Industry View of SDR and CR

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Key Points of This Presentation

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- **SDR for Public Safety (PS)….**
  - is not a “magic bullet”, just a collection of technologies
  - continues to enable advancements in radios’ capabilities in a way that makes sense from **SWaP-C tradeoffs**
  - since the last PS Workshop SDR’06, has made **multiband radios** a reality
  - is far from passé yet; **multi-service, multi-bandwidth radios are next** in the industry
- **CR for Public Safety….**
  - is really **nothing mysterious**, just automation of smart decisions
  - **is used in manufacturers’ radios today** (e.g., trunking, roaming), but…
  - more CR capabilities should continue to be implemented for PS, but in a “baby step” fashion

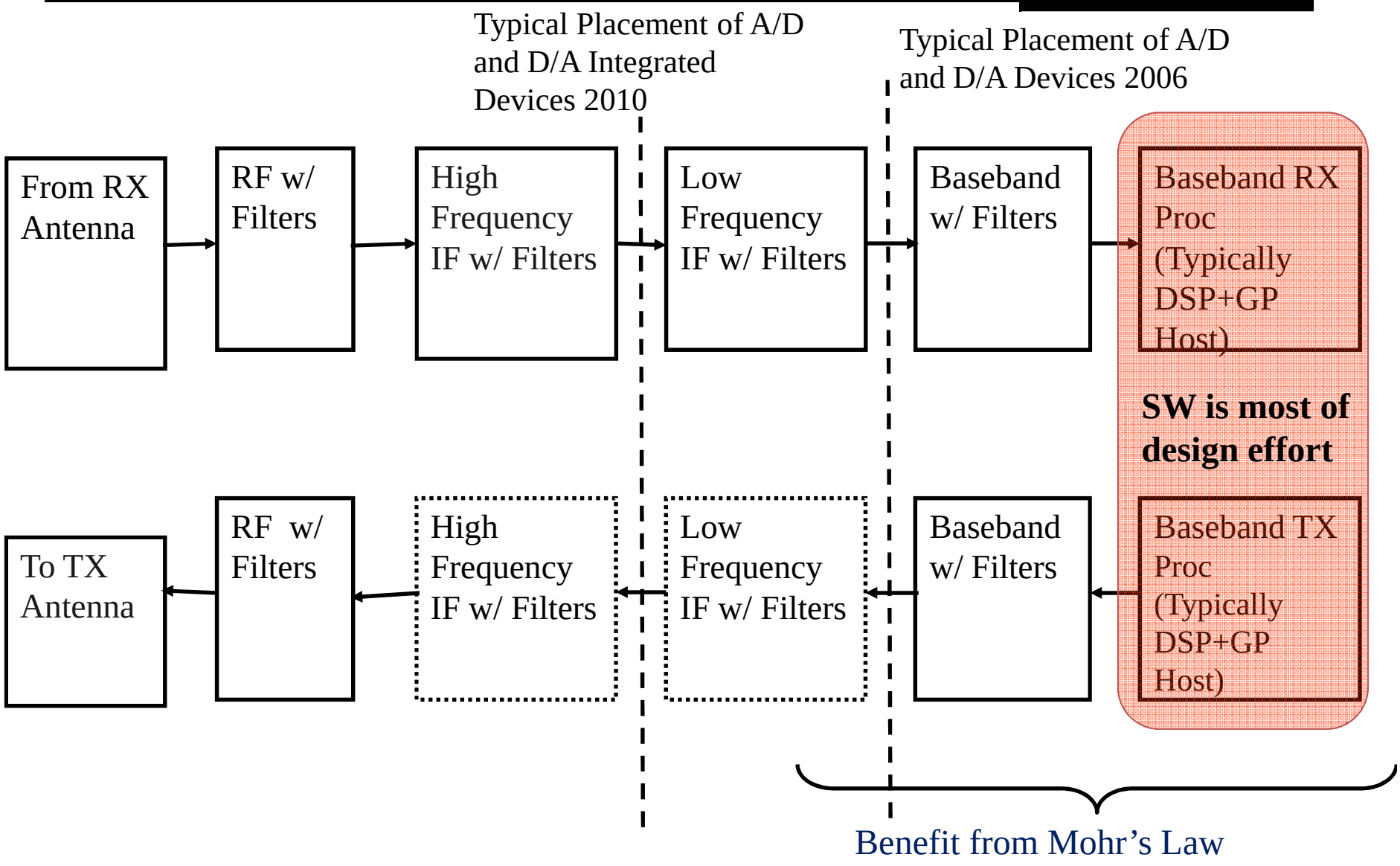
Bottom Line- SDR and CR for PS are ***Evolutionary, not Revolutionary,*** exist in Public Safety systems and radios today, and will continue to evolve to enable further advancements in capabilities

Definitions from Wireless Innovation Forum Website

- **SDR-** *"Radio in which some or all of the **physical layer functions are software defined"***

- **Cognitive Radio-** *"…radio in which communication systems are **aware of their internal state and environment… (and) can make decisions about their radio operating behavior** by mapping that information against predefined objectives.*

SDR Architecture Evolution in PS Radios



SDR TX HW SWaP-C Tradeoffs

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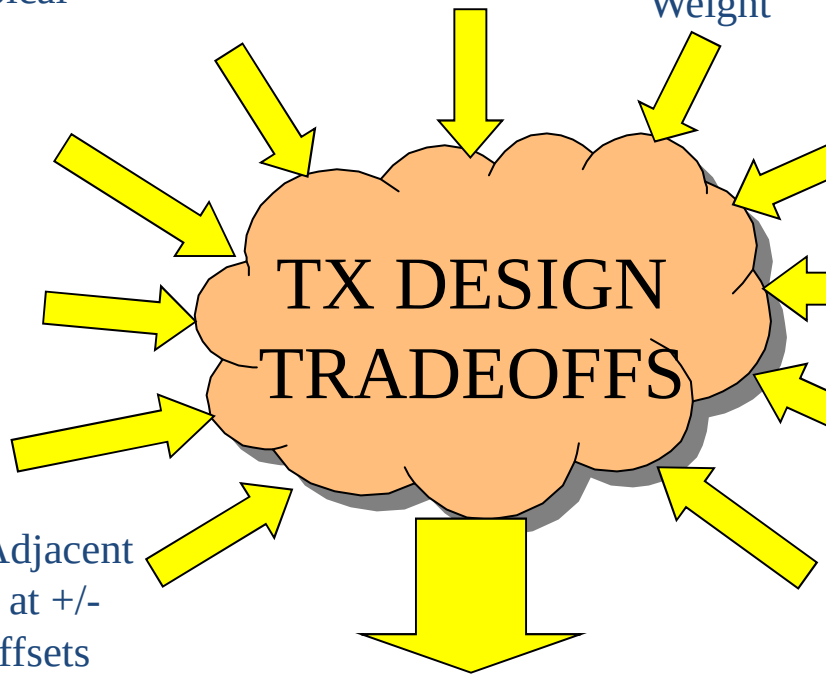


Digital transmit eye pattern closure < about 3% typical

3 Watt TX Power

Small Size, Low Weight

TX spurious outputs better than -70 to -90 dBC

Optional Linear TX Waveforms

Freq stability often better than 0.1 ppm

Multiple Protocols

Optional Multiple Bands

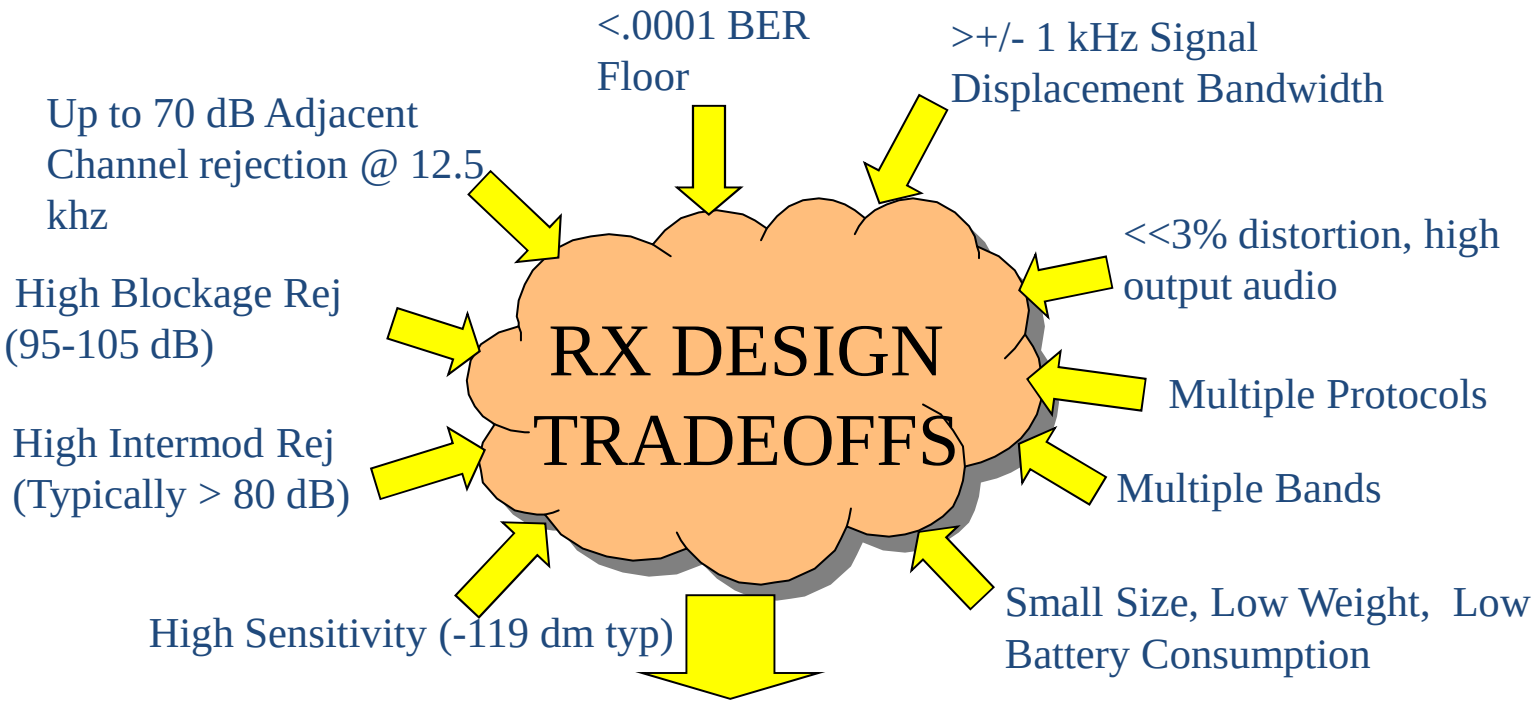
FCC Masks

> 67 to 80 dB Adjacent Channel Power at +/- 12.5, 25 kHz Offsets

Low Battery Consumption

- High Stability, low phase noise oscillators
- Low DAC Noise (≥ 14 Bits Typically Required)
- Low Group Delay Distortion TX Filtering
- PA: High Isolation in small enclosure
  Optional linear PA
- Software defined baseband processing

SDR RX HW SWaP-C Tradeoffs



- Low Noise, High Dynamic Range Front End
- Low Phase Noise, Stable Oscillators
- RX IF and BB Filters with Low Group Delay Dist, yet high selectivity
- High Dynamic Range If-Baseband and A/Ds (≥ 12 Bits)
- AFC
- High Dyn Range, Low Noise CODECS, SPKRs, Mics, and Audio Circuitry
- Software defined baseband processing (typically DSP + GP Host)

What More Can SDR Do?

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More Stringent RF
- TDMA
- Linear Mod
- Broadband (BB)

Multi-Services (LMR+BB Data, Cellular, Sat…)
- Video on Demand
- Sat Imaging
- Floor plans
- Internet/Intranet data Access

Sense/Ctrl
- License Recog using Camera
- Voice Recog
- Biometric
- ITS Monitor/Ctrl

Safety
- Biometrics
- Better Coverage
- Robot Ctrl
- Chem Sense

Track/ Status
- RF ID
- Smart Cards
- Situational Awareness

Convenience
- Larger Data Storage
- Touch Screen
- Lower SWAP

SDR

- Other PS
- Transportation
- Telematics
- Utilities
- Cellular
- Paging
- BB

Ubiquitous Interoperability

Ruggedized MultiMode, Multiband, **Multi-BW, Mult-service,** Low-Cost Handheld Public Safety Radio ("PDA-Like" Display)

Example of Advanced Portable Capabilities Afforded by SDR Today

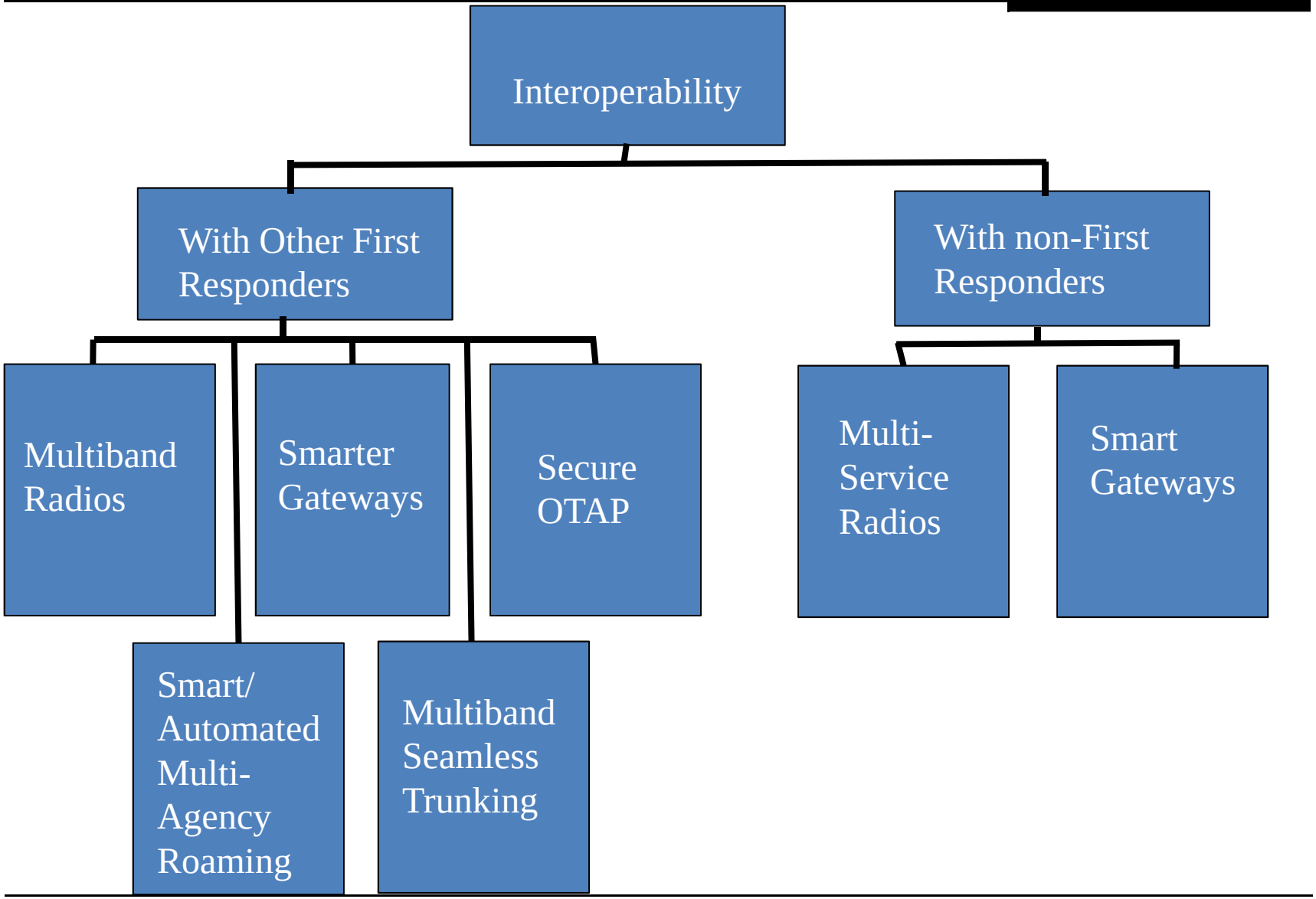
- **Situational Awareness** in the Field
  - GPS built in
  - Sends/Receives positional data
  - Large color display
  - Memory capacity to support street level mapping (future)
- Secure **Bluetooth®** Wireless Technology
  - Secure Wireless Connections
  - Audio Accessories
  - Wireless Radio Programming
- 2 Microphone, DSP **Noise Cancellation**

Cognitive Radio- What Makes Sense for Public Safety?

- Trunking and Roaming Exist Today- Are They Cognitive?
- PSSIG's CR Use Case Documents Are On Target for Setting Direction for New CR Capabilities
  - Interoperability
  - Incident Coordination and Aiding Decisions
  - Spectrum Efficiency Enhancements/Dynamic Spectrum Access
  - Coverage Enhancements
  - Resource Management
  - Communicate New Configurations and Rollback

***Not* a Solution for Interoperability**

Interoperability Enhancements



Incident Coordination & Decision Aiding

- **Situational Awareness** in the Field
- **Data and Control Access** to building management [alarm status/maintenance] systems.
- **Multisensor Integration**
  - Monitor weather/environmental information, Hazmat, Firefighter in-building location systems
- Video and/or other **traffic and transportation data** from traffic control centers and/or data from traffic sensors

Spectral Efficiency Enhancements/ DSA

- Inter-Service
  - Spectrum Sharing
- Inter-Network
  - Dynamic Frequency Sharing/Control
- Intra-Network
  - Dynamically spectrum optimization/control …..
    - access priority per subscriber unit
    - Throttle bandwidth used per user
  - Dynamic Frequency Control

CR's Challenges for Coverage Improvements

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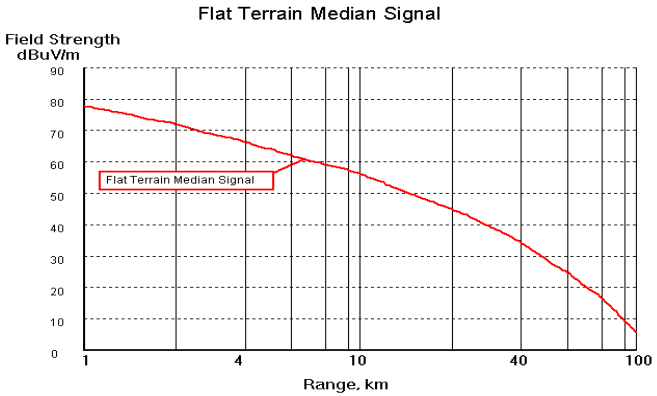
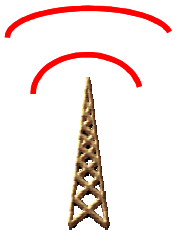
Long Distance with Fading



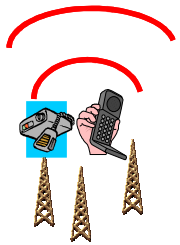
In or Behind Obstructions

Terrain and Foliage

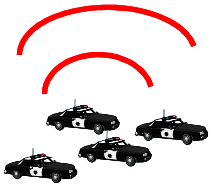
Interference



Nextel



Adjacent Other Systems

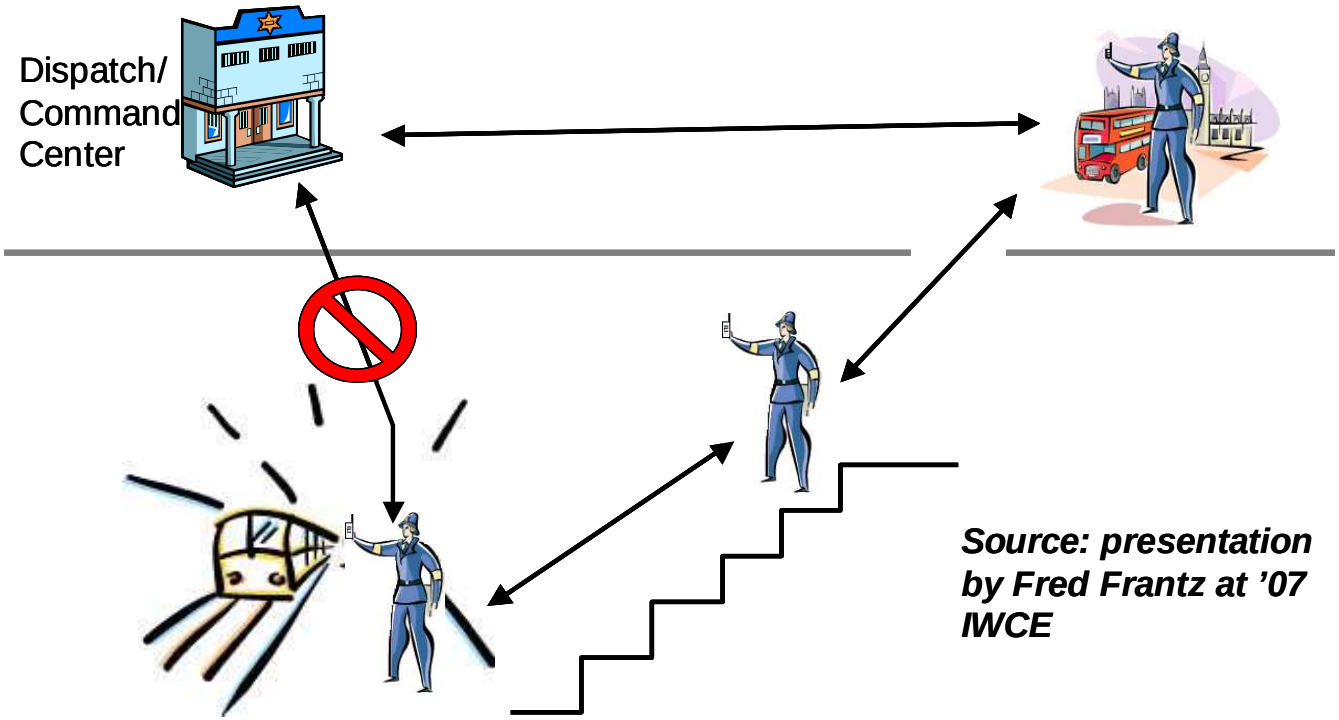


Same System "Near/Far"

Retain Coverage During Disasters

Previous Coverage- Related Use Cases from the PSSIG

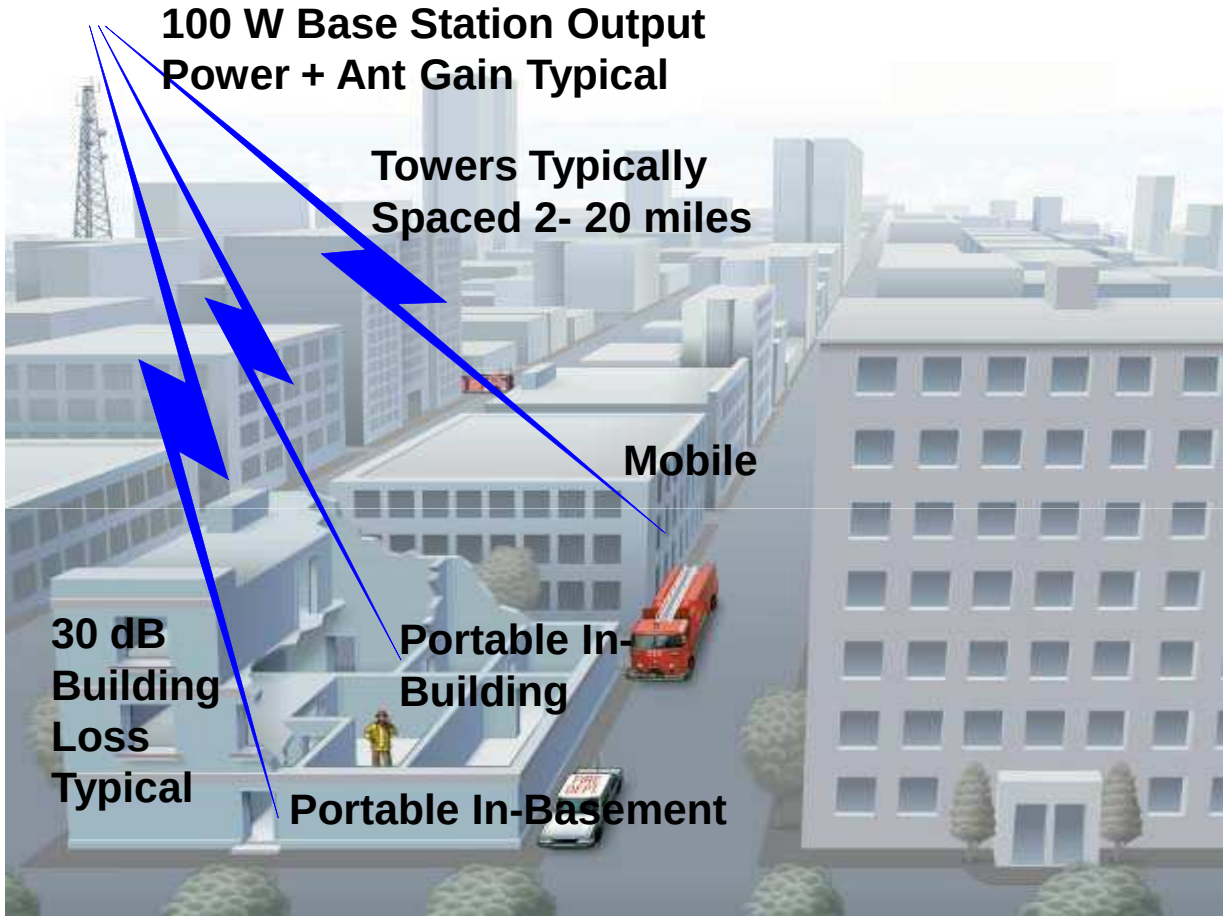
- **London Bombing Use Case Coverage Extension**



Source: presentation by Fred Frantz at '07 IWCE

- **Chemical Plant Scenario Interference Mitigation**
  - **This Presentation is an Expansion of Use Case 4, "Coverage Performance Improvement**

CR Must Address Typical Coverage Requirements

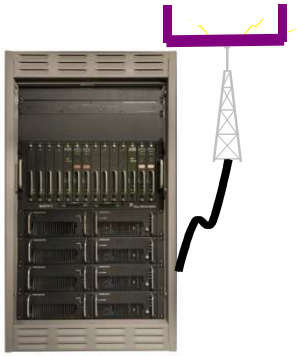


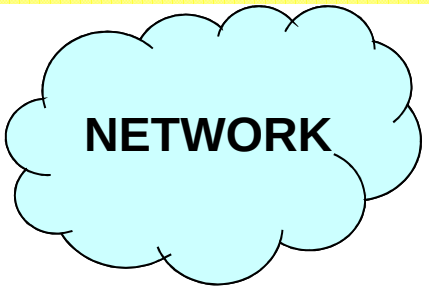
- Coverage Reliability Req't Typically 95-98%
- Service Areas: From Small Towns Through Statewide
- 3 Watts Portable Output Power

"Simple" CR Link Budget and Interference Rejection Enhancements

$$d = K/(Mf)\sqrt{\frac{G_{ts}G_{rs}P_{ts}}{(E_b/N_0)(R/B)[N_0B + \sum_{j=1}^{N}(ACR_j\frac{G_{tij}G_{rij}K^2P_{ij}}{f^2d_{ij}^2})]}}$$

Power Control Algorithms QoS Metric Sensing Geolocation	QOS Metric Sensing	Algorithms for power control using geolocation
Multiband radio Automated Freq Change (Roaming) Automated Band Change (Roaming) Smart RX Filter	Smart RX Filter	Algorithms for Interference Mitigation using Geolocation
Smart TX and RX Antenna	Smart RX Antenna	Algorithms for Smart Antennas using Geolococation
Multimode Radio & Control Algorithms	Multimode Base Station(s) & Control Algorithms	Algorithms for mode control using geolocation





What Does the Future Hold for SDR and CR?

- Advances in Designs
  - *As SDR & CR technologies advance, so will the radio design*
- Advances in Requirements
  - *Should continue to evolve to keep pace with SDR technologies*
  - *Requirements developers (standards organizations, users, and technical consultants) must be cognizant of SDR's and CR's cost/benefit tradeoffs in order to judiciously levy new requirements*
    - Radio designers/manufacturers must work with those that establish the public safety radio requirements to provide feedback and education

Bottom Line: Smart Evolution, *Not* Revolution

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Bottom Line- Both SDR and CR are ***Evolutionary, not Revolutionary,*** exist in Public Safety systems and radios today, and will continue to evolve to enable further advancements in capabilities

Questions?

Note: Send an e-mail to
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