 MW)
  - Built-in antennas
  - MUST use cell site

Other Differences

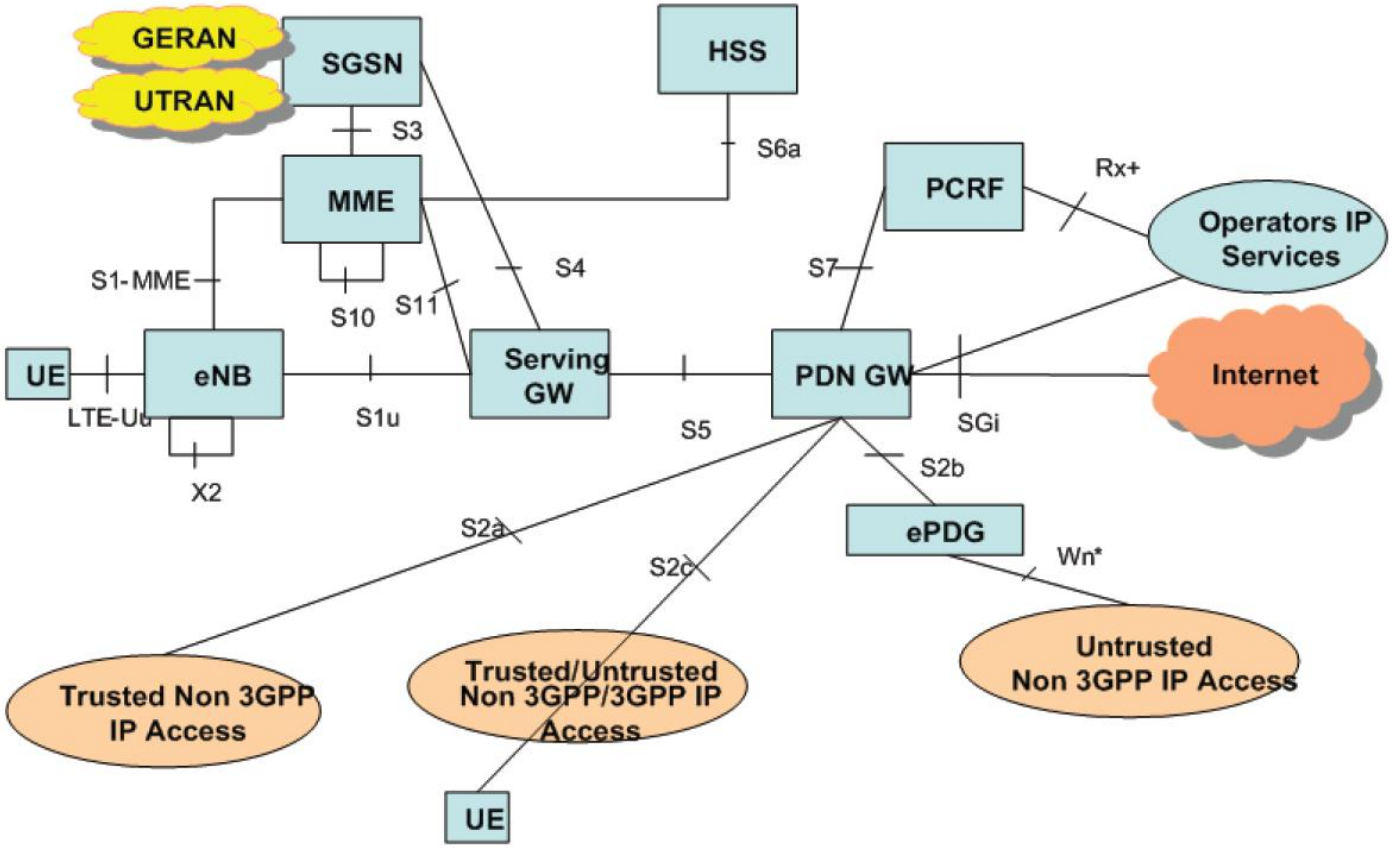
- LMR
  - Wireline/control station/microwave
  - Low capacity requirements
  - Dumb networks
    - Trunked are semi-smart
  - Set and forget
  - External spkr/mic
  - Channel change by user
- LTE Broadband
  - Fiber/microwave
  - High capacity
    - 30-50+ Mbps per site
  - Smart cell sites
  - Requires network core
  - Modify perimeters to handle data demand on real-time basis
  - Channel change by network

Typical LMR System Diagram





LTE Architecture:
A Complex Network



Sites Versus Coverage

- Santa Barbara County Fire
  - VHF (150 MHz)
  - 6 simulcast sites
  - Covers 95% of county
  - Indoor coverage: good to 5W HT
  - Connections
    - Microwave
    - Control stations
  - One-to-many: yes
- LTE Broadband system (proposed)
  - 700 MHz
  - 62 sites
  - Covers 93% of county
  - Indoor coverage will be fair
  - Connections
    - Fiber
    - Microwave
  - One-to-many: no

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LMR and LTE Terminology

Two Different Wireless Languages

LMR and LTE: Different Languages

LMR Speak

- Base station/repeater
- Tower/radio location
- Mobile/HT
- Omni-directional antenna
- Output power in Watts
  - 5 Watts = 37 dBm
- Connection to dispatch
- Simulcast
- Narrowband voice

LTE Speak

- eNodeB
- RAN (Radio Access Network)
- User device
- Sectored antennas
- Output power in dBm
  - 24 dBm = 250 MilliWatts
- Network backhaul
- Multi-cast (future)
- Broadband Data

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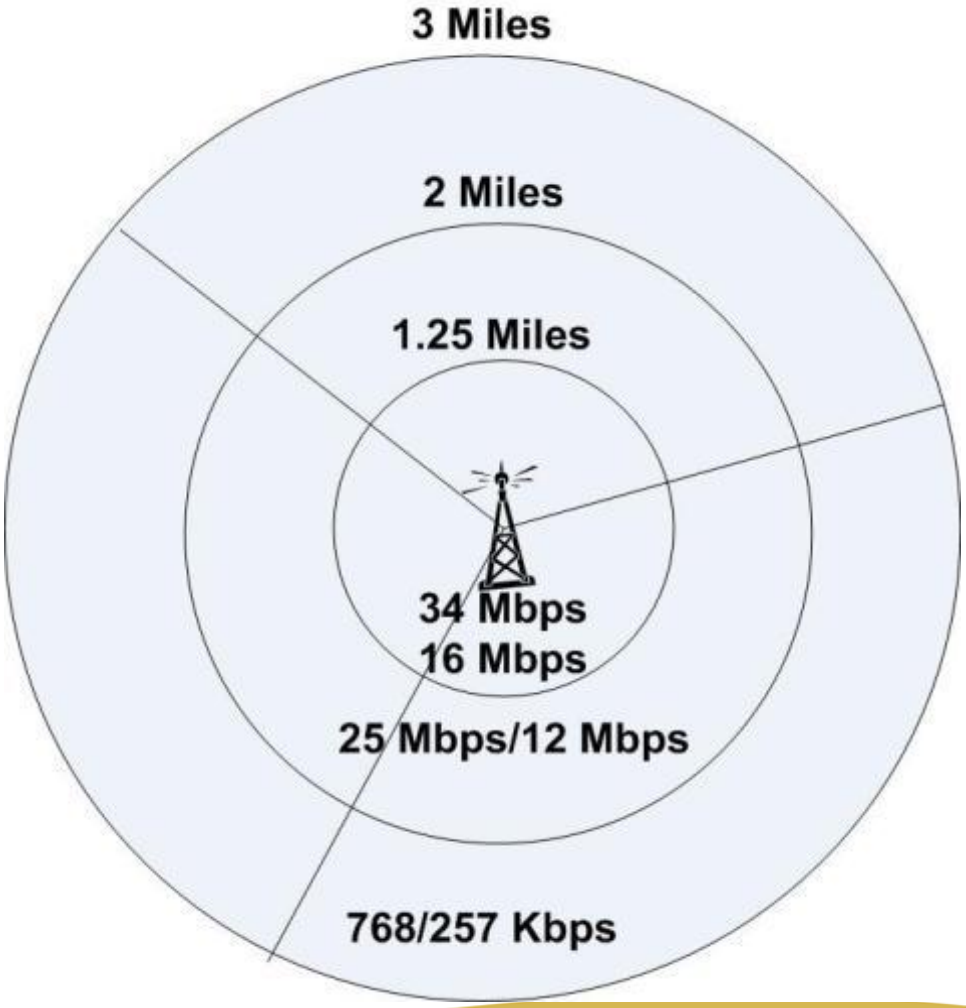
LTE Basics

LTE System Basics

- LTE is cellular-based
  - Mostly low-level sites with 3 sets of antennas, each covering 120 degrees (called cell sectors)
  - LTE reuses same spectrum for each sector and each cell site
  - System design is critical because overlapping cell sectors can cause system interference thus reducing data rates
- LTE uses three outbound and two inbound data rates
  - Closer you are to cell center the higher the data rate
  - At cell edge, data rates can be very slow (256 Kbps or less)
- LTE is designed for multiple antenna use—MIMO
  - Can be configured for MIMO from the cell site, one antenna from the device (Verizon's system) *Note: Impact to tower rentals and wind loading*
  - Can be designed for MIMO in both directions
  - MIMO increases range and data speeds
  - MIMO reduces interference from multipath

Typical LTE Cell Site at 700 MHz

- Data Speeds down to device/up from device Speeds/Capacity are per sector. 3X for site
- Capacity in each sector shared by all users in the sector
- These are typical numbers, may vary from system to system
- 3 Data Speeds to devices
- 2 Data Speeds from devices



LTE System Basics

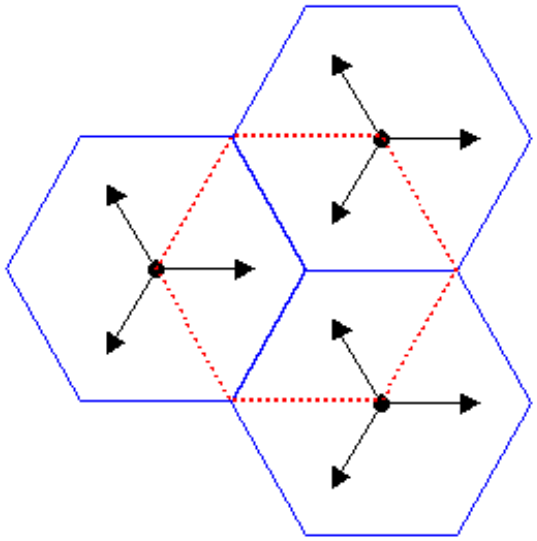
- LTE was designed to operate on different amounts of spectrum
  - 1.4, 2.5, 5, 10, 15, and 20 MHz (Times 2)
  - The more spectrum available, the better the data rates and the more capacity on a per-cell-sector basis
  - Verizon building out in 10X10 MHz of spectrum (20 MHz total)
  - Public safety now has 10X10 MHz also (20 MHz total)
- Cell sizes supported
  - 5 Km (3+ miles)
  - Maximum of 100 Km (62 miles)
  - **However, network degradation beyond 30 Km (18.5 miles)**

LTE System Basics (cont.)

- LTE includes many parameters for network performance
  - Data rates up and down can be changed
  - Quality of Service (QoS) implemented in LTE
  - Various levels of priority service available
- Networks can be set for static configurations or parameters can be changed based on demand for services
- Network will evolve making use of several types of cell sites
  - **Macro sites**—main sites with 3 sectors to cover major areas
  - **Micro-sites**—smaller sites, used for fill-in where not practical to build full macro sites
  - **Pico sites**—even smaller sites again used for fill-in or to add capacity
  - **Femtocell** and **Distributed Antennas Systems** (DAS) will be used to enhance in-building coverage

All LTE Wireless Bandwidth Is Shared

- Bandwidth is shared
  - On a sector basis
  - Data speeds vary
    - Close to cell center
    - Mid-range in coverage
    - Edge of cell
  - Single user within a sector
    - Gets all capacity and speed
  - Multiple users share total available bandwidth
- Each Cell Site
  - Divided into 3 sectors
  - Each sector has same capacity



Shared Bandwidth/Capacity

- For normal dispatch, patrol, location and other services spread out over a city or county, bandwidth will not be an issue
- Where it becomes an issue
  - When a large incident happens in a confined area
    - LTE coverage from only one to two cell sectors
- In this case real-time network management will be required
  - Priority traffic settings, which videos are important

Public Safety LTE Devices

Generation One

- Narrowband mobile and handheld
  - Conventional and trunked
  - 150/450/470/700/800-MHz coverage
  - Analog and P25
  - Multi-channel
  - Mobile and portable
  - Power 5 to 100 watts
- LTE broadband
  - USB/ trunk-mount modem 250 MW
  - LTE for public safety only or
  - LTE and 3G capable
  - Data only (for now)

Generation Two

- LTE-only handheld devices
  - Like smartphones but hardened
  - Some may use Bluetooth to talk to LMR Radio
  - Will have AT&T/Verizon capabilities
- LTE/3G devices
  - Support LTE/3G data
  - 3G voice (telephone)
  - Perhaps non-mission-critical PTT

Generation Three

- LTE/LMR combination devices
- Mobile radios (soonest)
- Handheld devices—next
  - Maybe LTE PTT-capable

Public Safety Broadband Changes Everything!

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Public Safety Broadband

- Nationwide
- Interoperable
- Adds data, streaming audio, video to public safety in the field
- Enables operations center, incident commander to see in real time
- Dispatch will include video from nearest camera
  - Incoming units will be able to see what they are heading into
- IC and swat commanders will be able to see what sniper sees through his/her scope
- Real-time, full-motion video (within reason) will change public safety forever
- Full 12-lead EKG and ultrasound / other vital signs for EMS
- Other applications will make life on the street easier and safer!

Broadband Will Change Dramatically

- Video from dispatch to units responding
- Video from scene to dispatch/EOC
- Incident Command will have view into the incident from front, sides, rear and the sky
- Building plans sent to responders en route
- Hazardous materials types and locations
- Police/fire/EMS will all have access

Broadband Will Change Dramatically

- More information about the response before arriving on scene
  - Prior history, firearms registered to location
  - Picture of suspect if avaialble
- Normal dispatch activities
  - License checks, location, reports
  - Video from a stop if there is a problem
  - Filing reports from the field

Mission-Critical Voice over the LTE Broadband Network

It Won't Be Available for a While If At All!

LTE Voice

- Commercial operators will, at some point, support
  - Voice over IP (VOLTE) for telephone calls
  - Non-mission-critical voice
    - Some believe commercial operators are already providing voice over LTE—NOT TRUE
    - Voice today is handled on their 2G and 3G networks NOT on their LTE networks
  - Voice may be available in 2013-14 timeframe

Typical Commercial Voice Services

- Voice for telephone calls
  - Single user to network for voice calls
  - Dial or receive call from another person
- Push-to-talk services
  - Available today on some 2G and 3G networks
  - Will come to LTE after voice calls (commercial)
  - Non-mission-critical in nature
  - Ability to assign multiple talk groups

LTE: Multiple Types of Voice

- Types
  - VoIP for telephone calls
  - On-network push-to-talk
  - Off-network (simplex, tactical, talk-around)
- Two levels of voice services
  - Non-mission-critical (administrative)
  - Mission-critical (full public safety grade)

On-Network Voice Services

- Administrative on-network push-to-talk
- Mission-critical on network push-to-talk
  - Multi-zone dispatch and citywide
  - Incident coordination channels
- What we know
  - Non-mission-critical PTT is possible
- What we don't know
  - What else is possible and when

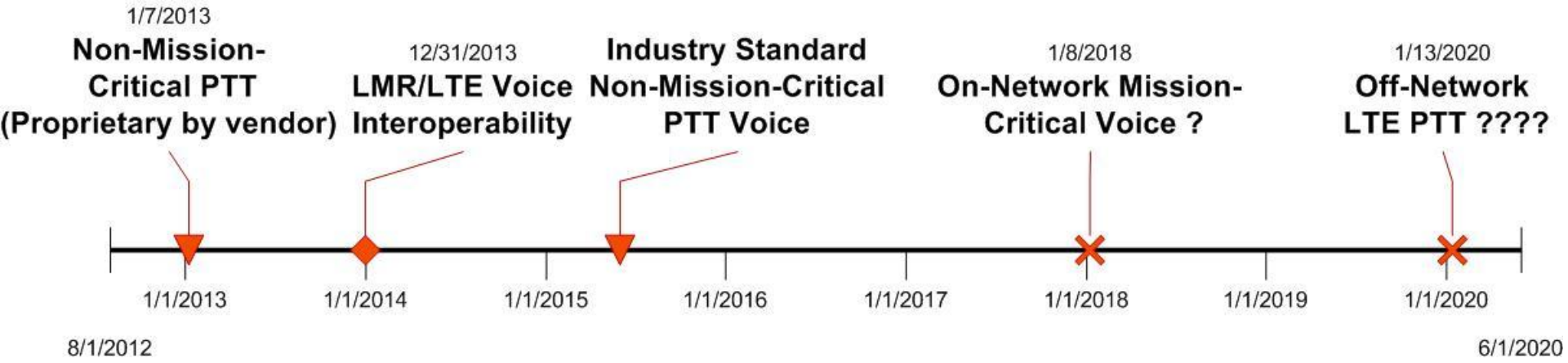
Off-Network Voice Services

- Commercial operators do NOT understand this requirement
  - They believe that on-network voice is all that is required
- Yet it is one of the most important elements of public safety communications
- In-building, out-of-network coverage voice communications is still vital!

Off-Network Voice

- In-building coverage
- Out-of-network coverage
- Multiple channels available
  - Wild fires require MANY off-network channels
- Easy to use, fast to set up
- TODAY: no support for off-network voice
  - Standards body only starting to look at this

LTE Mission-Critical Voice Timeline



Note: Timeline is an estimate based on discussions with vendors and my own assessment of the technology

Conclusions

LTE Benefits

- LTE public safety broadband
  - Mission-critical data and video services to public safety communications
  - Nationwide, fully interoperable data/video network
  - Lower-cost devices because they are based on commercial technology
  - Public safety will have full control of the public safety LTE network
    - Won't have to share the network with commercial customers
- Public Safety was given the D Block because
  - 10 MHz of spectrum would not provide enough data capability even for routine incidents that will require data and video services
  - Public safety needs complete control over all the spectrum it needs
- Public/private partnerships will provide both public safety and commercial broadband services to rural America
  - And faster than any other proposed rural broadband plan!

What Public Safety Will Have to Learn

- LMR and LTE systems are very different
  - Different design criteria
  - Different types of operation
  - Different types of applications and capabilities
- LTE systems bandwidth will need to be managed on an incident-by-incident basis
- The networks will cost more to build and operate
  - Device prices will be lower and more affordable
- Network construction will be an ongoing process
- How to integrate voice and data networks
- The limitations of LTE for mission-critical voice services
- That both narrowband and broadband networks will be needed for at least a decade if not longer

Any Questions?