Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Unlicensed Operation in the TV Broadcast Bands	)	ET Docket No. 04-186
	)	
	)	ET Docket No. 02-380
Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band	)	
	)	

Shared Spectrum Company Reply Comments

In its Notice of Proposed Rule Making in the proceeding captioned above, 19 FCC Rcd 10018 (released May 25, 2004), the Commission proposed initially two types of cognitive radios in the bands in which television broadcasters operate: (1) "personal/portable" unlicensed devices, similar to Wi-Fi, limited to 100 milliwatts peak power and (2) higher–power fixed/access devices generally operated from fixed locations providing a wireless broadband service, such as used by WISPs, limited to 1 watt peak power. Shared Spectrum Company (SSC) supports the introduction of both types of devices.

Our reply comments cover two areas:

- A key factor in the success of the above cognitive radio behaviors is the ability to detect TV signals well below the noise level. In these comments, we provide a summary of field experiments conducted by SSC to validate that high sensitivity "feature" detectors can detect TV signals below the noise level and below the threshold levels (-129 dBm) suggested by Intel in its comments[1].

- While the FCC's proposals are both worthy steps in the right direction, they do not represent the optimal cognitive radio configurations that can be achieved by technology that is rapidly coming to market. In these comments, we describe a fixed-networked system that provides a low risk and high benefit method that could be deployed along with the unlicensed, low-power approach.

[1] Intel Comments, November 30, 2004, Appendix A, Page 6.

Ultra-Sensitive TV Signal Detector Verification

A key factor in the success of the above cognitive radio behaviors is the ability to detect TV signals well below the noise level. In these comments, we provide a summary of field experiments conducted by SSC to validate that high sensitivity "feature" detectors can detect TV signals below the noise level (and below the threshold levels (-129 dBm) suggested by Intel in its comments)[2].

The engineering report on High Sensitivity TV Signal Detection attached as Appendix A to these Reply Comments explains some of the results from Shared Spectrum's experiments and analysis of TV band feature detectors. The key finding of this report is experimental proof that the required detector sensitivities are obtained except in high RF noise environments, where spurious signals will trigger false positive detections in "simple" feature detectors. In this case, the cognitive radio will not transmit and will not cause interference. Use of "advanced" feature detectors reduces the false alarms and allows operation in all environments.

Figure 1 shows the feature detector's measurement of the analog TV signal strength versus TV channel as measured in a typical suburban residence (McLean, VA). The local TV Channels of 4, 5, 7, 9, and others are correctly detected with a high carrier signal value. The spurious signal levels (caused by computer noise and other sources) in the other channels are well below the -129 dBm value listed in Intel's comments. Hence, the spurious signals are small enough to not cause false alarms and the detector works well.

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[2] Intel Comments, November 30, 2004, Appendix A, Page 6.

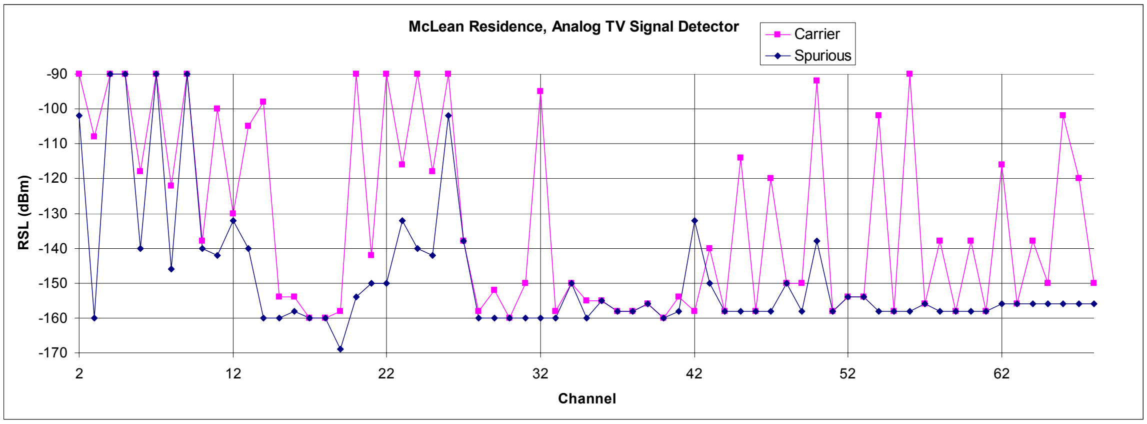

Figure 1. Analog TV signal carrier power and spurious signal level versus TV channel measured in McLean, VA.

Figure 2 shows the digital TV pilot amplitude versus carrier TV channel as measured in a typical suburban residence. The local digital TV Channels of 34, 36, and others are correctly detected with a high pilot signal value. The spurious signal levels in the other channels are well below the -129 dBm value listed in Intel's comments. Hence, there are insignificant false alarms in the digital signal case and the feature detector works well in this situation.

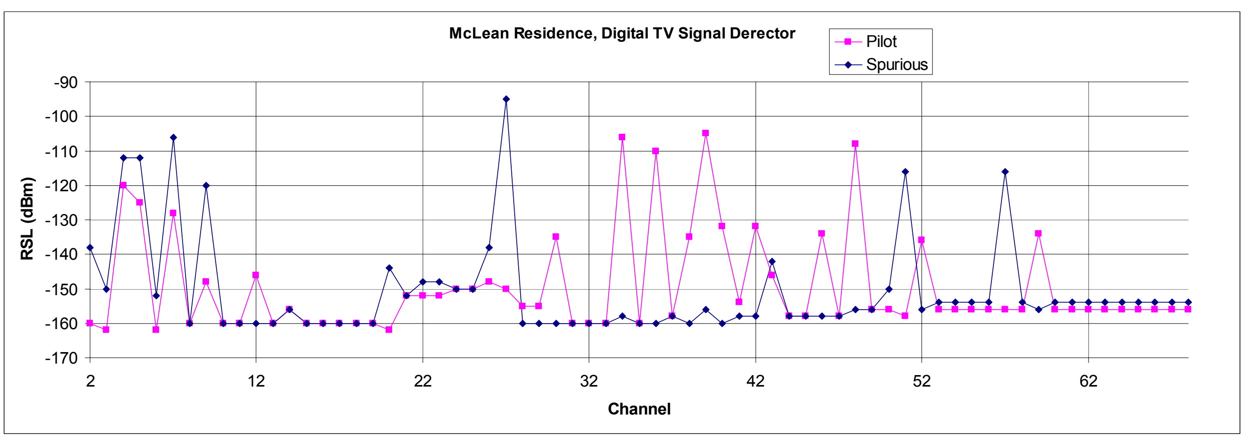

Figure 2. Digital TV signal pilot and spurious signal level versus TV channel measured in McLean, VA.

The results from other locations (rural and isolated) show similar results that verify that a cognitive radio feature detector can meet the sensitivity requirements to avoid causing interference.

The measurements from a high RF noise location (a typical office environment with numerous computers) show that the spurious signal levels may be at the same power level threshold (-129 dBm as suggested by Intel) and frequency as the TV carrier/pilot signal. This will cause “false positive” detections in simple detectors. Operation in this type of environment requires additional logic to recognize and ignore the spurious signals. Shared Spectrum has developed a detector to operate in this environment, and is currently conducting field tests using it.

The overall conclusion is that feature detectors provide the required detection sensitivity to avoid interference, even in high RF noise environments.

Fixed-Networked Systems With Peak Power Up to 10 Watts Should be Permitted

To permit an orderly development of optimal configurations while at the same time allaying concerns regarding the possibility of destructive interference by incumbent users of the band who are not eager to see others join them, Shared Spectrum suggests that the Commission also authorize the use of Fixed Networked systems of more advanced cognitive radios using powers as high as ten (10) watts in appropriate circumstances. Such systems can move incrementally to their maximum power subject to Commission review. Such systems would make greater use of the inherent advantages of software defined radio by developing in an evolutionary manner made possible by careful continuing analysis of their own operational experience. Since such systems would be centrally controlled by network operators responsible for avoiding interference by any unit, the Commission can monitor and guide the development in detail over time with assurance that the Commission will receive rapid and accurate reporting and its guidance will be followed. The Commission would not be called upon necessarily to define the ultimate limits in advance of considerable operational experience in a variety of conditions. The Commission can use its existing authority for experimental authorizations for as long as that may be needed.

Such systems can be particularly useful in advancing rural Internet broadband access, public emergency and counter-terrorism services, and the provision of video links for a variety of special purposes. The use of such broadband capabilities in conjunction with UAVs, for example, could make possible stunning quantum improvements in public services. Use of the VHF and UHF television bands by devices with high data rates could provide, for instance, comprehensive coverage for a variety of services to West Virginia (where a 15 kilometer-range from existing antenna sites would achieve virtually ubiquitous coverage). The rapid setup capability made possible by cognitive radio will facilitate not only emergency reporting requirements for public safety users but will also make possible a highly flexible electronic news gathering capability.

Because the system uses software defined radio, its parameters can be readily adapted to experience, the Commission's evolving requirements and shifting market demand. The system can be developed in an evolutionary way in response to market demands and without the discombobulations created when the Commission is forced to take the drastic step of moving out users of older technologies to make room for newer ones. To provide an additional degree of security regarding interference concerns, such systems would provide central control over the software in each transceiver so that the software can be adjusted instantly to respond to any indications of harmful interference that may be experienced and in response to any direction by the Commission. Claims of potential interference could be subjected to analysis on the basis of substantial operational experience in a variety of conditions.

Extent of Central Control Over Network Devices

The network controller would have the ability to shut down units and the ability to remove a given frequency or set of frequencies from the list of frequencies available for testing for upcoming transmissions. He would also have the ability to reduce power output or modify waveforms on suspect frequencies. Individual units would communicate their confirmation to the controller that they have actually taken the necessary steps. The network would also have the ability to communicate more detailed temporary rules to cover periods during which longer- term answers to a possible interference problem are sought off-line.

Cumulative Detection Can Overcome the Hidden Node Problem Effectively

Another advantage of operating on a network basis is that the overall detection capability of the intercommunicating units would be substantially increased. Since it becomes possible to detect signals from many locations, not all of which will be obstructed, any potential problem of possible obstruction of some primary signals to a stationary cognitive radio can be overcome.

Figure 3 illustrates how a cognitive radio network creates significantly less interference than individual radios. In this situations, Cognitive Radio A attempts to communicate to Cognitive Radio B using spectrum within the TV band. Both Radio A and B must agree that the channel is not being used locally for TV broadcast before they transmit. For Radio A to cause interference to nearby TV receivers, the four simultaneous conditions shown in the figure must exist. This would be very rare.

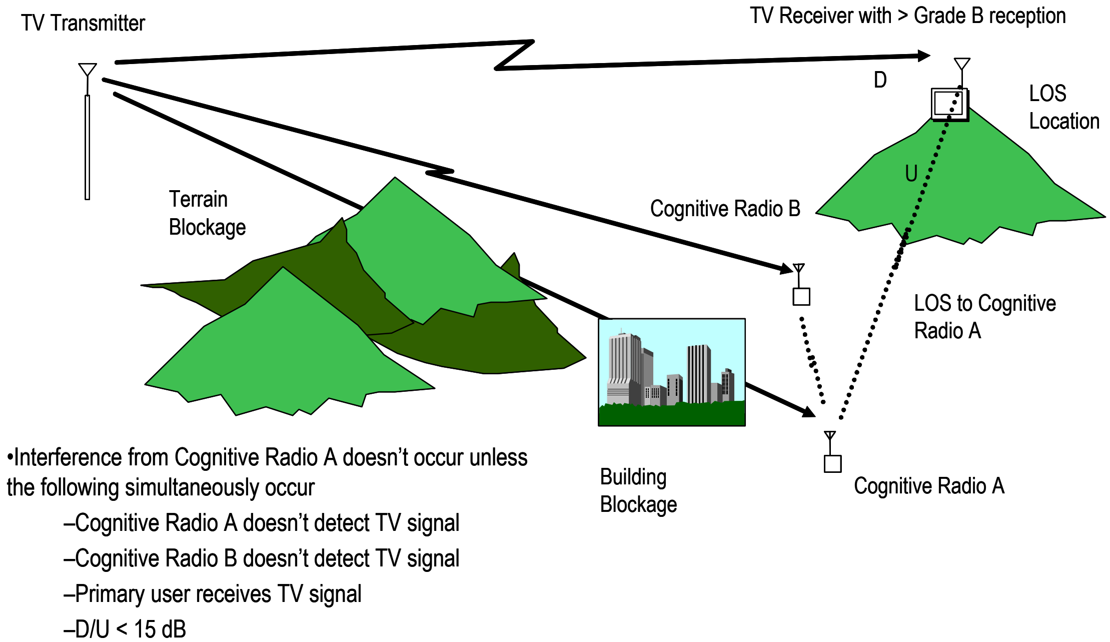

Figure 3 Cognitive Radio A (when communicating with Cognitive Radio B) can cause interference to a TV receiver only if a simultaneous combination of four events occurs.

This mode of operation would effectively dispose of the Hidden Node problem discussed by Shared Spectrum in earlier filings. Shared Spectrum's studies of such "cumulative detection" (or "group behavior") show that, in addition to enhancing interference avoidance, it will reduce the number of false interference alarms, reduce the need for each unit to employ ultra-sensitive detection capability (lowering per unit cost) and thus increase overall effectiveness and efficiency.

We note that Shared Spectrum's studies have shown the use of conclusions regarding the great value of employing group behavior to avoid interference to passive receivers and to increase overall system efficiency are supported by the studies made in the San Francisco Bay region by Adaptrum, Inc.. We agree with their conclusion that: "Collective sensing (or sensing information sharing) is the key to alleviate hidden terminal problem in shadowing environment and the hidden terminal probability can be reduced to an arbitrary low level with a large number of cognitive users sharing their sensing information." (Adaptrum Comments at 20.) The "sensing approach is more adaptive, scalable, and can better exploit spectrum opportunities." *Id.*

Conclusion

Shared Spectrum therefore recommends that the Commission provide the opportunity for development of fixed-networked systems with peak power up to 10 watts.

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