Wireless Microphones and the White Spaces

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Agenda

- Introduction
- Use Cases and User Expectations
- Technical characteristics
- Interference protection mechanisms: database and spectrum sensing
- Database requirements
- Spectrum sensing requirements
- Questions

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Wireless Microphone Use Cases

- Electronic News Gathering (ENG), Sports, Entertainment Venues, Movie Making, Theaters, Schools, Houses of Worship, Meeting Rooms in Corporate, Government, and Public Facilities, and Law Enforcement Activities
- Additional Uses: Interruptible Fold Back (IFB) Monitors, In Ear Monitors, Wireless, Intercoms, and Wireless Assist Video Devices (WAVDs)

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FedEx Field

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The Majestic Theatre – New York City

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Hope Church – Memphis, TN

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User Expectations

- Wireless microphones are at the “front end” of the audio chain, so user expectations are very high
- Noise and dropouts are not tolerated
- Audio frequency response: 50 Hz – 15 kHz
- Audio dynamic range: >100 dB
- Audio latency: <5 msec
- Working range: 100m, typical

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More User Expectations

- The number of systems in simultaneous operation can exceed 200 for large productions (e.g., the Super Bowl™)
- Battery life: >8 Hours
- Transmitter antenna: Internal
- Mechanically rugged and reliable
- Operational lifetime: 5-10 years

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Technical Characteristics

- Wireless microphones that operate in the TV bands are covered under Part 74.801 of the FCC Rules
- Power output: <50 mW in 174-216 MHz and <250 mW in 470-698 MHz
- Most systems have 1-5 mW ERP; antenna efficiency and body absorption are significant
- Transmission may be analog or digital
- Emission bandwidth: <200 kHz
- FCC and ETSI (EU) mask differ slightly

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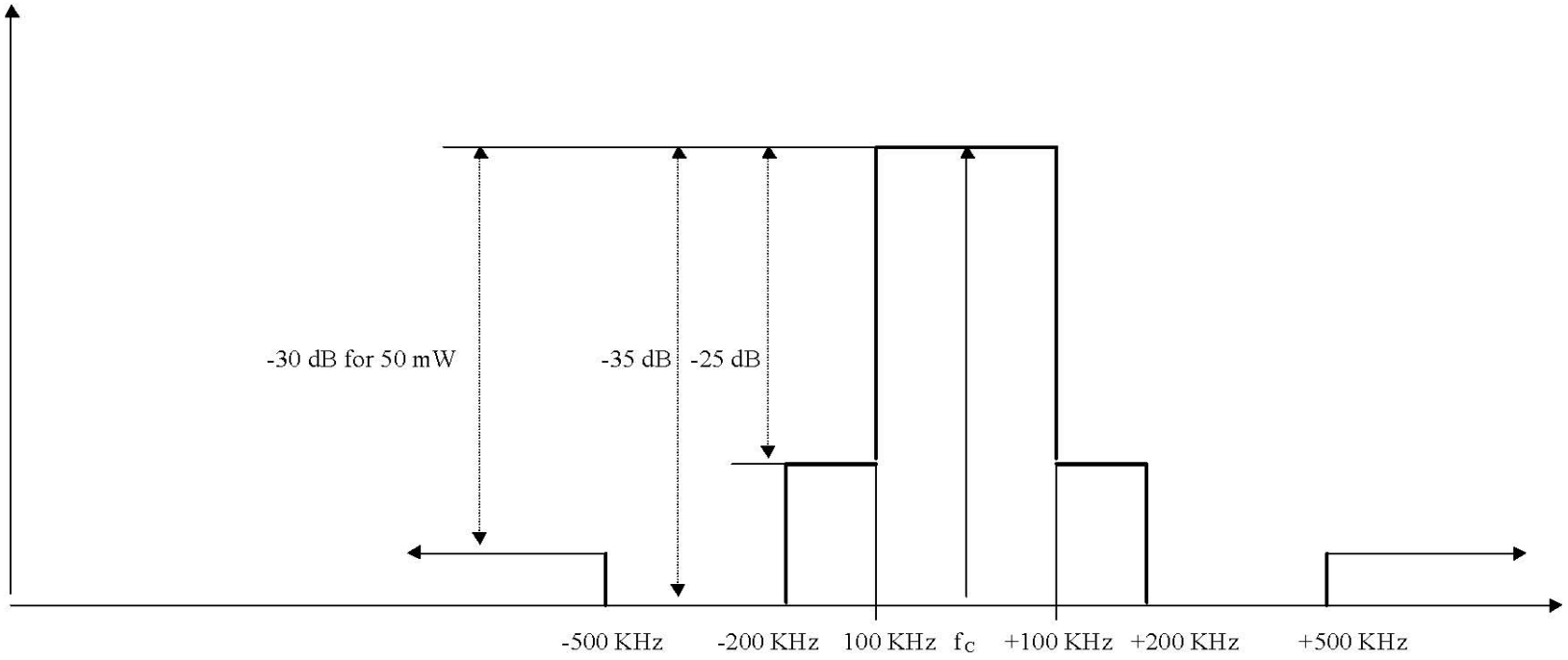
Emission Characteristics

FCC OCCUPIED BANDWIDTH MASK

FCC occupied bandwidth limit section 74.861 (e) (6)



f_C = Transmitter carrier frequency

Beyond ± 500 KHz from carrier, spurious levels must be at least: $43 + 10 \cdot \log_{10}$ (*power* output in watts) dB below the carrier level.

Example: For 50 mW; $43 + 10 \cdot \log_{10}$ (0.05 W) = 30 dB

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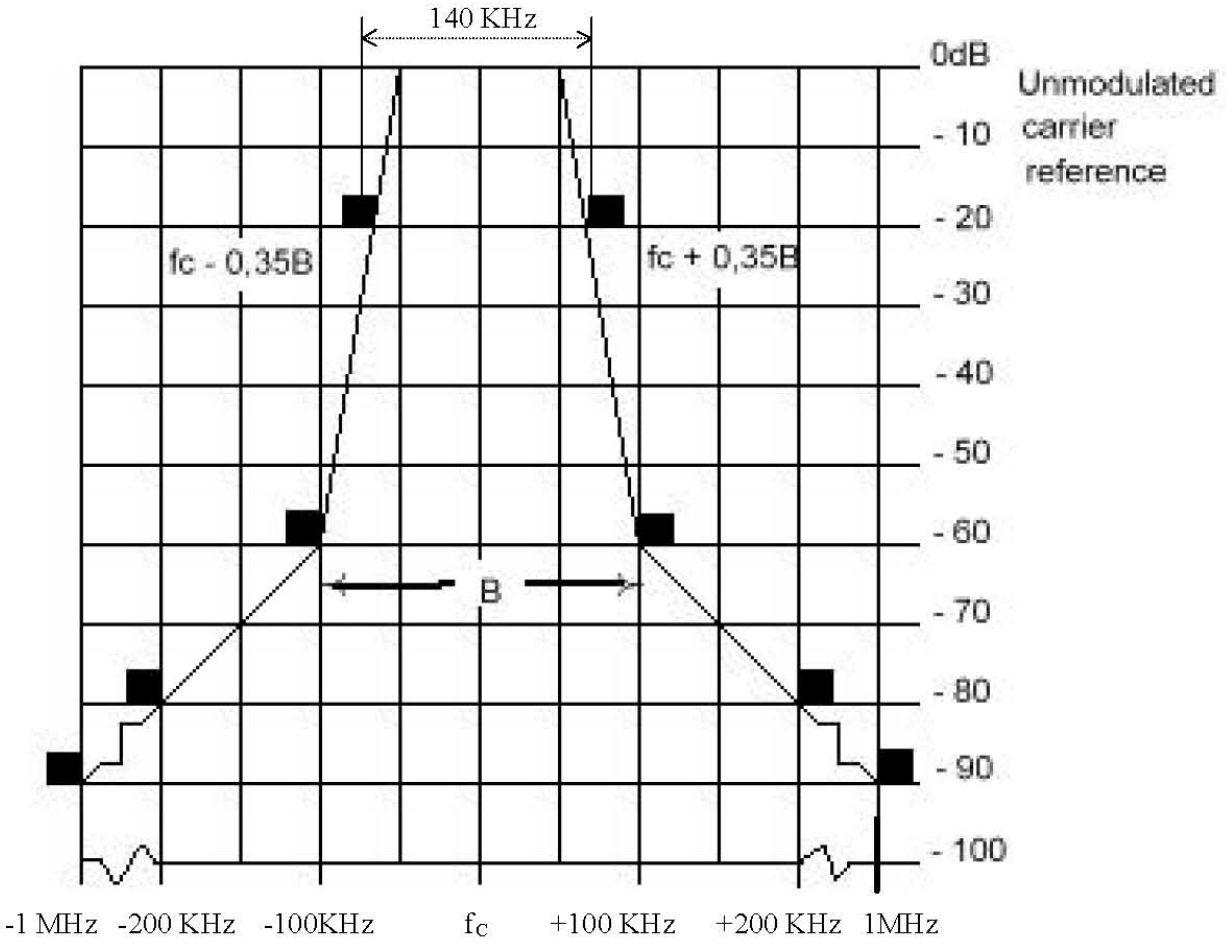
Emission Characteristics

ETSI SPECTRAL BANDWIDTH MASK

Occupied Bandwidth Limit per ETSI EN 300 422 V1.2.2 (2000-08) Section 8.3.3



f_C = Transmitter carrier frequency

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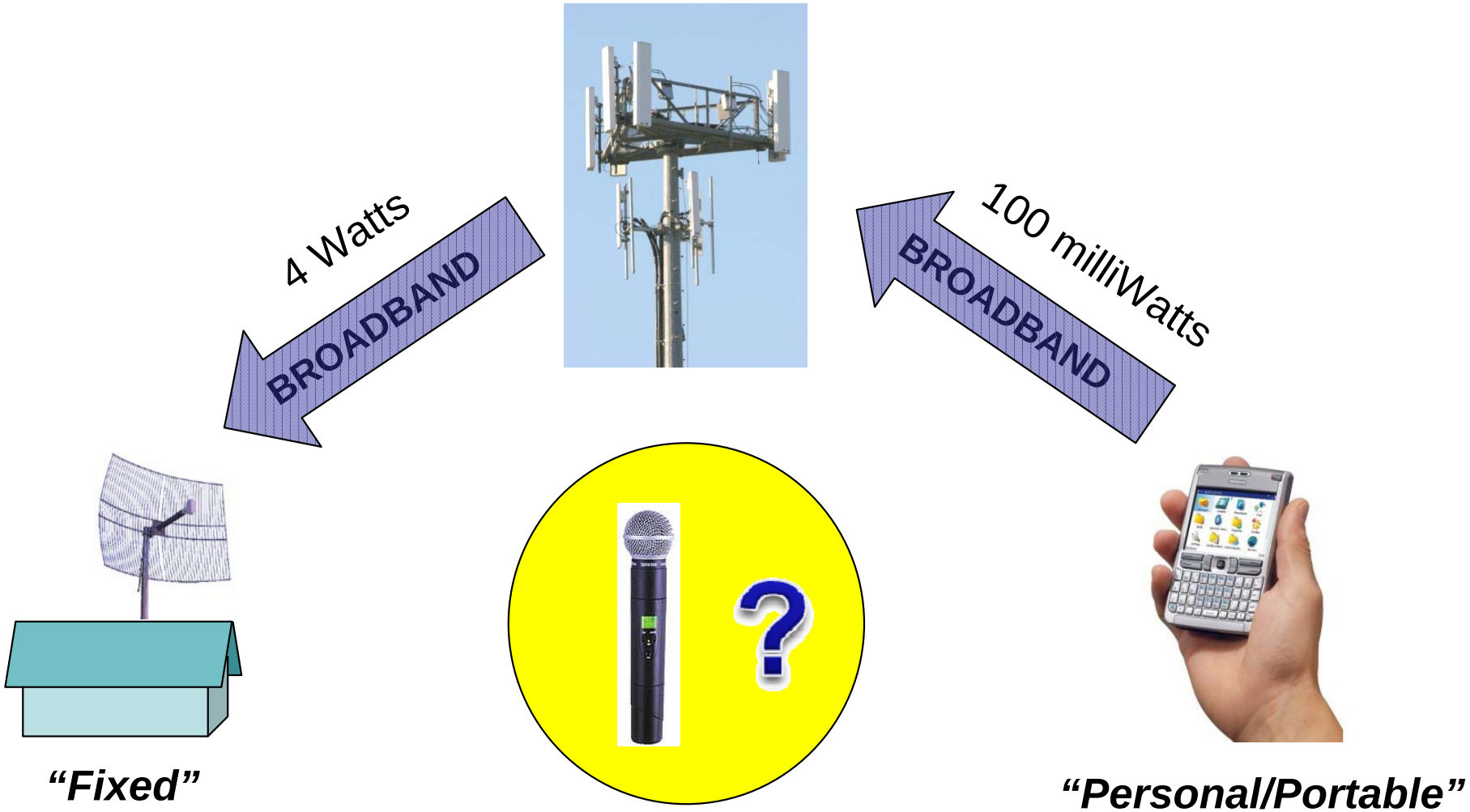
Coexistence with TV Band Devices



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Interference Protection Techniques

- Geolocation + database
- Spectrum sensing
- Protected Channels

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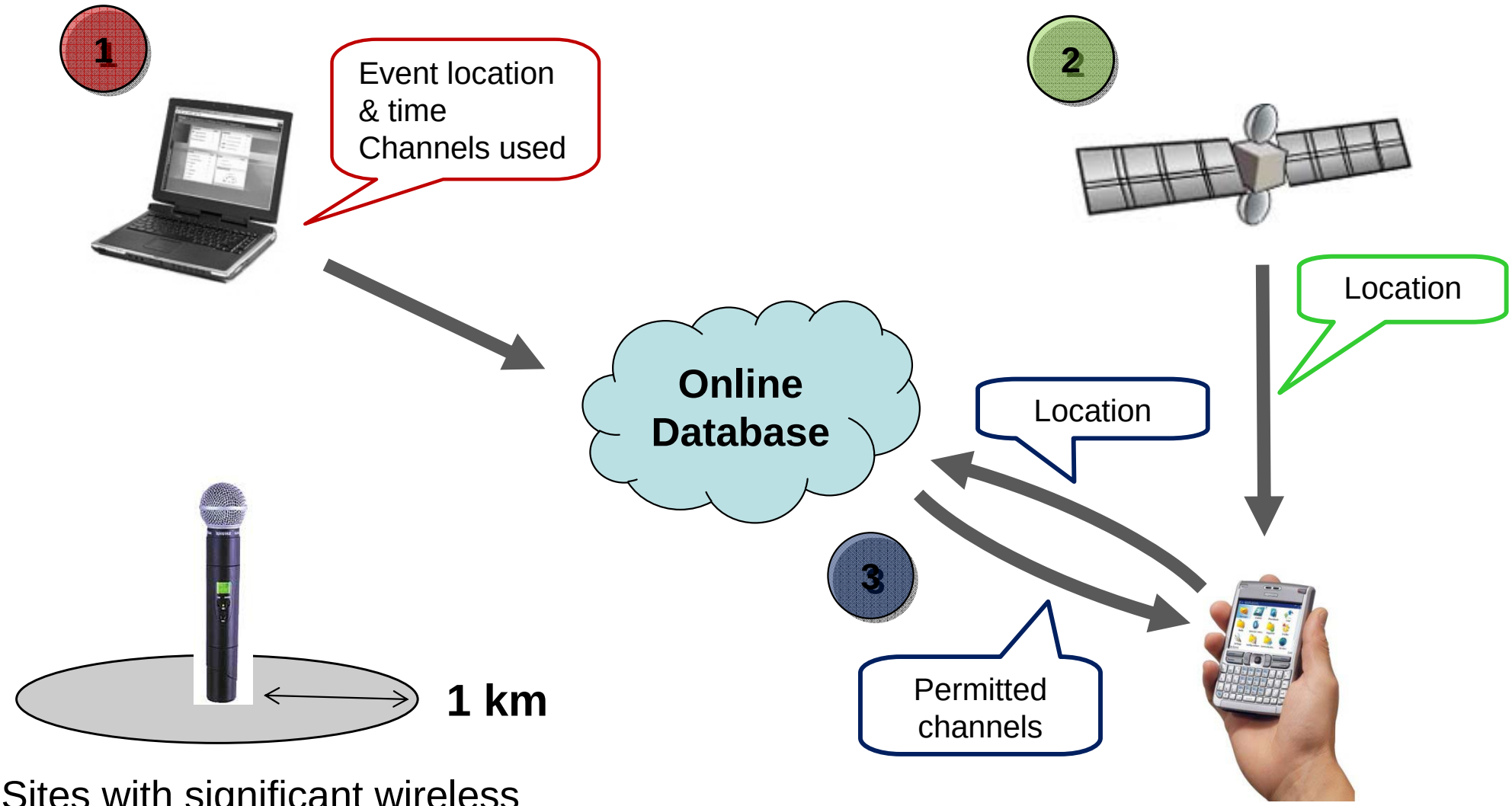
Geolocation + Database



"Sites with significant wireless mic use at well-defined times and locations"

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Database Concerns

- The database must be accurate and up to date!
  - If there are multiple databases, they must be synchronized frequently
- TVBDs must query the database at least once an hour or whenever there are changes
- TVBDs must shut down if they lose connectivity to the database

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Geolocation Concerns

- The Geolocation accuracy must be significantly better than 100m
  - An uncertainty of 100m is comparable to the working range of most wireless microphones
- TVBDs must shut down if they don't know where they are
  - Geolocation devices typically do not work indoors
  - "A man walks into a theater wearing a TVBD..."

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Spectrum Sensing

- A TVBD scans spectrum at its location; detects and avoids TV & wireless mics
  - Must check TV channel for 30 seconds before transmitting
  - Must re-check TV channel once/minute
  - When a wireless mic is detected, the TVBD must vacate the channel within 2 seconds
- Future TVBDs could use spectrum sensing only, IF they pass more rigorous performance tests

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Making Spectrum Sensing Work

- Required sensing threshold: -114 dBm
- Appropriate sensing bandwidth: 200 kHz
- The sensing threshold requirement is determined by:
  - The required D/U ratio at wireless microphone *receiver*
  - The ERP of the TVBD in comparison to the wireless microphone
  - The ability of the TVBD to sense correctly in a channel that is adjacent to a strong DTV signal

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Making Spectrum Sensing Work

- "Network" (cooperative) sensing is required to mitigate hidden node problems
  - The path between the wireless microphone and the TVBD is *not* reciprocal!
  - The wireless microphone transmitter and receiver are physically in different locations
  - The path from the wireless microphone transmitter to the TVBD may be obstructed

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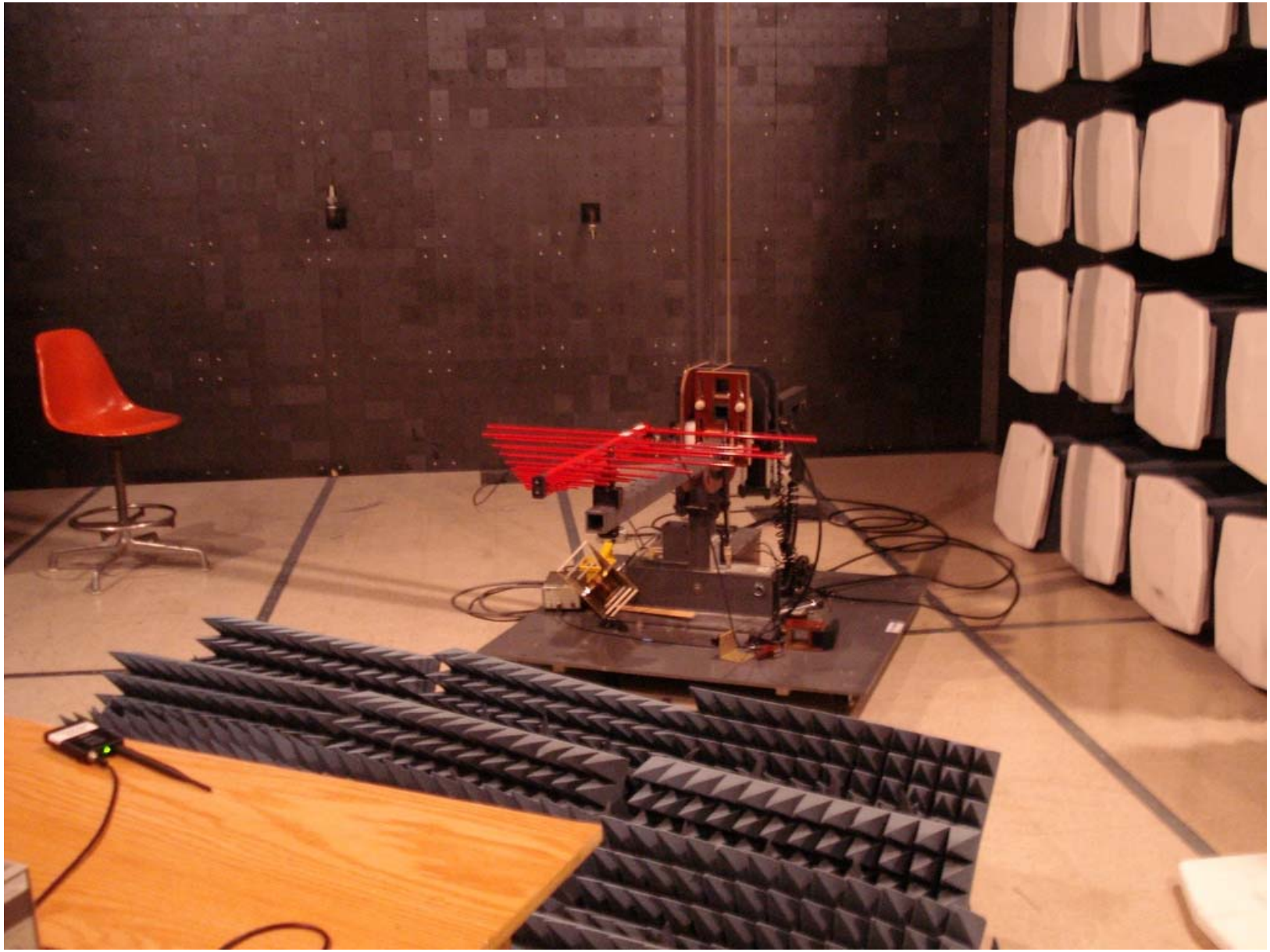

Making it work here is one thing…

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Making it work here is another!

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Protected Channels

- 'Protected Channel' = no TVBD operation
  - Channels adjacent to occupied TV in 14-20
  - Two additional channels in ~~13~~ 11 cities where Public Safety uses channels 14-20
  - First available channels above/below TV 37
- Net result: Wireless microphones will migrate to these protected channels when feasible

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Summary

- Making use of the TV “White Spaces” is a noble goal, *but*
- It’s tricky to implement without causing interference to important incumbent services!
- The FCC has adopted a reasonable framework that requires the use of both Geolocation/database and spectrum sensing techniques

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