



Frequency Agile Radio Technology

Presentation to:
NSF NeTS Focus Area
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Programmable Wireless Networking



Shared Spectrum Company

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Agenda

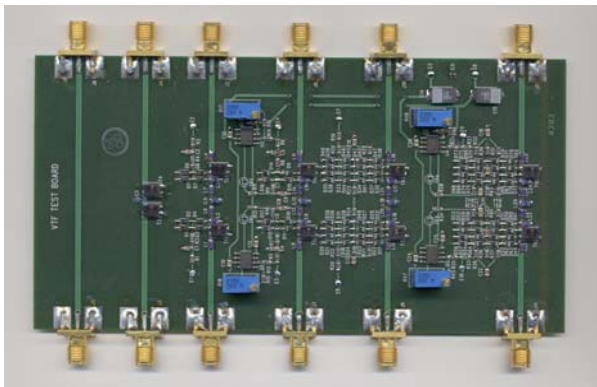
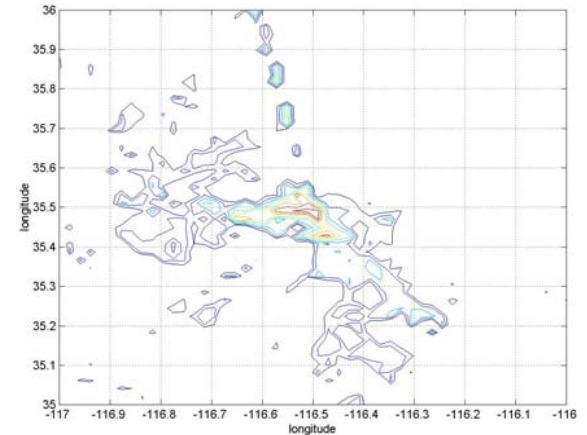
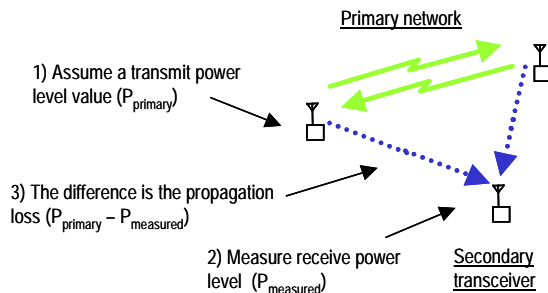
- Company Overview
- Frequency Agile Technology
- Spectrum Occupancy is Low
- Noise Measurements



Shared Spectrum Company

- Frequency agile networking and tuner technology
- RF and networking R&D
- Simulations, field tests, and prototyping
- Government customers

$$P_{\max \text{ TX}} = P_{\text{allowable interference}} + P_{\text{primary}} - P_{\text{measured}}$$



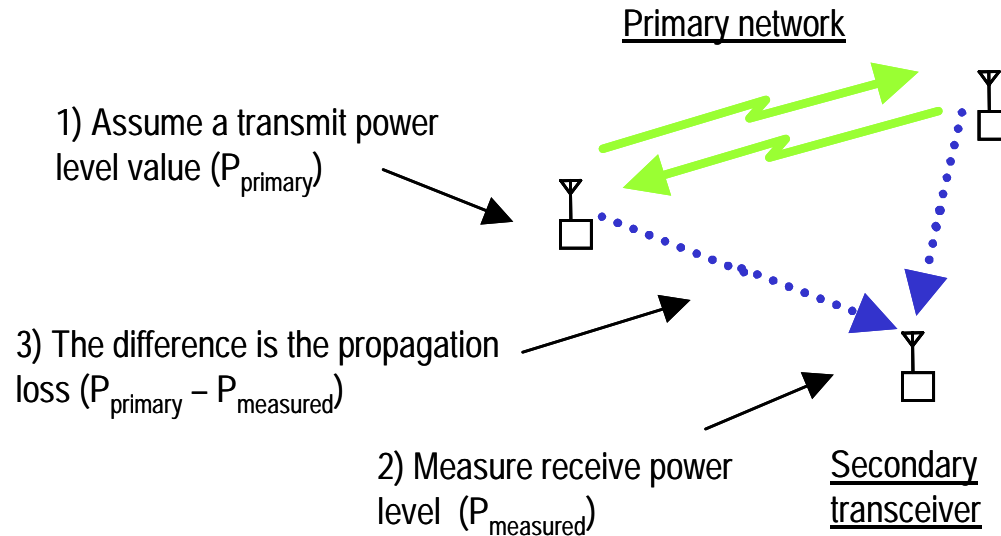


Frequency Agile Radio Technology

- Dynamically use spectrum on a secondary basis
 - Uncooperative Primary users
 - Create insignificant interference
- Enable a new regulatory framework
 - Minimal requirement for coordination with Primary system licensees
 - Unlicensed with equipment certifications on a system basis
- Need to operate in multiple bands
 - Assured capacity
- Offer cost/capacity/link range/deployment benefits
 - Access more (10 X?) spectrum than any current system
 - Operate in VHF/UHF TV band – Link range
 - Rapid spectrum agreements for itinerate use

Adaptive, Receive-Only Spectrum Access Method

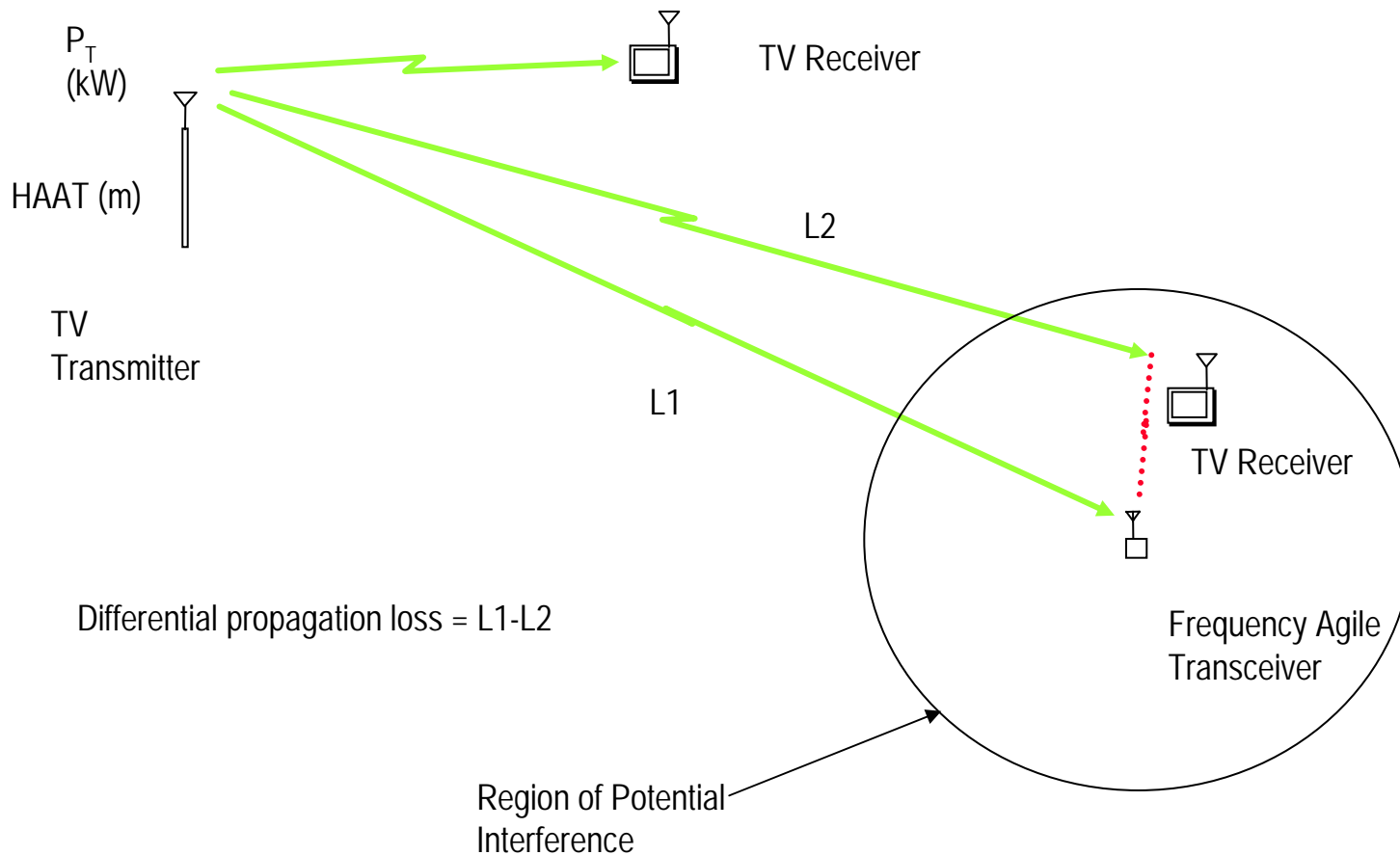
$$P_{\max \text{ TX}} = P_{\text{allowable interference}} + P_{\text{primary}} - P_{\text{measured}}$$



- $P_{\max \text{ TX}} = 10 \cdot \log_{10}(k \cdot T \cdot B) + P_{\text{Primary}} - P_{\text{measured}} - \text{Margin}$
 - Margin = 10 to 20 dB, required for cumulative effects, rapid propagation changes, false alarm minimization
 - T = Interference Noise Temperature, in K
 - B = signal bandwidth, in Hz

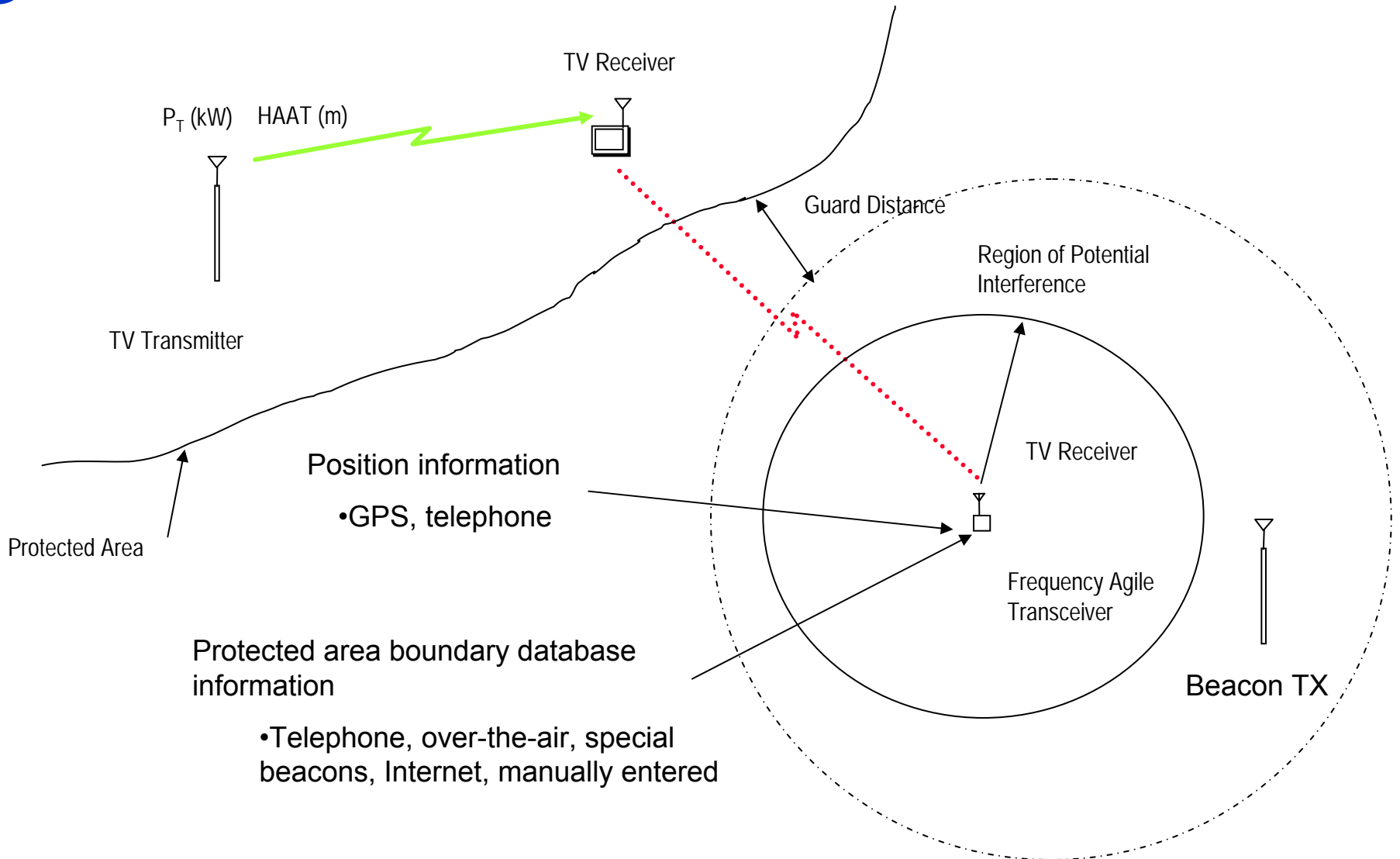


Listen-Only Method in the Broadcast Bands





Geo-Location Method





Technical Challenges

- Developing spectrum sharing behaviors
- Sensitive detection
- Frequency assignment negotiation
- Resource allocation
- Security
- Integration with “spectrum market”



Spectrum Occupancy Is Low

- “In many bands, spectrum access is a more significant problem than physical scarcity of spectrum, in large part due to legacy command-and-control regulation that limits the ability of potential spectrum users to obtain such access.”¹
- Shared Spectrum’s measurements indicate
 - Many bands have no detectable occupancy
 - Some bands have low occupancy
 - Some bands have high occupancy

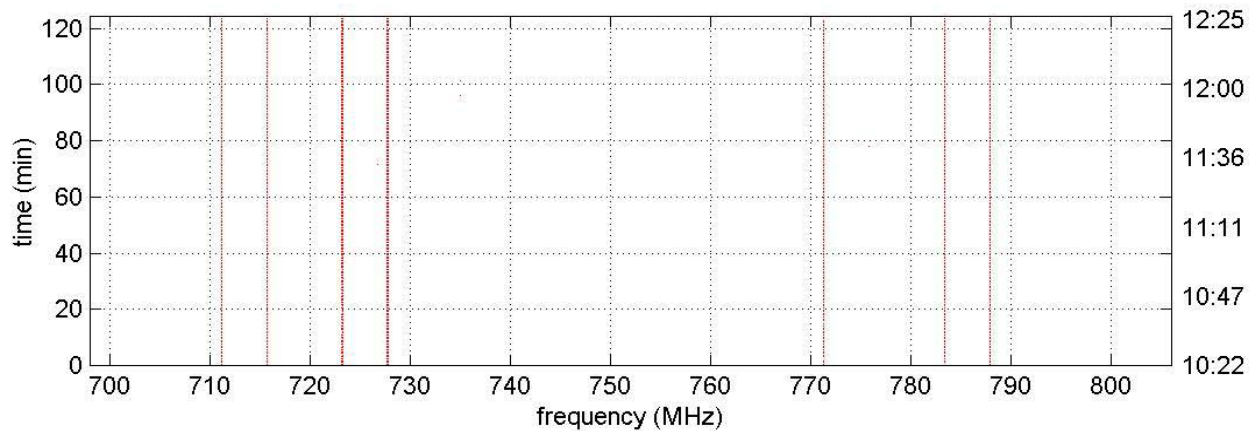
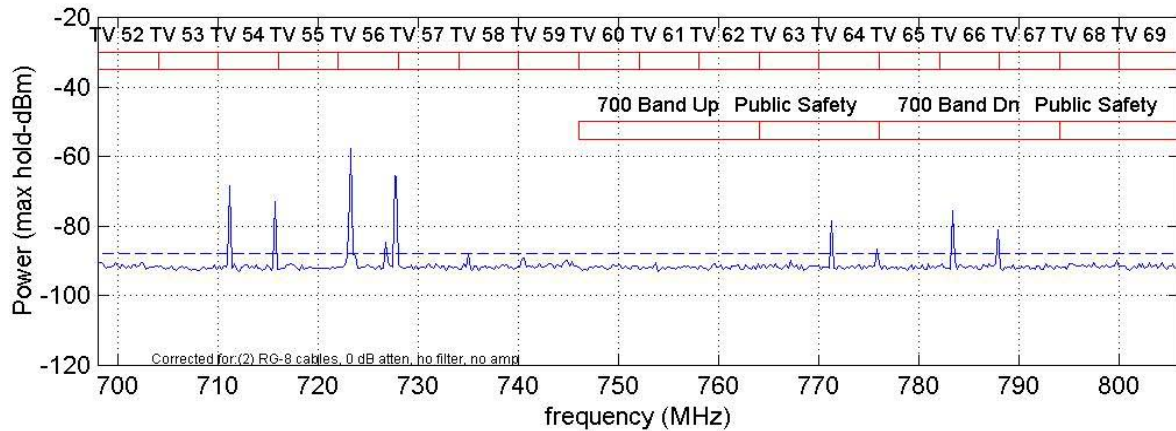
Note 1: FCC Spectrum Policy Task Force Report, page 3



Low Utilization Example

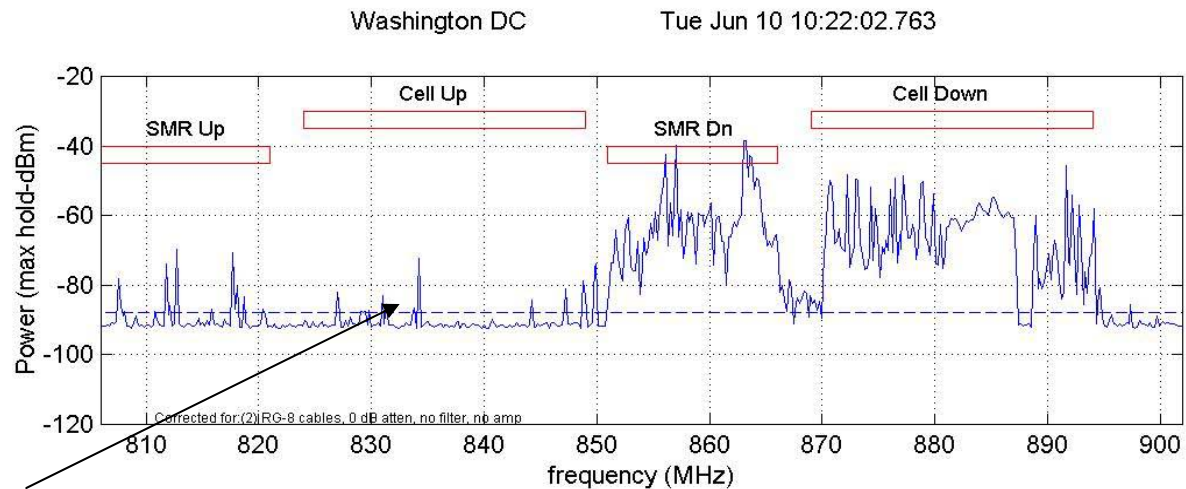
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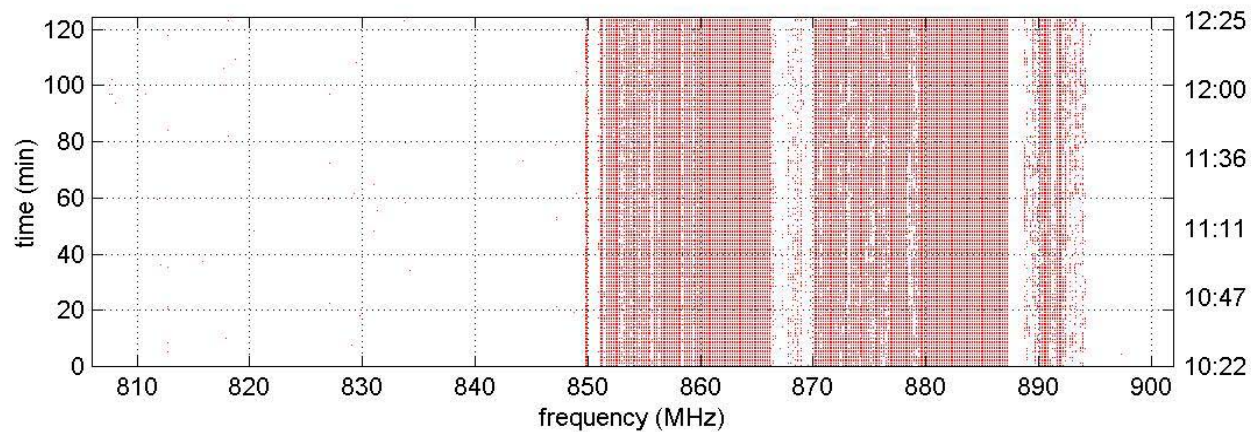




High Utilization Example



Hidden nodes





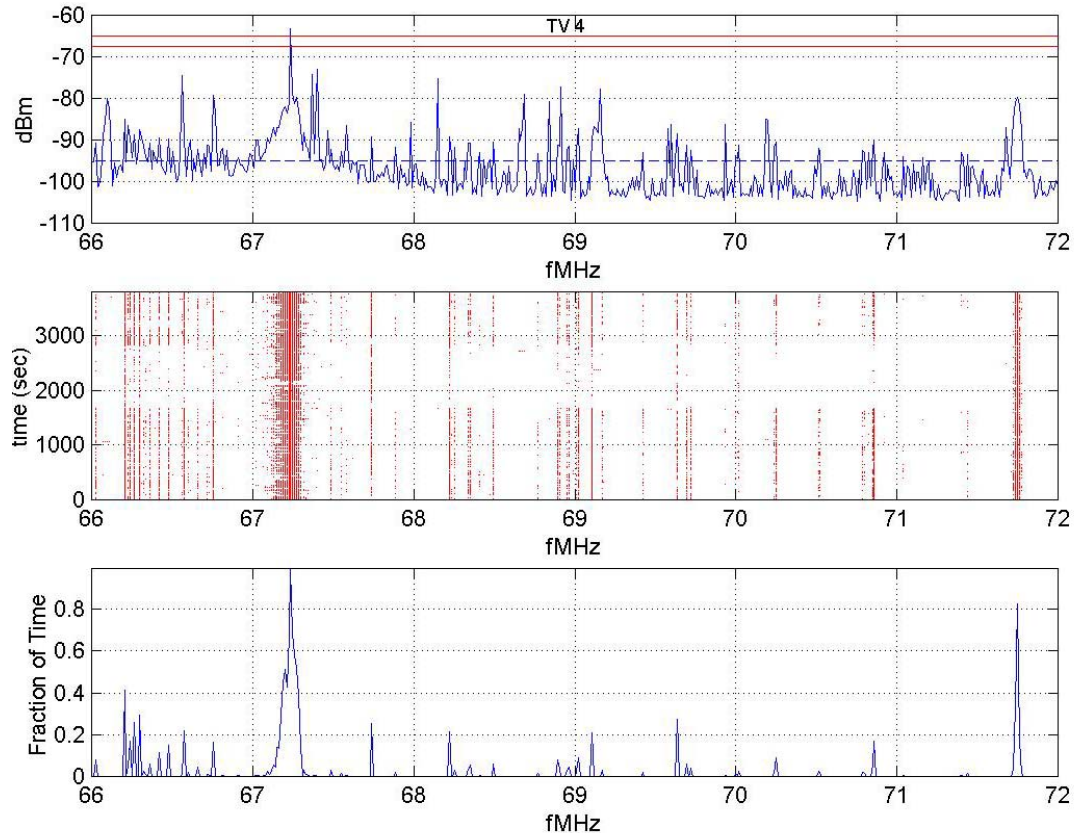
Noise Measurement Issues

- Frequency agile radio “noise” \ll other noise sources
- Multiple noise sources
 - Cumulative
 - Proximate device
 - Sideband transmitter
 - Distant user
 - Spurious receiver
- Strength and probability of proximate devices dominant noise statistics and measurement difficulty
- Should be measured/modeled independently



Typical Noise Levels

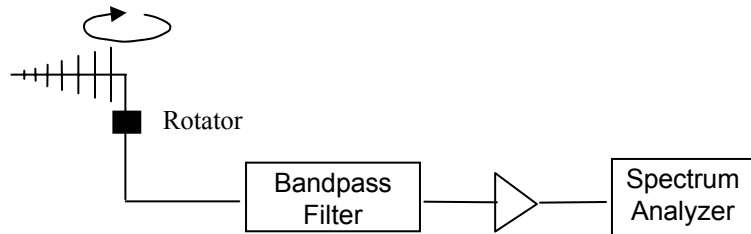
- Antenna continually rotating
- TV channel 4 (66-72 MHz)
- Interior office environment
- 1 hour duration
- Combination of TV signal and equipment noise



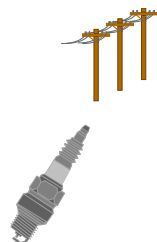


National Radio Testbed

(Univ of Kansas, Shared Spectrum, Stevens Inst)



Parametric Model of RF Noise Floor



Impact

- Establish baseline for spectrum use rights
- Understand FCC “Interference Temperature” implications
- Establish FCC “Smart Radio” interference levels

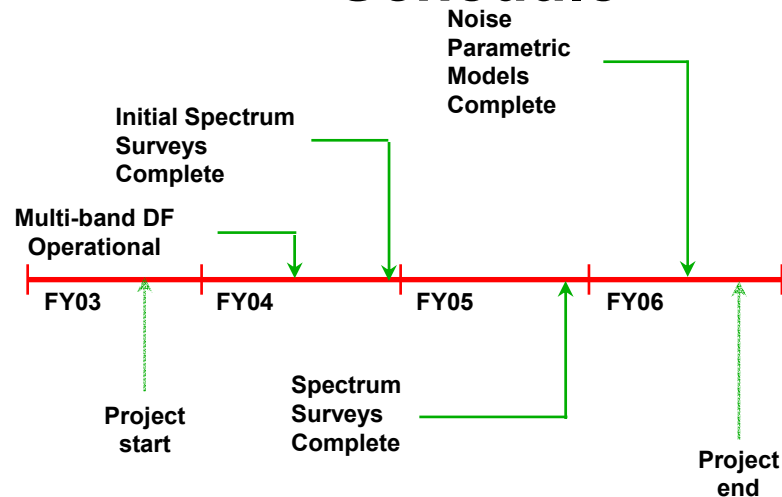


Affordable Broadband Wireless Technology

Innovative Ideas

- High dynamic range measurement system
- Single RF channel DF system
- Multi-band study (30 MHz to 3000 MHz)
- Proximate device based noise model

Schedule





Summary

- Frequency agile radio utilizes spectrum without causing interference to Primary users
 - Enables new regulatory framework
- Offer cost/capacity/link range/deployment benefits
 - Access more (10X?) spectrum than any current system
 - Operate in VHF/UHF TV band
 - Rapid spectrum agreements for itinerate use
- Multiple, robust spectrum access methods
 - Listen-Before Talk
 - Geo-location/database
- Actual spectrum use is very low