White Spaces Trials: Lessons Learned and Future Opportunities

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Trials to Date

Location	Application	Environment	Partner
Claudville, VA	**First WS Network** Rural Broadband	Hills/Foliage	Microsoft
Plumas, CA	Smart Grid	Mountains/Desert	PLUMAS-SIERRA REC Electricity • Telecommunications, Google
Logan, OH	Telemedicine	Suburban Medical Indoor & Outdoor	HOCKING VALLEY COMMUNITY HOSPITAL, Google
Wilmington, NC	Smart City	Urban Coastal City	TVBS
Helsinki, FI	Investigation: Interference to Broadcasting	Large City	NOKIA, Digita
Cambridge, UK	Coexistence & Location Services	Various	NOKIA

Applications

To Date:

- √ M2M
- √ Smart Grid / Telemetry
- √ Video Surveillance
- √ Broadband

Planned:

- ❑ Femtocell
- ❑ Content distribution (multicast video and data)
- ❑ Backhaul

Avoided:

- × High QoS (unlicensed/shared)
- × TDMA (need clean channel)
- × Narrowband (due to PSD limits)
- × High mobility (only 40 mW limit for personal/portable)

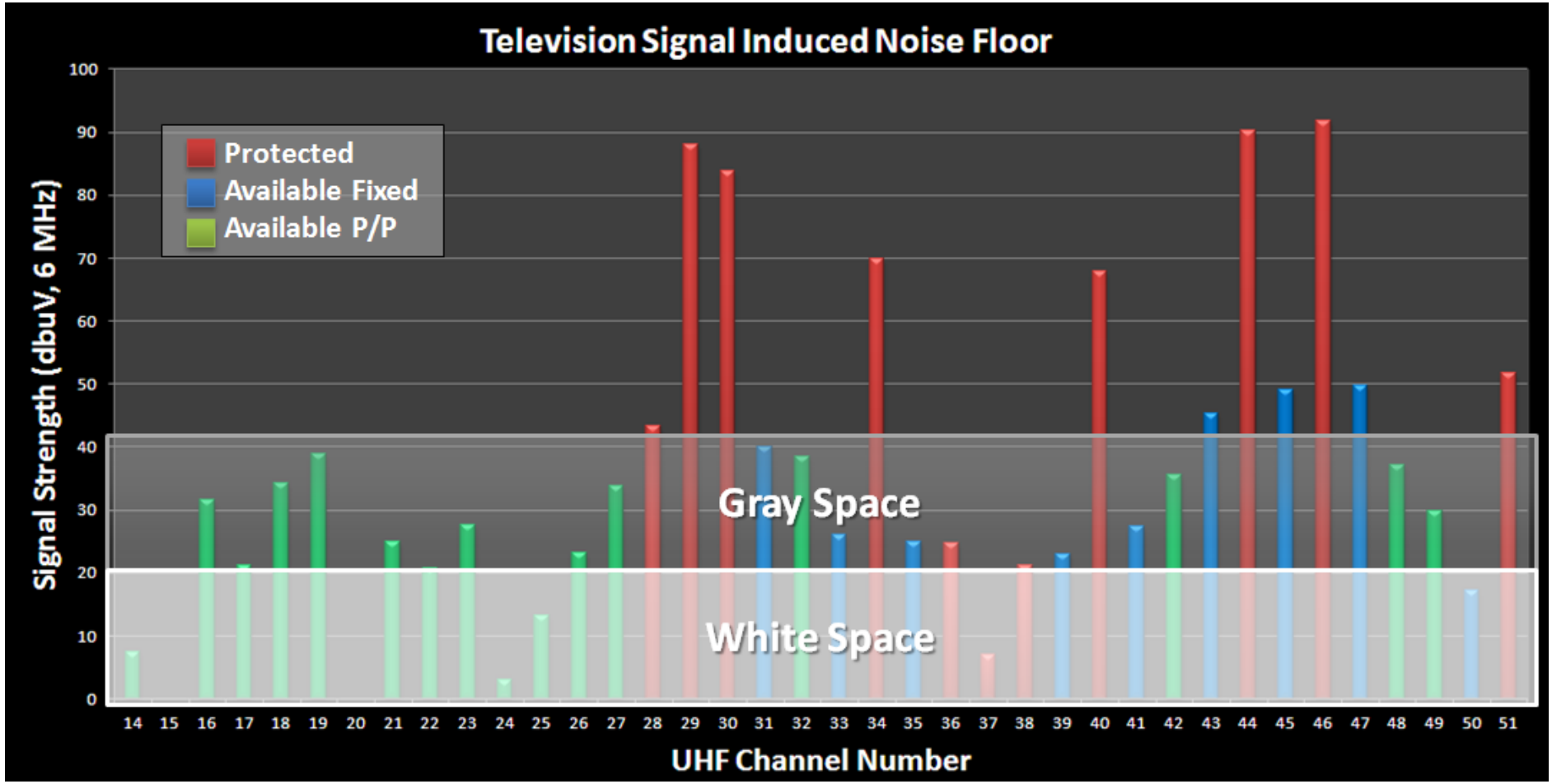
Lessons Learned

- A healthy regulatory landscape motivates industry… uncertainty and complex rules result in stagnation.
- White Space is really gray
- Lots of concerns about co-existence between WS users
- Operators want assurances of continued WS availability, before making capital investments
- VHF frequencies are challenged by multipath, fading, antenna size and ability to operate over 2 octaves (when coupled with UHF)
- Need for wideband (300 MHz) log-periodic, omni-directional UHF antennas
- Diminishing returns with higher antenna sites
- 13 OEMs actively developing products (that we know of), many more contemplating

White Space is really Gray

- A product of mixing *MegaWatt* and *milliWatt* transmitters in the same ecosystem.
- Need for co-existence is exacerbated by the nature of excellent VHF and UHF propagation.
- A data base provides the opportunity to mitigate the interference effects of TV services and TVBDs.

White or Gray?

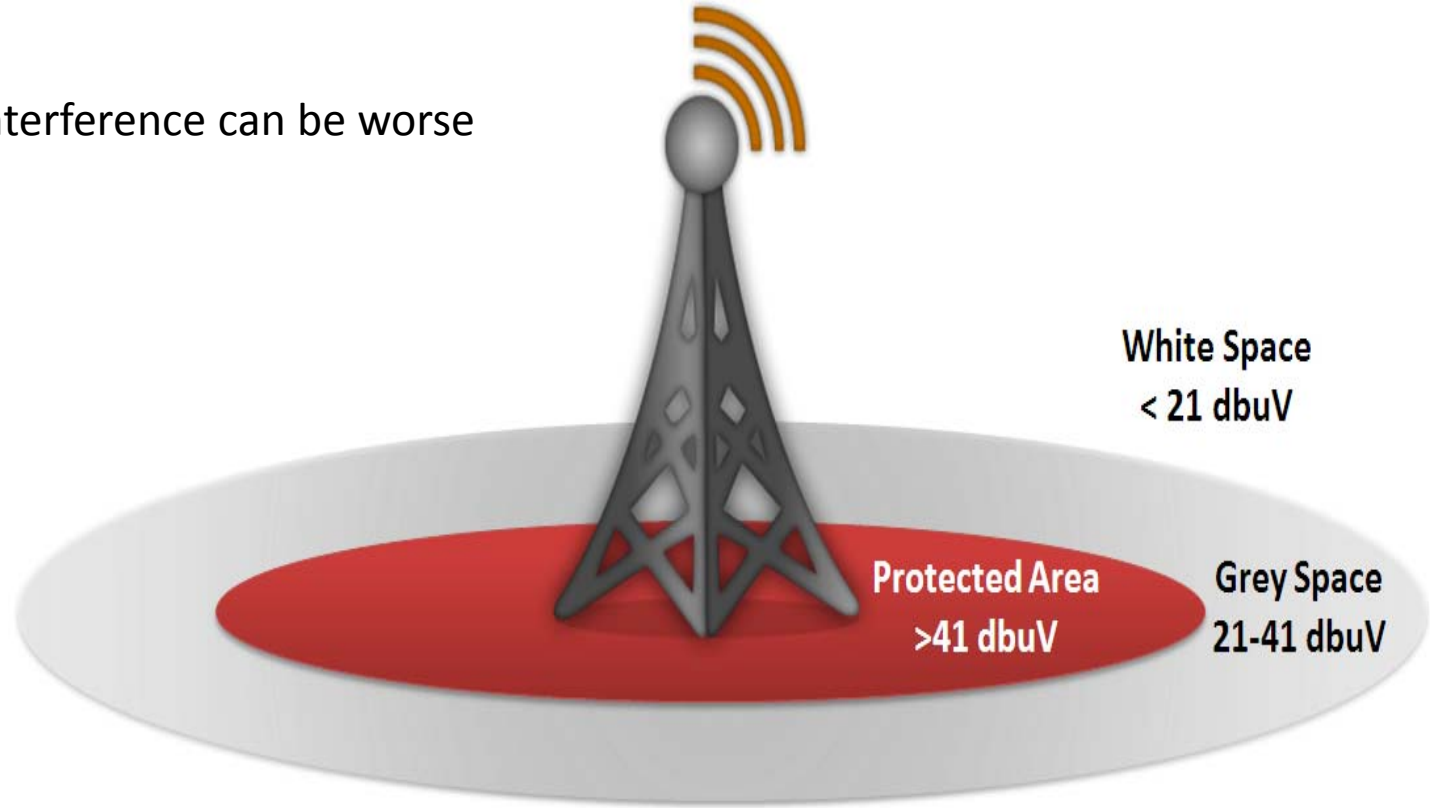


Caution ! Diminishing returns with higher antenna sites

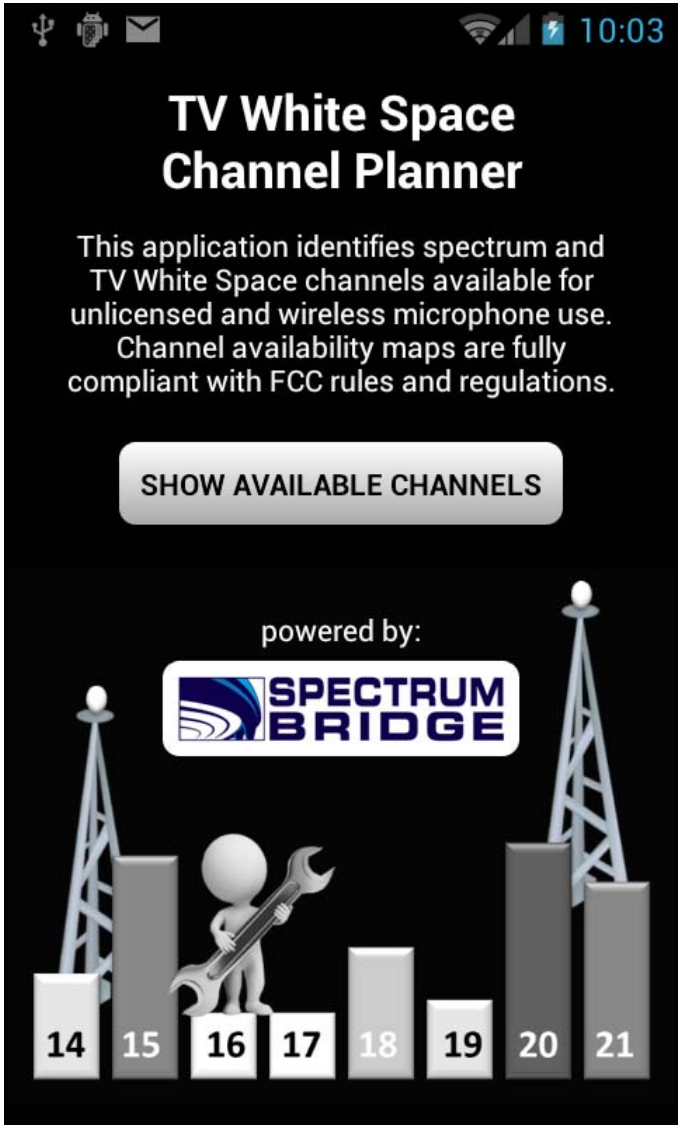
Permissible vs. Usable WS Example

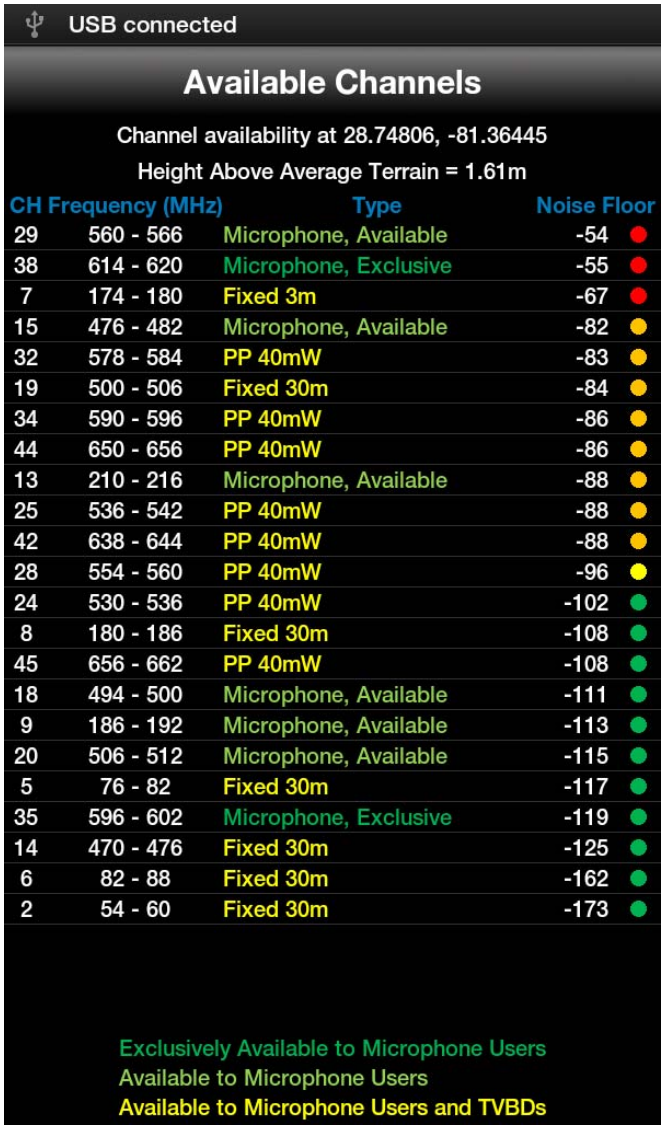
- A TVBD (with 6 dBi antenna, 600 MHz) at TV contour edge (41 dbuV)
  - o exposed to an undesired signal of ~ -85 dBm
  - o notwithstanding antenna polarization discrimination

- Adjacent channel interference can be worse



A Spectrum Bridge Solution

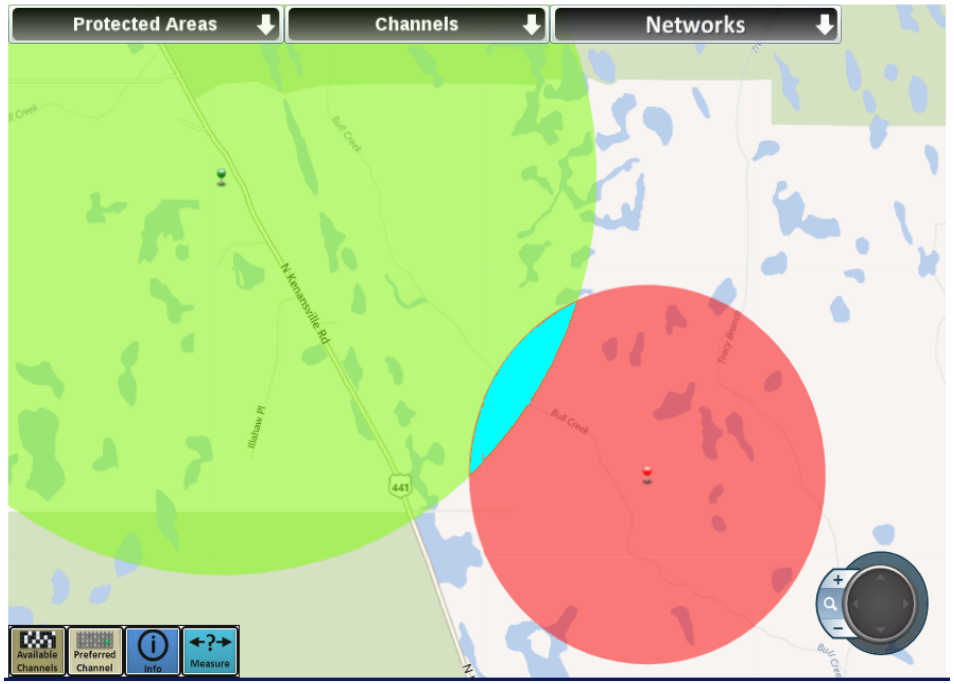




CH	Frequency (MHz)	Type	Noise Floor
29	560 - 566	Microphone, Available	-54
38	614 - 620	Microphone, Exclusive	-55
7	174 - 180	Fixed 3m	-67
15	476 - 482	Microphone, Available	-82
32	578 - 584	PP 40mW	-83
19	500 - 506	Fixed 30m	-84
34	590 - 596	PP 40mW	-86
44	650 - 656	PP 40mW	-86
13	210 - 216	Microphone, Available	-88
25	536 - 542	PP 40mW	-88
42	638 - 644	PP 40mW	-88
28	554 - 560	PP 40mW	-96
24	530 - 536	PP 40mW	-102
8	180 - 186	Fixed 30m	-108
45	656 - 662	PP 40mW	-108
18	494 - 500	Microphone, Available	-111
9	186 - 192	Microphone, Available	-113
20	506 - 512	Microphone, Available	-115
5	76 - 82	Fixed 30m	-117
35	596 - 602	Microphone, Exclusive	-119
14	470 - 476	Fixed 30m	-125
6	82 - 88	Fixed 30m	-162
2	54 - 60	Fixed 30m	-173

Promoting Co-Existence and Sharing

- Network Operators are not picky about how this is accomplished
- Automatic notifications when:
  - Potential interference or channel conflict occurs or might occur
  - Future use of spectrum is at risk
- Feedback of channel selection and sensing data facilitates best results
- Results in active and passive resolution of interference “Stand-offs”
- Active view of existing usage



Other Opportunities

Current TVWS rules are rudimentary but do not prevent the inclusion of additional services

The Database can provide very granular and flexible protection

- Change is easy and has no impact on deployed technology
- Updates/enhancements to the rules easily absorbed by the Database
- Rules can be tailored to any combination of location, frequency, time, device

The Database does not have to provide free (unlicensed/license exempt) access to spectrum

- Clearing house options
- Alternative to auctioning spectrum

The Database can manage priority access, QOS and coexistence

- The “air traffic controller” for radios
- Permissions can be limited to maximum “clearing” time
- Permissions can be rescinded for priority use

Enable less sophisticated radios with cognitive capability

- Collect and share sensing data
- Provide ranked channel lists with channel ‘goodness’ metrics
- Interference mitigation (even without sensing data or channel feedback)

Conclusion

Thank You

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