5G: From a Public Safety Perspective

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5G technology definition is accelerating

Consortia Reports

- Final report on architecture (METIS - 3/2015)
- 5G Vision (5GPPP - 3/2015)
- 5G White paper (NGMN Alliance – 2/2015)
- 4G America’s Recommendations on 5G (10/2014)

Public funding

- 5GPPP (EU - €700M)
- 5G forum (ROK - $750M through 2020)
- IMT-2020 Promotion Group (China)
  - Three ministries (MIIT, NDRC and MOST)
- “2020 and Beyond Ad Hoc (20B AH)” (Japan)

Cooperation

- 5G-PPP and 5GMF (2/2105)
- 4G Americas and 5G PPP MOU for 5G (3/2105)
- 5G Forum / EU (6/2014)
- 5G Forum / 20B AH MOU (12/2013)
Public Safety Broadband is gaining momentum

**Commercial Broadband**
- Broad use of commercial services
- Limited priority and interoperable capabilities

**Public Safety Broadband**
- FirstNet Funded in 2015
- International effort: UK, S. Korea, Canada, Australia, Sweden

**Uphill Road**
- Continued investment in LMR
- Build out of Band14 Public Safety networks will take time
- Relatively Small user base compared to commercial use

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FirstNet by the Numbers

**Vision**
To provide emergency responders with the first high-speed, wireless nationwide public safety broadband network (NPSBN)

**The Law**
2.22.12
FirstNet becomes Law PL 112-96

**Funding**
$7B authorized to build the FirstNet Network. Funded by spectrum auctions through 2022.

**Governance**
The FirstNet Board has 15 members, including those with telecommunications and public safety backgrounds.
Each Governor appoints one single point of contact and governing body to represent the state’s interests to FirstNet.

**Band Class (BC) 14**
20MHz of bandwidth has been dedicated to public safety in the prime upper 700MHz frequency range.

**Who Will Use FirstNet**
Over 5 Million potential FirstNet public safety users nationwide

FirstNet’s goal is to ensure there is service in all 50 US states, 5 territories, and the District of Columbia.

http://www.firstnet.gov/sites/default/files/firstnet_by_the_numbers_v2.pdf
Public Safety value from 5G?

User view:

• Appear ubiquitous and limitless
• Support emerging applications
  • Direct mode PTT
  • Emergency sensor networks

Operator view:

• Higher area capacity (1000x greater)
• Higher capacity density (~1000 bits/s/Hz/km²)
• Higher connection density (~10,000/km²)
• Lower latency (ms)
• Lower energy consumption
• Software-defined flexibility
A 5G worldview

- Direct mode communications
- Multihop communications
- Multi-eNodeB communications
- M-to-M communications
- Shared spectrum
- Sensor networks
- Ultra-dense
- Small cells
- Multi-RAT
- Beamforming (high data rate)
- Vehicular communications
Potential Public Safety Use Case: Spectrum Sharing

- Direct mode communications
- Multihop communications
- Multi-eNodeB communications
- M-to-M communications
- Band 14 sharing with preemption
- unlicensed off-load

- Sensor networks
- Ultra-dense
- Small cells
- Multi-RAT
- Beamforming (high data rate)
- Vehicular communications

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Potential Public Safety use case: Direct Mode Capability

- Direct mode
- Group communications
- PTT communications
- Multihop communications
- Multi-eNodeB communications
- M-to-M communications
- Sensor networks
- Ultra-dense
- Small cells
- Multi-RAT
- Vehicular communications
- Beamforming (high data rate)

REL 12/13

unlicensed off-load
Band 14 sharing with preemption

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Potential Public Safety use case: Relayed Communications

- Direct mode
- Group communications
- PTT communications
- UE-UE relay
- Relay communications
- Multi-eNodeB communications
- Sensor networks
- Ultra-dense
- Multi-RAT
- Beamforming (high data rate)
- Vehicular communications
- M-to-M communications

unlicensed off-load
Band 14 sharing with preemption

REL 12/13
REL 13+

Potential Public Safety use case: Relayed Communications

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Potential Public Safety use case: Resilient Communication

- Band 14 sharing with preemption
- Unlicensed off-load

- Direct mode
- Group communications
- PTT communications

- UE-UE relay

- Multi-eNB communication resilience
- Multi-eNB communication resilience

- Ultra-dense
- Multi-RAT
- Beamforming (high data rate)

- Sensor networks
- Vehicular communications
- M-to-M communications

- Potential Public Safety use case: Resilient Communication

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Potential Public Safety use case: M2M and Sensors

- Band 14 sharing with preemption
- unlicensed off-load

- Direct mode
  - Group communications
  - PTT communications

- UE-UE relay
  - Multi-eNB communication resilience
  - Critical M-to-M communications
  - REL 10+

- Hazard sensors body networks
  - Ultra-dense
  - Multi-RAT
  - Beamforming (high data rate)

- Multi-eNB communication resilience
  - REL 11

- Vehicular communications

- Potential Public Safety use case:
  - M2M and Sensors

- REL 12/13
  - REL 13+
  - REL 12-13
Potential Public Safety use case: Vehicular Communication

- Direct mode communications
- Group communications
- PTT communications
- UE-UE relay communications
- Multi-eNB communication resilience
- Multi-RAT (high data rate)
- Band 14 sharing with preemption
- Ultra-dense networking
- Small cells
- Beamforming
- Relay communications
- Hazard sensors
- Body networks
- Critical M-to-M communications
- Emergency Vehicular communications

Use cases:
- Potential Public Safety: Vehicular Communication

Technologies:
- REL 12/13
- REL 13+
- REL 11
- REL 12-13
- REL 10+
- REL 14
Potential Public Safety use case: Incident Area Networks

- Band 14 sharing with preemption
- unlicensed off-load
- Direct mode Group communications
- PTT communications
- UE-UE relay
- Relay communications
- Multi-eNB communication resilience
- Hazard sensors body networks
- In-building coverage (small cells)
- Deployable Small cell
- Incident Area Network
- Critical M-to-M communications
- Emergency Vehicular communications
- REL 10+ / 13
- REL 10+ / 13
- REL 11
- REL 12-13
- REL 10+ / 13
- REL 10+
- REL 14

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NIST CTL Priorities and 5G Programs (Today)

Through the development of appropriate measurements and standards:

1. Enable robust, mission-critical, interoperable public safety communications

2. Enable effective and efficient spectrum use and sharing
   - Center for Advanced Communications
   - National Advanced Spectrum and Communications Test Network (NASCTN)

3. Enable advanced communications technologies – 5G
5G Program: Millimeter Wave Metrology

5G mmWave Channel Model Alliance

- Kick-Off: July 8-9, 2015 in Boulder, CO
- Purpose: assemble worldwide expertise to tackle fundamental challenges in channel measurement and modeling.

- Participants to include Qualcomm, Samsung, Nokia, Alcatel-Lucent, Huawei, Keysight, National Instruments, NYU Wireless, University of Southern California, Fraunhofer Institute, The Ilmenau University of Technology (Germany).

- Provide improved channel measurement techniques, repository for channel sounding techniques, measurement data, and library of channel models.
5G Program: Ultra-Dense Networks

**Major objectives**
- Develop new propagation models for ground-to-ground communication links
- Model PHY and MAC layer processes, interference mitigation schemes
- Develop mobility management mechanisms for coordinating communications between base stations and for UEs moving through dense station deployments.

**Motivations**
- Increase capacity with dense deployments of small/heterogeneous cells.
- Enable offloading from macrocells where needed.

**Progress to date:**
- Developing mobile virtual cell models and simulation platforms.
5G Program: Massive MIMO

Major objectives

• Antenna metrology for MIMO arrays
• Array calibration procedures
• Characterization of field-deployed arrays

Motivation

• Leverage the highly multipath nature of environments for improved throughput
• More efficient use of radiated power in narrow beams
• Reduced interference between intended users
• Requires development of detailed characterization methods and models

AND

• Development of robust and efficient test methods for performance verification

200 antenna MIMO simulation