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	

Via the ECFS

COMMENTS OF IEEE 802.18

IEEE 802.18, the Radio Regulatory Technical Advisory Group ("the RR-TAG") within IEEE 802[1] hereby submits its Comments in the above-captioned Proceeding. This document was prepared and approved by the RR-TAG, and also was reviewed by the IEEE 802 Executive Committee.[2]

The members of the RR-TAG that participate in the IEEE 802 standards process are interested parties in this proceeding. We appreciate the opportunity to provide these comments to the Commission.

INTRODUCTION

1. On October 12, 2006, the Commission adopted a First Report and Order and Further Notice of Proposed Rulemaking with the purpose of allowing new, low power devices to operate in the TV bands on channels/frequencies not being used for

[1] The IEEE Local and Metropolitan Area Networks Standards Committee ("IEEE 802" or the "LMSC")
[2] This document represents the views of IEEE 802.18. It does not necessarily represent the views of the IEEE as a whole or the IEEE Standards Association as a whole.

authorized services. In IEEE 802.18's view, this represents a significant opportunity for industry to participate in developing new technology and applications for wireless services, in support of which we offer the following comments to the Commission.

2. In our comments, we begin with a brief statement of our position regarding personal/portable devices in the TV Band, and then continue with recommendations related to fixed operation. As the Commission is aware, IEEE 802.22 ("802.22") is a working group within IEEE 802 which is developing a standard for fixed operation Wireless Regional Area Networks ("WRAN") intended to operate on unused TV channels under the final rules adopted by the Commission for the TV bands. Our recommendations related to fixed operation are based on the substantive work which 802.22 has completed to date in developing requirements and drafting a standard.

3. IEEE 802.18 notes that the IEEE 802.22 standard development project is limited, by the scope of its Project Authorization, to fixed point to multipoint systems (excluding fixed point to point systems) to provide wireless broadband access. Our comments here should be taken in the context of fixed operations unless otherwise noted.

4. We want to further point out that no technical work has been done, as part of an authorized project in IEEE 802, to support or evaluate the feasibility of personal portable devices in the TV bands. We recognize that many parties have expressed concerns regarding the potential for harmful interference from personal/portable devices to the protected operations of TV broadcast and licensed Part 74 services. On the other hand, the potential benefit of personal/portable devices operating under constraints which prevent harmful interference to licensed services leads us to believe that, eventually, technical solutions may be found which will allow this class of device to coexist successfully with licensed services under an appropriate set of future rules.

5. The scope of the IEEE 802.22 standard development project was specifically limited to fixed point to multipoint systems to provide wireless broadband access because the Study Group that defined the scope of the project felt that that was the

"best and highest use" of unused TV band spectrum and essentially agreed that non-fixed devices generally pose a greater risk of harmful interference to authorized operations than fixed devices for the same reasons cited by the Commission in this proceeding.

IEEE 802.18 RECOMMENDS THAT THE COMMISSION REMAIN OPEN TO THE POSSIBILITY OF A FUTURE RULEMAKING WHICH WOULD PERMIT OPERATION OF PERSONAL/PORTABLE DEVICES IN THE TV BAND

6. While IEEE 802 presently has no task group working on a standard for Wireless Local Area Network ("WLAN") or Wireless Personal Area Network ("WPAN") devices targeted at personal/portable applications in the TV band, we would not want to see the opportunity to develop such devices permanently foreclosed by the Commission.

7. As the Commission has noted in the TV Band NPRM:

> "Part 15 unlicensed devices and wireless broadband services using such devices have been extremely successful. The past few years have witnessed the development of broadband unlicensed industry standards such as IEEE 802.11b (Wi-Fi), Bluetooth, and Home RF that have greatly expanded the number and variety of devices that operate in the 2.4 GHz and 5 GHz industrial, scientific and medical equipment (ISM) bands." [3]

8. We note that IEEE 802.11 WLAN devices, including those described in the amendments 802.11a,b,g, and the draft amendment 802.11n, are, and will continue to be, a large part of the economic success described by the Commission.

9. Also, WPAN devices, including devices compatible with the IEEE 802.15.1 standard (based on the Bluetooth™ v1.1 standard) and the IEEE 802.15.4 standard, are increasingly significant parts of this success story.

10. WLAN and WPAN devices operate in both fixed and personal/portable application spaces within the ISM bands, with WLAN devices used in client/server and peer to peer environments, and WPAN devices used in a variety of applications where mobility and flexible wireless connectivity are important.

[3] ET Docket No. 04-186, Para 9.

11. In the future, there may be a number of ways that personal/portable devices might be enabled to operate in the TV Band. For example, work now being done in the 802.11y Task Group, focusing on devices to be licensed under Part 90 rules in the 3650-3700 MHz band, may be applicable to personal/portable devices in the TV band associated with, and operating under the control of a base station, or access point in some future amendment(s) to either the IEEE 802.11 WLAN or the IEEE 802.22 Wireless Regional Area Network ("WRAN") standards. In addition, the IEEE 802.16 Wireless Metropolitan Area Networks ("WMAN") standard might be extended by an amendment specifying operation in the TV band either as a licensed or an unlicensed implementation, including the possibility of mobile personal/portable devices under control of the WMAN base station, with the appropriate level of protection for incumbents included in the standard.

12. In pointing to these examples, we are not offering an IEEE 802 roadmap for future amendments to any of these standards, nor are we suggesting the Commission close off one set of applications or services in favor of another.

13. Therefore, our recommendation is that the Commission remains open to the possibility of some future rulemaking allowing personal/portable devices operating in the TV band on a non-interfering basis.

IEEE 802.18 SUPPORTS THE COMMISSION'S PROPOSAL TO ADOPT RULES FOR FIXED OPERATION IN THE TV BANDS

14. IEEE 802.18 agrees with the Commission's conclusions in this proceeding that the protection of incumbent operations in the TV bands is a much more tractable problem when devices are limited to fixed operation. We also believe that fixed point to multipoint systems with a master/slave relationship between base stations and user terminals, coupled with sensing across the network, geolocation/database techniques, and transmitter power control, can provide a viable means of bringing broadband fixed access services to less densely populated rural areas and other unserved/underserved areas where spectrum is available.

15. Therefore, we support the Commission's conclusion that it can adopt rules to allow fixed low power operation on unused spectrum in the TV bands without causing harmful interference to authorized services. Later in this response to the Notice, we will provide responses to the Commission's requests for further input on topics such as spectrum sensing, geolocation, control signals, and other items where the Commission seeks input in order to craft a complete and effective set of rules for TV band devices.

IEEE 802.18 SUPPORTS UNLICENSED OPERATION AS THE BEST MODEL FOR IMPLEMENTING WIRELESS NETWORKING TECHNOLOGY IN THE TV BAND

16. While the technical recommendations presented in these comments could apply equally to licensed or unlicensed regimes, IEEE 802.18 believes that the most efficient and economical model for bringing the benefits of additional use of TV band spectrum to the public is the unlicensed model, with the caveat that, for systems based on fixed access base stations supporting client terminals installed at homes or businesses, there should be a requirement for registration of base stations. Base station location, technical parameters, and contact information for the operator should be made available in an Internet accessible database to allow licensed incumbents to rapidly identify and contact a base station operator to facilitate prompt resolution in the event of interference.

17. However, a very "light touch" licensing scheme (similar to the Commission's approach to licensing in the 3650-3700 MHz band), while somewhat less desirable than an unlicensed regime, might, under the right conditions, be an acceptable and viable alternative for fixed access base stations. If implemented, such a licensing scheme should be non-exclusive, should not involve auctioning or segmentation of the spectrum, and should present the minimum barriers to entry in order to allow these services to be presented to the public in the most rapid and economical manner possible. We don't believe that licensing for their associated Customer Premises Equipment ("CPEs") or user terminals would be necessary, and we believe licensing of CPEs would hamper consumer adoption of this technology.

IEEE 802.18 RECOMMENDS A COMBINATION OF METHODS AND TECHNIQUES TO PROTECT LICENSED SYSTEMS FROM UNLICENSED FIXED NETWORKS

18. IEEE 802.18 notes that the IEEE 802.22 Standard is being designed to incorporate a combination of techniques to assure that IEEE 802.22 compliant systems will not cause harmful interference to the licensed incumbent services:

- Distributed sensing (all devices in the network "cell" sense for the presence of the signals of licensed services above a threshold with centralized data analysis and decision-making at the base station).
- The base station controls the channel usage, power, and modulation characteristics of all CPEs.
- A geolocation/database system with location knowledge of all devices in the network to a required tolerance and an incumbent channel usage database at the base station covering a sufficient area surrounding the base station to completely encompass its potential sphere of interference.

19. While we believe that spectrum sensing is essential, we also believe that sensing alone is insufficient to adequately and completely assure the required level of interference protection for licensed services. For fixed systems, a geolocation/database component and Transmitter Power Control ("TPC") with a considerable control range are also essential components of a viable cognitive radio approach to meeting the requirement of operating on a strictly non-interfering basis to the licensed incumbents.

20. IEEE 802.22 user terminals will, by design, be prohibited from transmitting on any channel unless they have received control signals in the downstream direction from an 802.22 base station informing them of which channels may be safely used in the area. Additionally, all 802.22 user terminals will use both random idle time and scheduled times as directed by commands from the base station with which they are associated, to scan not only the operating channel but many other channels for activity, either from licensed services or from other 802.22 systems, and inform the base station of their findings. The base station will also sense during "quiet periods" on the channels that it is using, but sensing information from all of the user terminals is imperative, in our view, to implement

the most reliable sensing possible. This will allow 802.22 base stations to develop and maintain a "map" of available channels within their coverage area for the purpose of being able to rapidly move the entire network, or a portion thereof, to another channel should it become necessary to avoid causing interference to licensed services.

IEEE 802.18 RECOMMENDS THAT THE 6 MHZ CHANNELS USED IN TV BROADCASTING REMAIN THE MINIMUM CHANNEL SIZE FOR UNLICENSED OPERATION IN THE TV BAND

21. While not specifically addressed by the Commission in this Notice, we recommend that the Commission require equipment to operate with 6 MHz channels corresponding to the existing TV channel plan. 6 MHz is the basic channel unit in the developing IEEE 802.22 Standard[4]. We believe that allowing further subdivision of the 6 MHz TV channels would be counterproductive and detrimental to coexistence among systems.

22. We do, however, wish to clarify that this recommendation pertains to the channel granularity used by a system as a whole. For example, in an IEEE 802.22 system, the base station will generally occupy essentially the entire TV channel during its downstream burst, but user terminals will each use an assigned (by the base station) subset of the OFDM carriers that will fit within the allocated bandwidth to share the uplink bandwidth in an OFDMA manner. The collection of user terminals associated with a given base station will thus occupy essentially the entire TV channel, sharing the spectrum and uplink capacity through the use of OFDMA techniques.

23. Additionally, there may be occasions where it could be advantageous and desirable to "null" a block of OFDM carriers at one end of a TV channel or the other to provide additional guard band to further facilitate limiting emissions into an adjacent channel which might be occupied by Part 74 devices in order to better protect those licensed devices.

[4] At least for operation in the US where 6 MHz is the granularity of TV channels – in other areas of the world, the IEEE 802.22 Standard will support 7 and 8 MHz channels, based on the prevailing granularity of TV channel allocations.

24. Such adaptations of operating parameters for the purpose of protecting licensed services are not intended to negate the intent of our recommendation – that unused TV channels be reserved for use by broadband access applications, and that the Commission not allow the proliferation of multiple, incompatible narrowband systems – a move which would, in our belief, create significant coexistence problems, significantly increase the likelihood of interference to licensed services, and severely degrade the utility of the spectrum in question.

IEEE 802.18 RECOMMENDS PROHIBITING BOTH CO-CHANNEL AND ADJACENT CHANNEL OPERATION OF FIXED UNLICENSED SYSTEMS OPERATING WITHIN THE PROTECTED CONTOUR OF A DTV STATION

25. While it is clear that co-channel operation within the noise limited protected contour of a DTV station is not feasible, IEEE 802.22's studies and analyses have also determined that operation on first adjacent channels within the noise limited protected contour of a DTV station is likewise not feasible. The IEEE 802.22 Standard will, therefore, not allow co-channel operation or operation on first adjacent channels within protected contours.[5]

26. There are three reasons for prohibiting first adjacent channel operation within the DTV noise limited protected contour. First, to control the interference from low powered unlicensed devices operating on adjacent channels to a nearby DTV receiver, minimum separation distances will be needed. Based on the DTV protection ratios (DTV into DTV) for the first adjacent channels indicated in the FCC OET Bulletin 69, and in the first NPRM, (i.e., -28 and -26 dB for N-1 and N+1 respectively) which are assumed to also represent the case for the unlicensed devices' signals interfering with DTV reception, the minimum distances that would be required between the unlicensed device operating at the allowed maximum 4 W EIRP level and the DTV receiving installation were found to be 617 m and 776 m, respectively in free space propagation conditions, assuming 16 dB CPE antenna front to back ratio. Since the minimum acceptable distance to the DTV receiver is

[5] Or, additionally, for a necessary, nominal "keep out" zone beyond the edge of the contour.

10 m, uncontrolled location of the unlicensed devices within the DTV protected contour will not be possible on first adjacent channels.

27. Second, to keep the low power unlicensed devices' emissions in the channels adjacent to DTV signals sufficiently low would require onerous filtering and other measures in the unlicensed devices, with unacceptable impacts on device size, cost, power consumption, etc. In our view, "sufficiently low" is low enough to avoid causing more than 1 dB of desensitization to DTV receivers operating at or near the noise limited protected contour, or in areas of weaker signals within the contour.

28. Third, the emission levels in the first adjacent channels of a DTV transmitter that are allowed by the DTV RF transmission mask are sufficiently high to render those channels unusable by low powered unlicensed devices in most of the DTV coverage area.[6]

29. Therefore, as IEEE 802.18 recommended to the Commission in an earlier ex parte presentation in this Proceeding, we recommend that the Commission not allow operation either co-channel or on first adjacent channels to a channel occupied by a DTV station within its noise limited protected contour.

IEEE 802.22 HAS INITIALLY ADOPTED PRELIMINARY VALUES OF SENSING THRESHOLD, -116 DBM FOR DTV AND -107 DBM FOR PART 74 DEVICES, AS REQUIREMENTS FOR WRAN NETWORKS OPERATING IN THE TV BAND

30. The Commission states (at Para 37 in the Notice): "We observe that IEEE 802.22 is considering different threshold detection levels depending on the nature of the source signal, with levels as low as -116 dBm." and invites comment as to this value or alternative values for the detection threshold.

31. To clarify, IEEE 802.22 has considered different thresholds for TV and Part 74 devices, based on initial feasibility studies, and further work is ongoing in this area.

32. For protecting low power licensed devices operating under Part 74 of the Commission's rules, we have adopted a sensing threshold of -107 dBm (total power

[6] For example, unlicensed devices would be desensitized by more than 1 dB for F(50,10) within a radius of 51 km around a 1 MW ERP, 300 m HAAT DTV station for which the protected contour is around 120 km.

in the 200 kHz bandwidth allowed for Part 74 devices). This value is seen as a "practical best effort" threshold, based on the need to rapidly detect Part 74 devices, whose operation is intermittent and which cannot tolerate disruptive interference during live audio feeds (once the moment is gone, it is gone forever). Because this threshold is a "practical best effort," it is possible for a 4W EIRP unlicensed device (e.g., an 802.22 user terminal) to have an interference range that exceeds the range at which it could autonomously sense a low power Part 74 device, most of which operate in the 10-50 mW power output range and employ relatively inefficient antennas for a variety of practical reasons.

33. Because of this, IEEE 802.22 has a companion project in progress, IEEE 802.22.1, which is defining a new standard for enhancing the protection of low power licensed devices operating under Part 74. The technical direction of 802.22.1 is for a self-organizing network of "beacon" devices to be operated as licensed Part 74 devices within the technical constraints of Part 74. These "beacons" would operate at somewhat higher powers than the typical 10-50 mW wireless microphone (but not more than the 250 mW Part 74 limit) and would also enjoy the benefits of more efficient and better placed antennas than are possible in handheld or body-worn Part 74 devices. As a consequence, 802.22.1 devices would transmit a signal that could be much more easily recognized by the incumbent sensing capability of 802.22 fixed access systems to provide an appropriate "bubble of protection" around areas where licensed Part 74 devices are operating. IEEE 802.18 therefore recommends that the Commission include in its rules a requirement for all unlicensed devices to be able, in response to detecting such a licensed beacon, to vacate a TV channel as required to provide protection to devices licensed under Part 74 of the Commission's rules. Additionally, however, to prevent misuse of beacons by unauthorized parties, the Commission should enact rules to strictly limit the sale of such beacon devices to authorized Part 74 licensees.

34. For DTV broadcasting, we have adopted a sensing threshold of -116 dBm (total power in the 6 MHz bandwidth used by TV broadcasting). This was based on an initial analysis of what could be theoretically possible if one were sensing the DTV pilot at about -127 dBm in a narrow (e.g., 10 kHz) bandwidth with a 1 ms

integration time. The above -116 dBm and -127 dBm levels assume that both co-channel and adjacent channel operation within a TV station's protected contour is strictly prohibited and is assured through non-sensing means such as geolocation or professional installation.

35. However, as work has progressed in IEEE 802.22, a number of alternative sensing schemes have been proposed and are being evaluated at this time to quantify their efficiency, effectiveness, and relative complexity. It is intended that the results of these evaluations, as well as further analysis and simulation of the benefits of distributed sensing across an entire 802.22 network "cell," will be used to determine the optimum tradeoffs in terms of sensing threshold, probability of missed detection, probability of false detection, etc., while assuring the appropriate level of protection from interference to incumbent licensed services, and it is assumed that some adjustment in our recommended sensing thresholds may result.

IEEE 802.18 RECOMMENDS THAT FIXED ACCESS USER TERMINALS USE OUTDOOR ANTENNAS MOUNTED AT A NOMINAL 10 M ABOVE GROUND LEVEL

36. Based on IEEE 802.22's studies of interference potential and incumbent sensing requirements, the IEEE 802.22 Standard will require that 802.22 compliant fixed access user terminals use outdoor antennas (both the transmit/receive antenna(s) and the sense antenna), co-located and mounted at a nominal height of 10m above ground level in order to minimize the potential for interference and to assure effective incumbent sensing.[7]

37. The use of outdoor antennas well above ground level is very important to assure that incumbent sensing ability is not impaired by building losses and shadowing effects, and allows some correlation with the Commission's TV planning factors and propagation assumptions. It will also, in most cases, remove the transmit antennas from close proximity to TV receivers, which will reduce the

[7] Base station antennas may be considerably higher but will be in controlled locations and generally farther from potential victim receivers, e.g. on a mountain-top communications site.

likelihood of problematic levels of "ingress" interference (signals entering the TV receiver through unintended paths).

38. As a result, to minimize interference potential and avoid potentially problematic impairments to incumbent sensing ability, IEEE 802.18 believes that there is a need for a regulatory requirement that the device antenna be installed outdoors only and at a minimum antenna height of 10 meters AGL. While it is true that with greater antenna height the transmissions of the device will be able to reach farther, TPC functionality will help prevent the interference potential from these farther-reaching transmissions. The greater antenna height will also further alleviate our concerns that the sensing capabilities might be shadowed by either terrain or man-made structures.

39. Finally, the use of directional transmit antennas at the user terminals will have the effect of minimizing the area of potential interference by directing the transmitted signal power toward the base station and away from the protected contour of co-channel and first adjacent channel TV stations.[8]

IEEE 802.18 RECOMMENDS THE COMMISSION CONSIDER THE IEEE 802.22 APPROACH WHEN IMPLEMENTING RULES RELATED TO CHANNEL CLEARING

40. IEEE 802.18 notes that the IEEE 802.22 standard will require that the unlicensed system employ Dynamic Frequency Selection (DFS) which defines the behavior and parameters that an IEEE 802.22 system will use for sensing, and then vacating channels as required to prevent harmful interference to licensed incumbent services. In developing the DFS parameters, IEEE 802.22 considered the parameters used in 5 GHz band to sense military radar systems and adapted those numbers for the types of incumbent services that operate in the TV broadcast band (e.g., TV broadcasting and Part 74 devices such as wireless microphones).

41. IEEE 802.22 has determined that, in order to provide adequate protection for wireless microphones, an active WRAN channel must be checked for incumbent

8 *See* Technical Appendix in Reply of Sierra Digital Communications, Inc. to Comments of the American Radio Relay League, Incorporated, December 22, 1997, in RM-9189

signals every 2 seconds. This is based on the itinerant and intermittent nature of wireless microphone use, which cannot tolerate even short amounts of interference and thus requires rapid detection and subsequent channel relocation of the 802.22 system.

42. It is not necessary to check for the presence of a DTV station that frequently since it is expected that the majority of television broadcast signals on a channel will not be temporally dynamic on less than a daily basis. Indeed, a check time of 10 seconds or even longer is likely more than adequate for DTV.

43. However, the need to effectively detect Part 74 devices was the limiting factor at the time these requirements were developed. IEEE 802.22 may refine these DFS parameters as it considers further system simulations and actual test results. The currently required DFS parameters for the WRAN system are shown in Table I below:

Table I: IEEE 802.22 Preliminary DFS Parameters

DFS Parameter	Value for Part 74 Devices	Value for TV Broadcasting
Channel Availability Check Time	30 sec (recommended)	30 sec (recommended)
Non-Occupancy Period (minimum)	10 minutes (recommended)	10 minutes (recommended)
Channel Detection Time	<=2 sec to >=90% Probability of Detection with a False Alarm rate of <=10%	<=2 sec to >=90% Probability of Detection with a False Alarm rate of <= 10%
Channel Setup Time	2 sec	2 sec
Channel Opening Transmission Time (Aggregate transmission time)	100 msec	100 msec
Channel Move Time (In-service monitoring)	2 sec	2 sec
Channel Closing Transmission Time (Aggregate transmission time)	100 msec	100 msec
Incumbent Detection Threshold	-107 dBm (200kHz BW)	-116 dBm (6 MHz BW)

IEEE 802.18 RECOMMENDS SPECIFYING SENSING THRESHOLDS RELATIVE TO THE TOTAL POWER IN THE ALLOCATED CHANNEL BANDWIDTH

44. Studies conducted in IEEE 802.22 indicate that the unique spectral features of NTSC and ATSC signals can be exploited in a variety of ways to detect them at lower levels in the 6 MHz TV channel than at which it is possible to detect the more random spectral signature of part 74 devices in their 200 kHz channel bandwidth. The principal reason is that the analog FM emissions of the vast majority of Part 74 devices do not have consistent, predictable spectral features.

45. The -107 dBm (in a 200 kHz Part 74 channel bandwidth) and -116 dBm (in a 6 MHz TV channel bandwidth) thresholds under consideration by IEEE 802.22 are referenced to the total power in the respective bandwidths. Various sensing techniques may employ narrow effective sensing receiver bandwidths, but we believe that the best and most uniform way to specify sensing thresholds for each service is to reference them to the total power in their respective channel bandwidths.

IEEE 802.18 RECOMMENDS THAT THE COMMISSION TAKE ACTION TO REMEDY THE PROLIFORATION OF PART 74 DEVICES OPERATED WITHOUT PROPER AUTHORIZATION

46. In the cases where the low powered unlicensed devices need to sense wireless microphones to protect the low-powered Part 74 licensed devices, consideration should be given by the Commission to the fact that there will be no means at the WRAN devices to differentiate between Part 74 wireless low power licensed devices operated by broadcasters and other wireless microphones. This may have a major detrimental effect on the operation and availability of the WRAN systems.

IEEE 802.18 RECOMMENDS THAT THE COMMISSION CONSIDER THE CONCLUSIONS OF IEEE 802.22 IN DETERMINING RULES FOR UNLICENSED FIXED DEVICE ANTENNAS

47. The conclusions of studies in IEEE 802.22 indicate that the sensing antenna should have a minimum gain of 0 dBi, assuming that it is omnidirectional in azimuthal coverage, but we believe that the Commission's rules should not preclude alternative approaches as long as they can be conclusively demonstrated to provide equally effective, or superior, sensing performance (e.g., an electronically rotated gain antenna that has relatively high gain and achieves the effect of omnidirectional coverage by scanning in 360 degrees of azimuth).

48. Additionally, no matter what the directional gain in transmit, IEEE 802.22 fixed access user terminals obviously will not exceed the regulatory maximum EIRP (currently proposed as 4W EIRP) and focusing that radiated power in the desired direction – away from a co-channel or adjacent channel DTV station's protected contour – and limiting off-axis power through the use of directional antennas will actually reduce the probability of and potential sphere of interference.[9]

49. Requiring fixed access user terminals to employ antennas (both sensing and transmit/receive) at a nominal height of 10m improves sensing effectiveness. It also

9 *See* Technical Appendix in Reply of Sierra Digital Communications, Inc. to Comments of the American Radio Relay League, Incorporated, December 22, 1997, in RM-9189

increases the distance from TV sets, reducing the likelihood of unacceptable levels of signal ingress into TV sets through unintended paths.

50. Additionally, higher antenna placement will in many cases reduce the transmit power required to maintain link quality with the base station, resulting in an automatic reduction in transmitter power output via TPC.

51. We do not believe that the Commission should impose a maximum antenna height limitation or require a reduction in allowable EIRP if antennas are installed at heights greater than 10m, because in rural areas there may be situations where a higher antenna installation would be desirable and such an installation would decrease the transmit power required to maintain the link, increase the distance from potential victim TV sets, and improve incumbent sensing effectiveness.

IEEE 802.18 RECOMMENDS THAT THE COMMISSION ADOPT RULES REQUIRING GREATER POWER CONTROL FOR UNLICENSED DEVICE TPC IMPLEMENTATIONS IN THE TV BANDS

52. IEEE 802.18 believes the 6 dB TPC power reduction (and no TPC requirement if limited to 3 dB below the maximum permissible power) provisions that were enacted in the 5 GHz rules are inadequate for TV band unlicensed operation.

53. The 5 GHz rules on this subject were substantially designed to protect the Earth Exploration Satellite Service by reducing the received aggregate power on-orbit by 3 dB on average. The logic as we understand it is that some devices are assumed to be operating 3 dB below the maximum permissible power, with some devices operating at the maximum permissible power, and some devices operating 6 dB lower, so, on average, there would be an effective 3 dB reduction in on-orbit aggregate received power.

54. The situation in the TV bands is very different and IEEE 802.22 has adopted a requirement that all 802.22 user terminals have a TPC range that allows reduction from the maximum permissible power to a level at least 30 dB lower with a 1 dB step granularity. We believe that this is both a necessary and practical requirement and urge the Commission to adopt this recommendation. Fixed access

user terminals operating close to the base station will need far less than the maximum permissible power to maintain effective communications and should not employ more power than is necessary in the interest of minimizing interference potential.

55. Adopting this approach will not only assure a high degree of protection to licensed services in the TV bands, but will also facilitate coexistence between unlicensed devices and increase the efficiency of their spectrum utilization.

IEEE 802.18 SUPPORTS THE COMMISSION'S PROPOSAL TO REQUIRE A MASTER/CLIENT (OR "MASTER/SLAVE") NETWORKING MODEL FOR UNLICENSED OPERATION IN THE TV BANDS

56. The IEEE 802.22 Standard will have all user terminals (clients/slaves) under the total control of the base station (the master).

57. IEEE 802.22 user terminals will, by design, be prohibited from transmitting on any channel unless they have received control signals in the downstream direction from an 802.22 base station, informing them of which channels may be safely used in the area. Additionally 802.22 base stations will control the transmitter power (enforce TPC), modulation parameters, and transmission timing of all user terminals that are associated with them.

IEEE 802.18 OPPOSES RULES ENFORCING RESTRICTIONS ON THE DURATION OR DUTY CYCLE OF UNLICENSED TRANSMISSIONS

58. IEEE 802.18 notes that the IEEE 802.22 Standard is being designed with extensive attention to maximizing its efficiency of spectrum utilization by including explicit and comprehensive inter-system coexistence protocols to insure equitable sharing of channels between systems with overlapping coverage areas. These features will both prevent a single system whose coverage area overlaps with another IEEE 802.22 system from unfairly monopolizing the use of a channel (whether the overlapping systems are operated by the same party or not) and maximize the capacity available to provide broadband service to the public.

59. We urge the Commission not to enact any restrictions on the duration of transmissions or duty cycle, since we believe our sharing and coexistence protocols render such regulatory restrictions unnecessary.

60. We strongly recommend that any non-IEEE 802.22 systems that the Commission might allow to enter the TV band be required to employ comparable and compatible sharing and coexistence mechanisms in order to meet the Commission's intent to promote effective sharing of the TV bands.

IEEE 802.18 SUPPORTS THE COMMISSION'S EFFORT TO CONDUCT EXTENSIVE TESTING PRIOR TO DEVELOPING RULES AND MEASUREMENT PROCEDURES FOR UNLICENSED OPERATION IN THE TV BANDS

61. To advance the Commission's goal, IEEE 802.22, through its Spectrum Sensing Ad Hoc Group, is currently developing a uniform testing methodology to evaluate the sensing threshold performance of these unlicensed devices. The IEEE methodology uses off-air TV signal captures to evaluate the various sensing proposals using simple pass/fail criteria. Once finalized, the methodology could be made available to the Commission for use as interim measurement procedures to aid in its development of the final compliance measurement procedures.

62. While IEEE 802.18 agrees with the Commission's finding that the use of the 5 GHz U-NII test procedures for sensing incumbents in the 5 GHz band may not be appropriate in the TV bands, we disagree with the Commission's statement or tentative conclusion that it is simpler to detect signals from the types of devices operating in the TV spectrum than for radars.

63. In the case of 5 GHz radar systems, the ability of an unlicensed device to detect a radar signal directly translates into the ability of the unlicensed device to protect that radar system. In contrast, the ability of an unlicensed device to detect a TV signal does not directly translate into the ability to protect nearby TV reception. They are completely different problems.

64. Protecting a 5 GHz radar receiver is technically easier than protecting DTV reception. The radar receiver to be protected is usually co-located with the radar transmitter whose emissions can be "sensed" making protection of the radar receiver relatively easy and straightforward technically. In contrast, TV receivers are not co-located with the TV transmitter but rather are located throughout the TV station's service area.

65. For protection of TV reception, there is no signal that can be sensed practically and economically by an unlicensed device to tell the unlicensed device how close it is to a TV receiver.

66. While the radar signal is bursty and non-continuous, the sensing threshold level for a radar signal is -64 dBm. In contrast, the proposed sensing threshold

signal level for DTV detection is -116 dBm in 6 MHz, which is a very weak signal when compared to a radar signal. Detection at weak signal level conditions is generally more challenging than detection of strong signals.

67. Sensing antennas for unlicensed devices at 5 GHz are small, but efficient, and have a relatively uniform performance across the 5 GHz spectrum. In contrast, building a small, efficient and practical antenna that operates with a uniform antenna performance across the VHF and UHF TV bands is more difficult and complex.

IEEE 802.18 RECOMMENDS THAT GEOLOCATION/DATABASE METHODS BE REQUIRED FOR FIXED UNLICENSED OPERATION IN THE TV BANDS

68. IEEE 802.18 believes, based on the work done to date in IEEE 802.22, that geolocation/database techniques go hand in hand with sensing, master/client, TPC, etc. to form the complete package of cognitive radio features necessary to assure the appropriate levels and robustness of incumbent protection, and to ensure efficient sharing and coexistence between multiple unlicensed TV band systems.

69. IEEE 802.18 recommends against allowing unlicensed devices sharing the TV bands to operate indoors, since unlicensed devices are unlikely to be capable of efficiently sensing incumbents indoors. We therefore believe that the idea of assisted GPS to facilitate indoor operation is fundamentally flawed.

70. IEEE 802 has previously recommended to the Commission that fixed access base stations be required to be professionally installed – a requirement that should include proper site surveys, propagation/coverage predictions, and geolocation of the base station – coupled with the use of an accurate and up-to-date incumbent station database

71. The IEEE 802.22 Standard will include means to determine the location of user terminals associated with each base station to meet all of the requirements for incumbent protection and sharing/coexistence among IEEE 802.22 systems.

IEEE 802.18 SUPPORTS RULES ALLOWING FIXED UNLICENSED SYSTEMS TO OPERATE ON CHANNELS 14-20 IN AREAS WHERE THESE CHANNELS ARE NOT OTHERWISE OCCUPIED BY LICENSED OPERATORS

72. While we agree with the Commission's conclusion in the Notice that personal portable devices should not be permitted to operate on Channels 14-20, disallowing the use of geographically unused spectrum by fixed access devices, whose deployment can be controlled, does not further the Commission's goal of efficient spectrum utilization.

73. Given that there are large geographic expanses where channels 14-20 are not used by PLMRS/CMRS, IEEE 802.18 recommends that channels 14-20 not be "taken off the table" nationwide for fixed access devices, but that such use be precluded only in the areas where it is actually in use by licensed services, including the PLMRS/CMRS.

74. Clearly, licensed PLMRS/CMRS operations authorized in TV channels 14-20 under Part 90, Subpart L (§ 90.301 to § 90.317) of the Commission's rules must be protected. However, as the Commission observes (at Para 56 in the Notice), the PLRMS/CMRS are permitted by rule to operate in only 13 metropolitan areas in the country, and on only one to three channels in each of those areas. Furthermore, per 47 CFR § 90.305, PLMRS/CMRS base stations may not be located more than 50 miles from specified geographic coordinates, and mobile stations must be operated within 30 miles of their associated base station.

75. IEEE 802.18 recommends, rather than prohibiting fixed access systems from using channels 14-20 on an unnecessarily restrictive nation-wide basis, that the 80 mile operational radius from the specified geographic coordinates defining the "centers" of those 13 metropolitan areas be used as the basis to define an (expanded) "keep out zone" for fixed access base stations.

76. The proposed "keep out zone" would assure that the radiated emissions from a base station and its associated user terminals could not feasibly encroach into the authorized operational area of PLMRS/CMRS systems at levels that could cause harmful interference.

77. Additionally, we also note that PLMRS/CMRS operations have been authorized on a case-by-case basis in other areas under waivers of the Commission's

rules. Clearly, these licensed operations also must be protected, and systems currently authorized, and any that may be authorized in the future on this basis, should be afforded comparable protection areas.

78. IEEE 802.18 is not prepared at this moment to offer specific recommendations on the required size of the additional "buffer zone" that should be added to the 80 mile operational radius of PLMRS/CMRS systems in channels 14-20 in order to afford them the necessary protection. Clearly, from a technical point, the answer could be different in different areas due to differences in terrain. However, we also recognize that the Commission may, for administrative convenience, prefer to specify a fixed, conservative distance value or, alternatively, a table of values based on HAAT similar to those specified in Subpart L for the protection of TV broadcasting from PLMRS/CMRS systems for use in the system engineering associated with the site selection and installation of fixed access base station facilities.

79. In order to assist the Commission in developing the record on this subject, IEEE 802.22 will undertake to evaluate this subject in consultation with manufacturers of PLMRS/CMRS equipment and the National Public Safety Telecommunications Council ("NPSTC") (both Motorola, a major manufacturer of PLMRS/CMRS equipment and NPSTC have been participants in the work of IEEE 802.22).

IEEE 802.18 RECOMMENDS THAT CHANNELS 2-4 NOT BE AUTHORIZED FOR UNLICENSED OPERATIONS AT THIS TIME

80. While the IEEE 802.22 Standard will cover operation on frequencies from 54-862 MHz (to cover spectrum allocated to the TV Broadcast Service on a global basis),[10] IEEE 802 recommended in its comments on the original NPRM in

[10] Since the goal of the IEEE 802.22 Standard is global applicability, operation on channels 2-4 is included, but due to the antenna sizes at those frequencies (particularly antennas with directional gain), population density, propagation, interference potential, and other factors, it has always been envisioned that the use of channels 2-4 by IEEE 802.22 systems would likely only be practical and advantageous in the most remote and sparsely populated areas of the world where extremely large areas would need to be covered and regulators could assure that there was no over the air TV broadcasting on those channels.

November 2004 that channels 2-4 should be precluded from use in the US due to interference issues related to the large number of consumer devices (VCRs, DVD players, etc.) that use those channels for an RF interface.

81. IEEE 802.18 has no information at this time to support a change in this recommendation.

82. We do note that, with the conclusion of the DTV transition and the end of NTSC analog TV transmissions, we expect that there will be an ever increasing preponderance of DTV sets in the hands of consumers and, over time, fewer and fewer analog TV sets. Increasingly TV sets are employing non-RF interfaces such as component video and DVI. Thus, at some point in the future, the release of channels 2-4 for unlicensed use may be feasible in the US without presenting an undue risk of harmful interference (in areas where those channels are not used for over-the-air TV broadcasting).[11]

OPERATION OF FIXED ACCESS UNLICENSED DEVICES IN THE BORDER AREAS WITH CANADA AND MEXICO CAN EASILY BE CONTROLLED

83. IEEE 802.18 believes that the operation of fixed access devices in the border areas with Canada and Mexico can easily be prevented until necessary cross-border agreements are negotiated that would permit their operation in those areas.

84. Since IEEE 802.22 fixed access user terminals will, by design, not transmit without a base station to associate with, and base stations should be, per our recommendations, professionally installed at known locations and required to be registered in a database, it is simply a matter of specifying in the Commission's rules that fixed access base stations may not be located close enough to the borders to permit their coverage areas, or that of the CPEs under their control, to violate the necessary separation from the border. This restriction could be omitted if the necessary bilateral agreements are reached before the Commission promulgates its

[11] In light of the factors outlined in the footnote above, IEEE 802.18 and IEEE 802.22 do not envision channels 2-4 being used for IEEE 802.22 systems in the US. At this juncture, we can only speculate, but one potential use for these channels after the cessation of significant use of these channels for RF interfaces for consumer electronics might be for very low power in-home networks to provide a wireless interface connecting VCRs, DVD players/recorders, DTV receivers, etc. to

final rules and allows fixed access devices to be deployed, or could be dropped as soon as the necessary agreements have been executed. The fact that the IEEE 802.22 Standard will require geolocation capabilities allowing the location of each and every user terminal to be known by its associated base station can also provide an additional mechanism to prevent violation of cross-border agreements.

85. On the other hand, personal portable devices, which are by nature nomadic, could not be prevented from operating in the border areas unless they had means (for instance, using GPS) to determine autonomously their physical location and to disable automatically their ability to transmit when in a prohibited area. Given that such devices could, at least in theory, be operated indoors, the requisite geolocation capability may not be reliable – particularly in the rural environments characteristic of most of the subject border areas, where "assisted GPS" might not be available.

IEEE 802.18 BELIEVES THAT COMPREHENSIVE TESTING AND STRICT CERTIFICATION OF DEVICES IS ESSENTIAL

86. IEEE 802.22 is working, with significant participation by the incumbent licensees, to develop the necessary standards and test procedures (including those related to sensing) along with pass/fail criteria for these devices. IEEE 802.18 agrees that a comprehensive testing and certification plan is essential to assure that the Commission only authorizes devices for use in the TV bands that will truly coexist with the incumbent licensed services without causing harmful interference.

87. IEEE 802.18 recommends that the Commission include out-of-band interference testing through channel separations beyond adjacent channel. In order to perform a complete analysis of the out-of-band interference mechanisms, the testing should extend at least out to the third adjacent channel.

88. IEEE 802.18 also recommends that the Commission include testing to examine the effects of filtering and nonlinearity mechanisms in the TV receiver front ends. As an example of a means to test these mechanisms, a test should be

monitors throughout the home – but, presumably, only in areas where these channels were not used for over the air TV broadcasting.

performed using a noise-limited contour (distant) power level desired television signal on channel N, and a varying power level unlicensed device on channels N±2 to N±15. The effects of broad channel selectivity, nonlinearity, and image rejection (when applicable) could then be documented.

89. IEEE 802.18 also recommends that the Commission include testing to examine the effects of intermodulation interference mechanisms in TV receiver front ends. As an example of a means to test the intermodulation interference mechanism, a test should be performed using a noise-limited contour (distant) power level desired television signal on channel N, a strong power level (local) television signal on N+4, and a varying power level unlicensed device on channel N+2.

90. IEEE 802 had previously recommended that the Commission develop appropriate D/U ratios in interference tests while considering that they will depend on the modulation used by these devices. The set of RF parameters for these potentially interfering devices need to be determined before appropriate D/U ratios can be determined through interference tests. If the RF parameters for these devices change, the D/U ratios may also change. Nevertheless, until the modulation parameters for WRAN systems are finalized, we believe it is reasonable to utilize an ATSC DTV signal as the interferer in the above tests.[12]

91. As recently as the last session in November 2006, IEEE 802.22 agreed to a draft baseline set of RF parameters. As the development of the standard continues, the set of RF parameters will continue to be examined and possibly further modified.

SECTION 15.209 EMISSION LIMITS ARE NOT RESTRICIVE ENOUGH TO ADEQUATELY PROTECT INCUMBENT SERVICES

[12] The modulation parameters in the 802.22 WRAN standard will be similar, from the RF interference point of view, to an ATSC TV signal in so far as the spectrum occupied and relatively constant power spectral density across the 6 MHz TV channel are concerned. The co-channel D/U will tend to be closely related to the exact modulation parameters used for WRAN, but the adjacent and alternate adjacent channel D/U's will be less sensitive to the modulation parameters, since these D/U ratios are more related to filtering and intermodulation products in the RF front end of the DTV receivers.

92. IEEE 802.22 has determined through analysis that the emission limits stated in Section 15.209, namely 200 uV/m at 3 m in a 120 kHz bandwidth at UHF, are adequate for the first adjacent channel of the unlicensed device, assuming that the Commission implements in its rules our recommendation that the use of first adjacent channels not be permitted within the noise-limited protected contour. The emission limit for the second adjacent channel of the unlicensed device must be 4.8 uV/m at 3 m in a 120 kHz bandwidth at UHF to limit the DTV receiver desensitization to 1 dB at the edge of the noise-limited DTV protected contour at a distance of 10 m when no polarization discrimination is assumed between the WRAN transmit antenna and the DTV receiving antenna. This emission limit also corresponds to an adequate protection of wireless microphones[13] at a distance as small as 2.4 m from the unlicensed device.

CONCLUSION

93. We recognize that permitting operation of unlicensed devices in the TV band is a complex issue requiring carefully thought out rules to avoid interference with licensed systems. Our intention in these comments is to provide the Commission with our best analysis to date related to the operation of fixed, specifically point to multipoint, systems supporting unlicensed WRAN operations in the TV band.

94. We support the Commission's decision to develop rules permitting fixed access devices to operate in unused TV band spectrum on a non-interfering basis.

95. IEEE 802.18 recommends that the Commission remain open to the possibility of a future rulemaking which would permit the operation of personal/portable devices in the TV band while offering robust protection from harmful interference to licensed systems.

Respectfully submitted,

Michael Lynch

[13] Protection of wireless microphones corresponds to an interfering signal level securing 20 dB protection ratio for a -95 dBm received signal level.

/s/
Michael Lynch
Chair, IEEE 802.18 Radio Regulatory
TAG
2221 Lakeside Blvd.
Richardson, TX 75082
(972) 684-7518
freqmgr@ieee.org