Public Safety Needs both Wideband and Broadband Options

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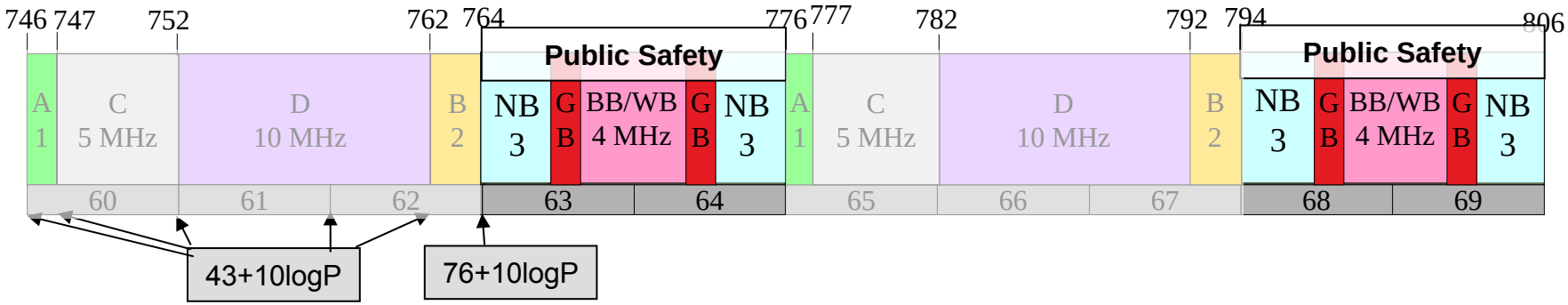
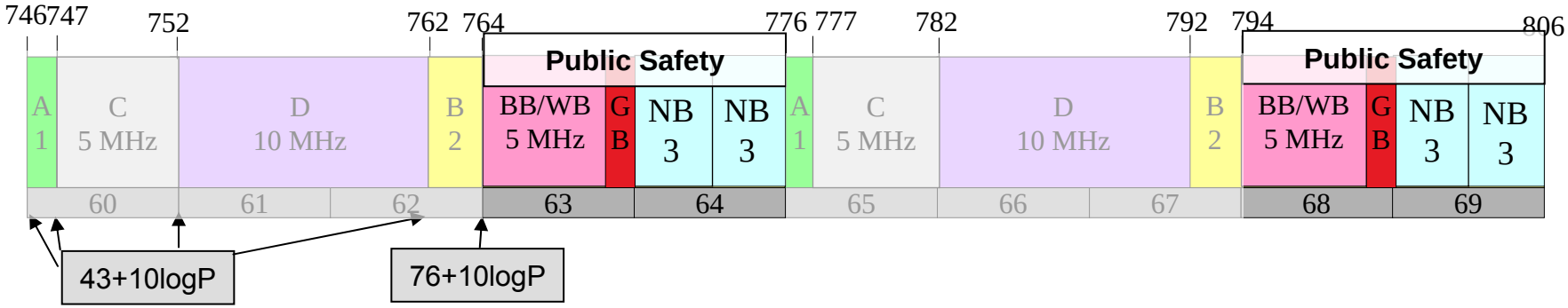
Reconfiguring PS Spectrum Provides Significant Benefits

Current Plan - 4 MHz for PS broadband*



Current Plan with rearrangement of PS spectrum – 5 MHz for PS BB/WB



<u>Consolidate narrowband channels</u>

- Reduces internal guardbands - increasing usable spectrum by at least 1 MHz
- Provides additional flexibility for broadband deployment
- Any wideband deployment can start adjacent to narrowband systems

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Broadband Wireless Technologies are Evolving to OFDM …

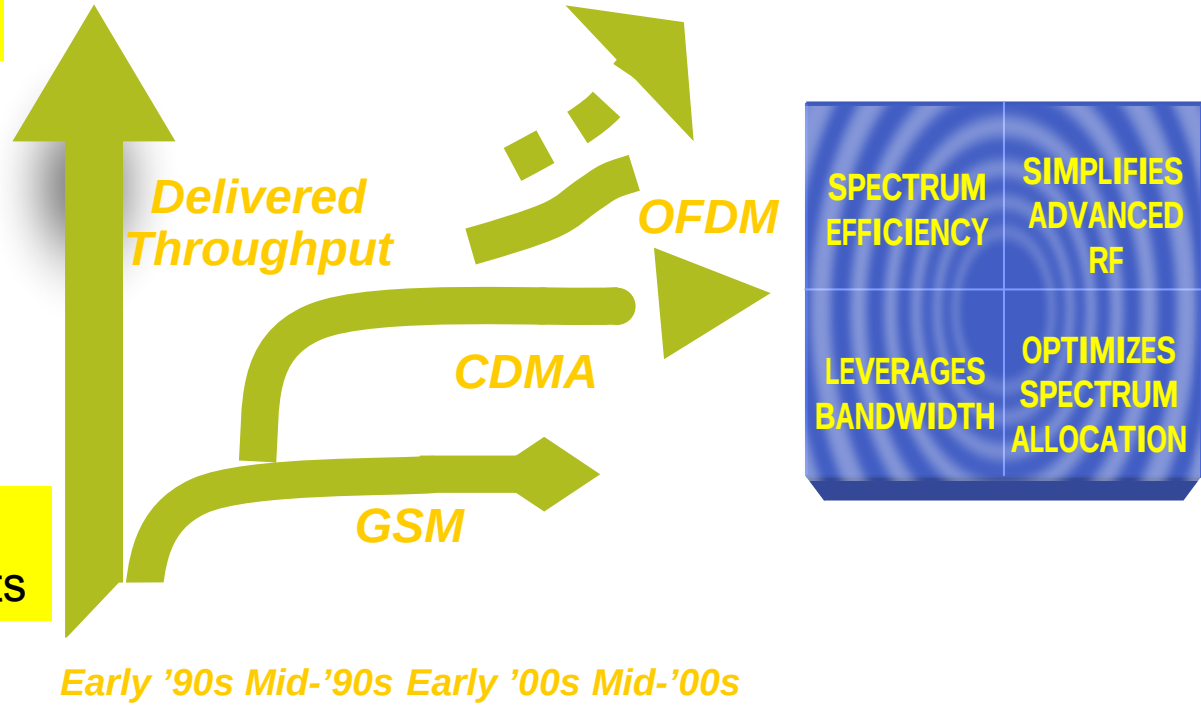
OFDM-Based Technologies Offer Advantages

- Greater spectral efficiency,
- 1:1 frequency reuse
- Better performance in multi-path environments

- Improved throughput & capacity
- Low latency

LTE – *A world-wide, next generation broadband standard*

- Suited to FDD spectrum
- Greatest scale → Lower costs



The broadband evolution path for >80% of worldwide CMRS

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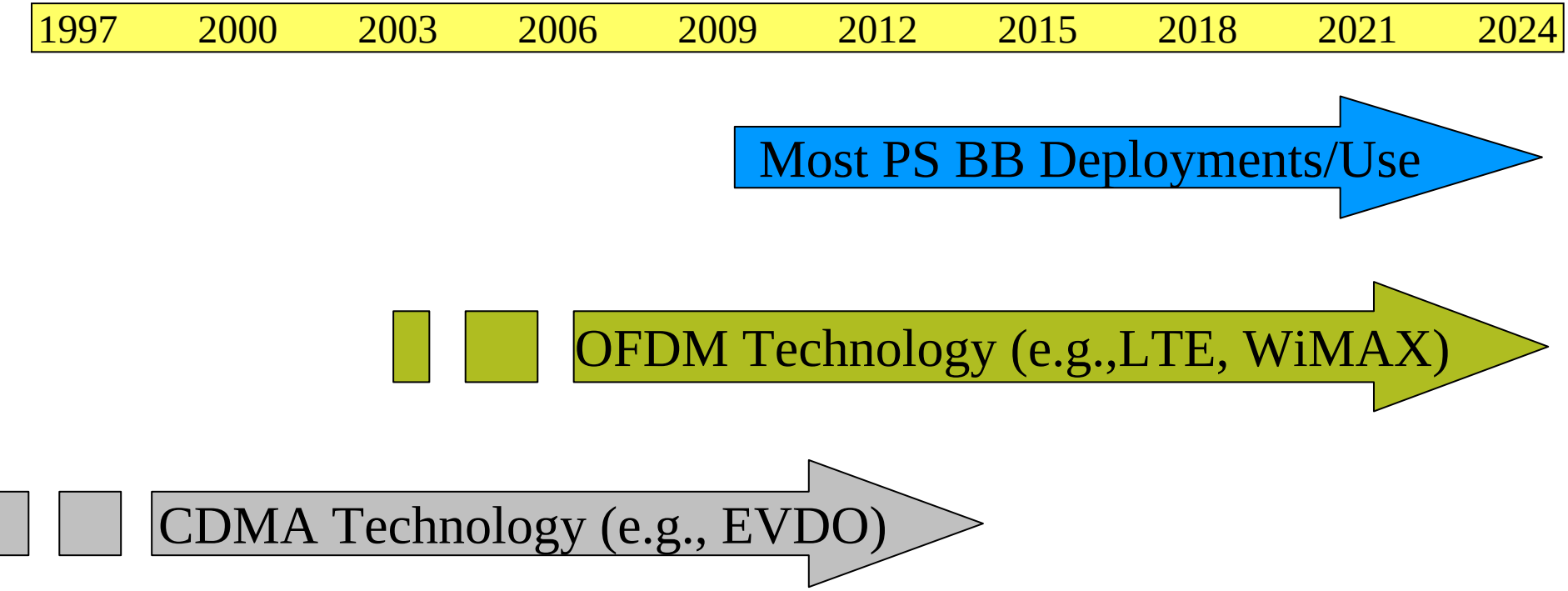
Look Forward: 10-15 Year Technology Platform



The FCC Should Not Select A Broadband Standard Yet

- Technology Options are Evolving
- No Broadband Technology Developed for Public Safety

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Flexibility Should be Provided to Allow Wideband

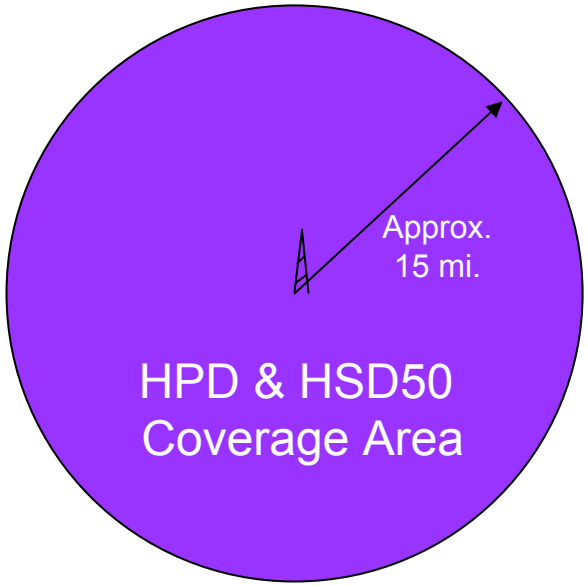
Wideband Data Enables Large Coverage Areas with Fewer Sites.

- Covers 700 sq. mi vs. 80 sq. mi for High Site Broadband.

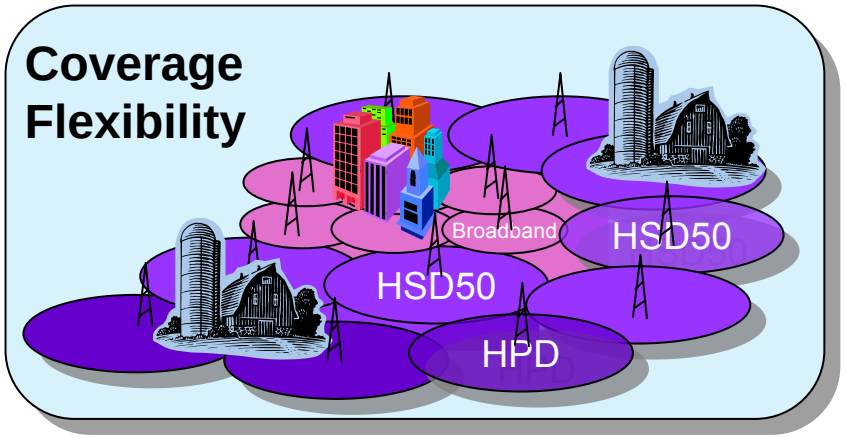
Equivalent Wideband Coverage Enables Re-Use of Voice Sites.

- Add Data Equipment to an Existing Site vs. Building New Sites.
- Building New Sites Can Cost as Much as $1M per Site.
- WB can also reuse switch from newer P25 systems

Extremely Cost Effective for Covering Large Rural Areas.



High Site Broadband Coverage Area



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Comments & Replies Support Providing the Option for Public Safety WB/BB Choice

FCC Should Allow WB/BB Option

- APCO
- Carnegie-Mellon University
- Data Radio
- GeoComand (wants WB only)
- Missouri State Highway Patrol
- Motorola
- NPSTC (collective voice of PS representing 14 associations)
- Philadelphia (City of)
- RCC Consultants
- 700 MHz RPC 22 (23 state/local agencies)
- 700 MHz RPC 24 (23 state/local agencies)
- 700 MHz RPC 39 (60 state/local agencies)
- Spectrum Coalition for Public Safety

FCC Should Mandate BB – No User Choice

- Alcatel-Lucent
- Cisco
- CTIA
- High Tech DTV Coalition
- Northrop-Grumman
- ***No public safety entities***

Flexibility provides more user choice and greater competition;
A broadband-only mandate provides less user choice and reduces competition

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Multiple Solutions Enable Public Safety Data Applications

Narrowband Channels

Tier 1 – 9.6 kbps IV&D (12.5 kHz)

- Messaging
  - Dispatch
  - Text messaging
- Query Databases
  - Driver's License
  - License Plates
  - Warrants
- AVL (constrained)
- Meter Reading

Text Based

Tier 2 - 96 kbps HPD (25 kHz)

- Includes Tier 1
- Fingerprints (Tx)
- Mug Shots (Tx/Rx)
- Reports (Tx)
- Intranet (constrained)
- Internet (constrained)
- AVL

Browser

Wideband Channels

Tier 3 – 100 to 500 kbps HSD (50 / 150 kHz)

- Includes Tier 1&2
- Intranet Access
- Internet Access
- Images (Tx/Rx)
- Video (buffered)
- Remote Camera

Graphics

Broadband Channels

Tier 4 - Megabits LTE, MOTOMESH

- Includes Tier 1-3
- Office Apps
- Video (full motion)
- Video (buffered)
- Multimedia
- Remote camera viewing / control
- OTAP (reflash mobile radios)
- Video archiving

Multimedia

Multi-Net Mobility enables Seamless Mobility across networks

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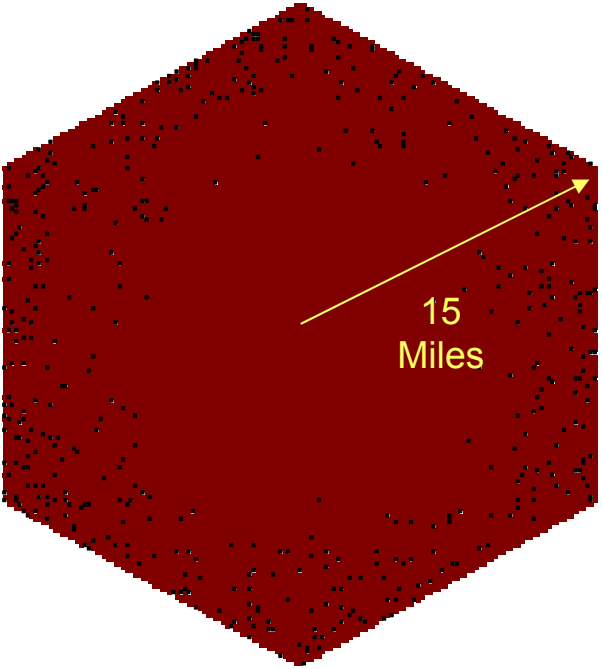
Outbound Bit Rate Comparison

- **"Apples-to Apples" Comparison**
  - Omni sectorization, typical power levels and 15 mile range are assumed.
  - The color indicates the bit rate available at each location
- **Data rates vary over coverage area**
- **BB & WB offer similar throughputs over most of the area**
- **WB consumes a fraction of the bandwidth of broadband**

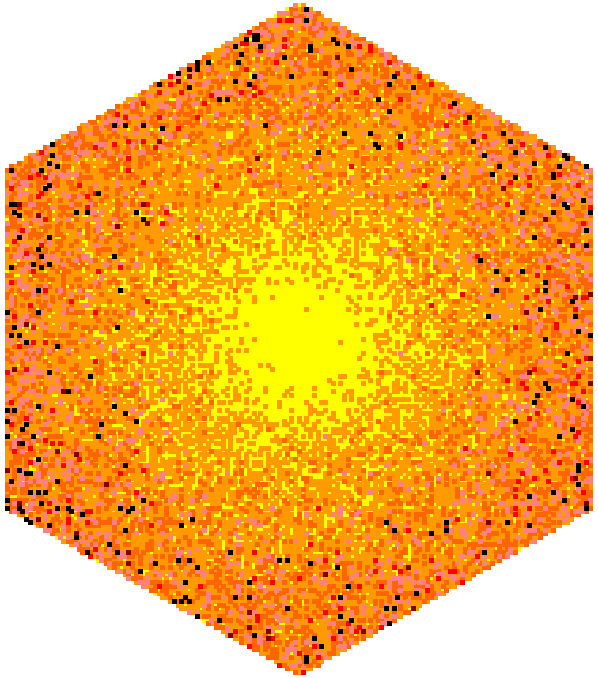
- ≥1228.8 kbps
- ≥614.4 kbps
- ≥307.2 kbps
- ≥153.6 kbps
- ≥76.8 kbps
- ≥38.4 kbps
- ≥19.2 kbps
- ≥9.6 kbps
- Outtage

Outage= Data speed < 9.6 kbps

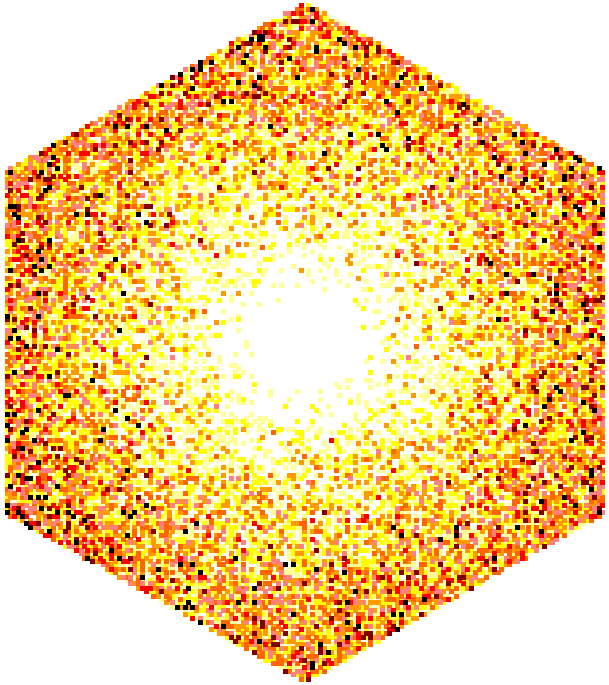
Narrowband



Wideband



CDMA Broadband



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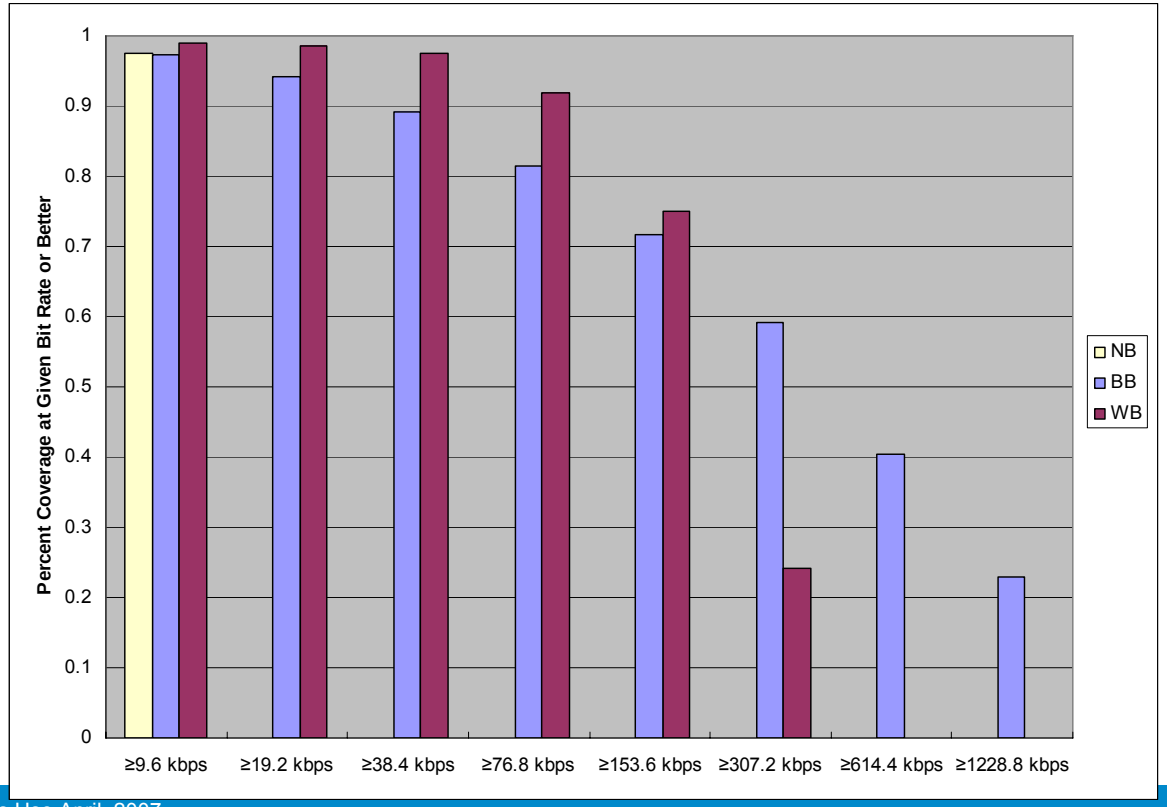
Coverage/Data Rates/Spectral Efficiency

- WB covers a slightly greater percentage of the area at 150 kbps or better compared to BB
- BB offers higher bit rates than WB in only about half of the coverage area
- BB requires 1.25 MHz channel + 1 MHz Guardband, i.e, 2.25 MHz
- WB150 with a 7 cell reuse pattern would require 1.05 MHz; Coverage same as voice so all sites could be co-located and no guardband required.
- For most tier 1 to 3 application data rates, WB is more spectrally efficient than BB.
- For most tier 1 to 3 application data rates, WB offers higher reliability of coverage than BB



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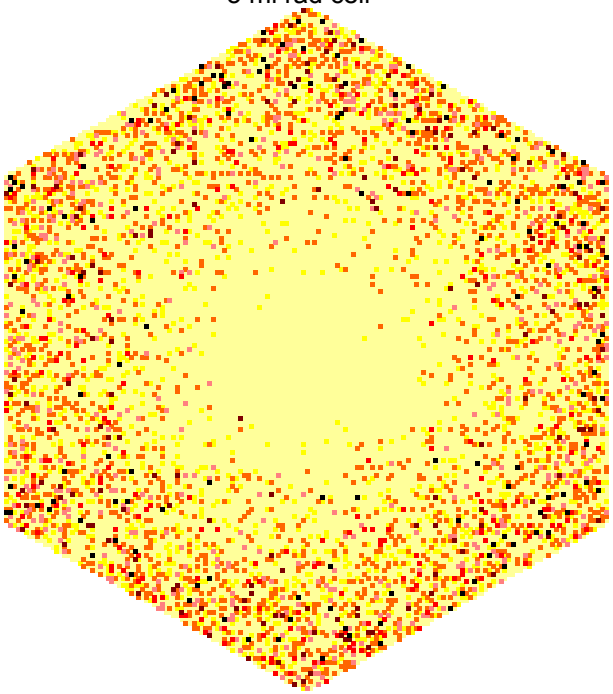
Inbound Bit Rate Comparison (5 mile range)

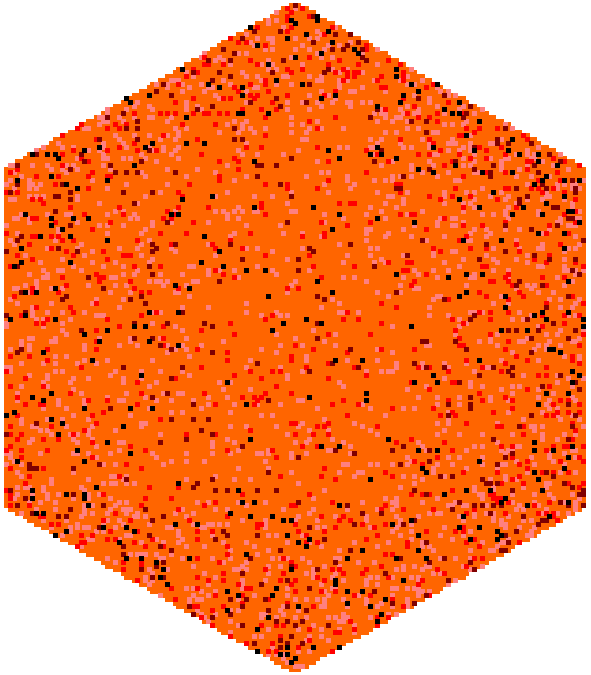
- **Reducing the range to 5 miles:**
  - For a single user the bit rate is at least 600 kbps at 77% of the locations
  - For two simultaneous users the maximum bit rate drops to 153.6 kbps – less than half – because with two users the SNR cannot be greater than 0 dB
  - For three simultaneous users the maximum bit rate is still 153.6 kbps but the maximum bit rate is less than 76.8 kbps at about 40% of the locations

- ≥1228.8 kbps
- ≥614.4 kbps
- ≥307.2 kbps
- ≥153.6 kbps
- ≥76.8 kbps
- ≥38.4 kbps
- ≥19.2 kbps
- ≥9.6 kbps
- Outtage

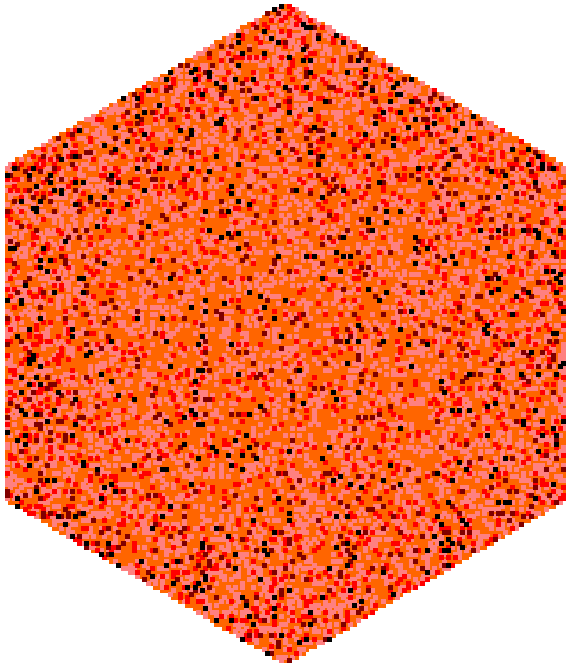
CDMA BB; Single User
5 mi rad cell



CDMA BB; Two Users
5 mi rad cell



CDMA BB; Three Users
5 mi rad cell



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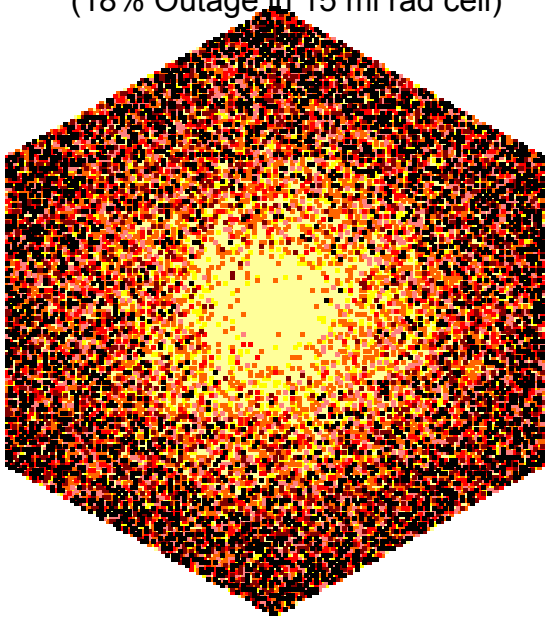
Inbound Bit Rate Comparison

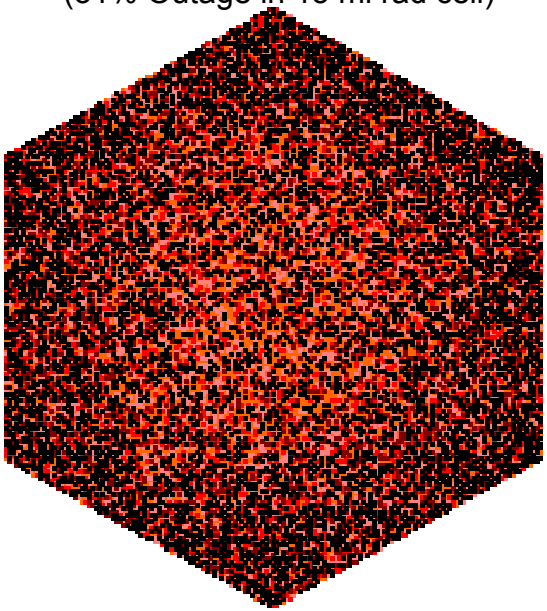
- **WB inbound and outbound bit rates are about the same because the systems are designed to be symmetrical and mobile unit powers will be used, i.e., 15 mile range**
- **BB CDMA inbound and outbound data rates have greater differences**
  - Power control is required so the closest unit is no stronger then the farthest unit
  - Subscriber power only approx. 200 mW; power must be increased, cell size must be reduced or greater outage tolerated.
  - Also, as you add simultaneous users, either range or data rate must be reduced
  - Example: 7 miles for 1 user reduced to 5.5 miles with 2 simultaneous users and 5 miles for 3 simultaneous users, to get 97.5% coverage of at least 9.6 kbps

- ≥1228.8 kbps
- ≥614.4 kbps
- ≥307.2 kbps
- ≥153.6 kbps
- ≥76.8 kbps
- ≥38.4 kbps
- ≥19.2 kbps
- ≥9.6 kbps
- Outtage

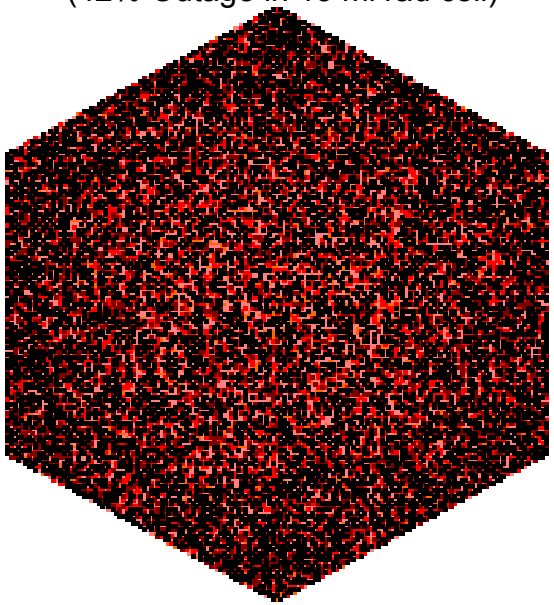
CDMA BB; Single User
(18% Outage in 15 mi rad cell)



CDMA BB;Two Users
(31% Outage in 15 mi rad cell)



CDMA BB;Three Users
(42% Outage in 15 mi rad cell)



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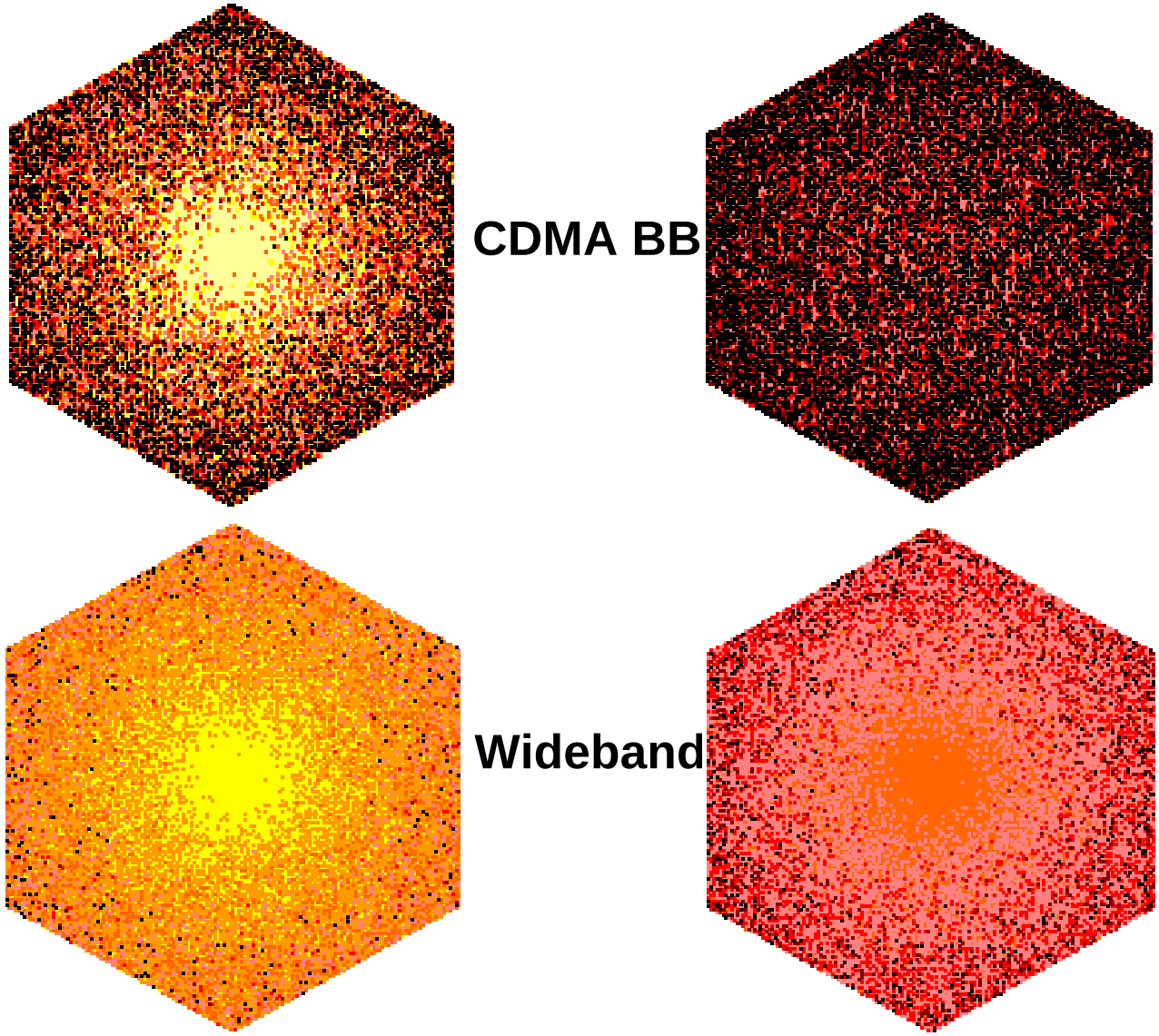
Inbound Bit Rate Comparison (15 Mile radius)

Single User | Three Users



- ≥1228.8 kbps
- ≥614.4 kbps
- ≥307.2 kbps
- ≥153.6 kbps
- ≥76.8 kbps
- ≥38.4 kbps
- ≥19.2 kbps
- ≥9.6 kbps
- Outtage

Wideband Provides More Consistent Reliable Coverage for Large Cell Sites

Bit rate on WB is divided by the number of users

- With three simultaneous users, the bit rate available to each user is divided by three
- Mobiles operate 10w

Bit rate on CDMA is dominated by the weakest mobile

- This may reduce the bit rate by more than three times for three simultaneous users
- Power control is required so the closest unit is no stronger then the farthest unit
- Subscriber power only approx. 200 mW (power must be increased, cell size reduced or greater outage tolerated.)

Use of high power mobiles for BB will not significantly improve picture if low power subscribers are also included

Including low power portables with wideband doesn't negatively impact rates for high power units

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WB and BB Tradeoffs for Current PS 700 MHz Spectrum

Wideband

- Offers data rates that support PS tier 1-3 applications
- Lower peak data rates than BB
- Greater outbound coverage per site than BB
- Greater inbound coverage per site than BB
- Can use current voice system sites
- Smaller channel widths allows band to support more independent systems
- Users with newer P25 systems can share same switch for WB
- Bases & Mobiles available in 2008 designed to PS specs & features
- Portables not yet available
- 7 cell re-use vs. single frequency re-use
- More spectrally efficient at most tier 1-3 data rates
- WB TIA standard provides for unit-to-unit operation

Broadband

- Higher peak data rates than WB
- Greater capacity than WB
- Less outbound coverage per site at BB speeds
- Much less inbound coverage per site at BB speeds due to low portable powers
- Will need additional sites beyond current voice systems
- Only 3 to 4 channels so systems must be shared
- Commercial economies of scale for low power portables
- Commercial Portables w/o PS specs & features
- No high power portables or mobiles; if made will not provide commercial economies of scale
- Single frequency re-use
- More spectrally efficient at tier 4 data rates
- Less spectrally efficient at tier 1-3 data rates
- Standard & current equipment do not provide for unit-to-unit

Conclusion: WB better for some situations, BB for others

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Interoperability

- **Both Operability and Interoperability Important**
  - Extremely high operability/reliability for wideband
- **Most operations are local or regional**
- **Public Safety seeks support from commercial carriers**
  - High cost to deploy BB, particularly in lower population densities
- **Commercial systems today use different standards**
  - No one technology has been chosen to meet all needs
- **"Interoperability" effected two ways:**
  - IP connections infrastructure-to-infrastructure
  - Voluntary Multi-mode handsets
- **Similar approaches can be used for WB/BB Public Safety interop.**
- **WB mobiles can include a BB card slot**
  - Enables WB mobiles to function as interop relay for BB portables to connect to BB or WB networks

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Conclusions

- **BB will have higher <u>peak</u> throughputs and capacity because it has larger bandwidth.**
  - But, higher bit rates do not occur throughout entire service area
- **At reliabilities of 75% and greater and data rates up to approx. 150 kbps, WB exhibits higher reliability than BB.**
- **WB has superior inbound range for typical power levels**
  - To meet the economy of scale prices cited as a BB benefit, only low power portables and computer cards will be available;
  - Higher power mobiles are not available for commercial use and if built especially for public safety would not enjoy commercial economies of scale
- **WB is a viable technology which can support the data rates required for many PS applications in less spectrum than broadband**
- **There are advantages, and no disadvantages to allowing both WB & BB.**

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Secondary Broadband Use of Narrowband Spectrum Should Not be Permitted

Narrowband Voice Services Critical to Public Safety

- No justification for risking interference
- Solving interference after the fact is unacceptable

Unclear How Sharing Could Be Implemented

- Broadband channel with necessary guardband would cover large portion of narrowband spectrum
- Narrowband channels for a given system spread across band

Cognitive Technology Not Sufficiently Developed or Tested to Provide Viable Sharing

- Cognitive sharing with mobile is very different than with fixed
- Sensing is unproven

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Summary of Motorola Recommendations for PS

- **Reconfigure the band to combine voice spectrum blocks below 776/806 MHz**
  - **Provides greater protection for voice**
  - **Reduces internal guardbands needed**
  - **Helps enable PS & Commercial cooperation**

- **Provide flexibility for public safety to deploy WB and BB technologies**
  - **WB better in some situations, BB in others**
  - **Where BB is the right solution, it will still be chosen**
  - **Dual mode units can help enable interoperability**

- **Maintain NB voice spectrum; i.e., no secondary BB use**
  - **High risk of interference to mission critical voice**
  - **Minimal if any benefit in areas where BB capacity most needed**

- **While it is premature to select a BB technology, FCC and Public Safety should consider next generation OFDM based commercial technologies, including LTE**
  - **Can fit the 700 MHz band**
  - **Offers most likely economies of scale over 15 year system life PS needs**
  - **Still opportunities to include PS elements in LTE standard**
  - **Should be available in same time frame as spectrum clearing**

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