

**From: Noise Environment Sub-Committee**

**Subject: Proposal for Noise Environment Assessment**

**Date: November 24, 1999**

## **Task Definition**

In response to FCC requests, the TAC formed three sub-committees covering various topics impacting radio spectrum policy. These topics were Software Radio, Ultra Wideband Radio and the Noise Environment.

The charter of the Noise Environment sub-committee was defined as follows.

### **Noise Environment Sub-Committee Charter**

Assess and report to the Commission the current state of knowledge on electromagnetic noise levels and the effects of such noise on the reliability of existing and future communications systems. Identify, if possible, man made causes of electromagnetic noise that have or are likely to have harmful effects on wireless communications. Identify issues or causes of man made electromagnetic noise that justify FCC attention or action. Determine what types (if any) of electromagnetic noise create significant concerns and suggest technical approaches for obtaining sufficient information on the subject.

### ***Scope***

The approach chosen to address this charter was to first define the scope of this effort. We felt that potential noise from RF communication devices (Cell phones, two-way radios, microwave equipment, etc), other types of devices (e.g. computers, cars, power lines, industrial equipment) and natural phenomena (atmospheric noise, sun spots) should be included as possible sources.

We also felt it necessary to focus any efforts that dealt with noise from RF communications devices. The FCC and industry already work closely to identify limits of emissions for services in specific bands. These efforts help ensure that different types of communications systems designed for a specific service (such as cellular) can co-exist in their defined band. The processes currently used appear to be effective within specific bands.

However, we also noted that there are many new system types that will lead to a large increase in the number of mobile devices. These systems include third generation cellular systems, WLANs, personal area networks, wireless bypass systems, wireless sensors and entertainment devices. This large number of new devices has the potential to cause a rise in the noise level over a broad range of frequencies. This noise can potentially impact communications systems in other than the assigned bands. As a result, we propose that the out of band noise from a variety of these new systems and devices be evaluated as

well as the more traditional sources. The potential future impact of these sources on communications systems should then be evaluated.

### ***Approach***

Based on the trends in new wireless devices and systems, the sub committee concluded that the noise environment may degrade significantly in the near future and therefore it warrants significant additional focus at this time. The sub committee also concluded that the FCC as trustee of the nation's spectrum resources should gather the appropriate information on the noise environment and review regulations to ensure that current communications systems are not compromised and that future communications needs can be met. The sub committee supported the FCC in this task by the development of this proposal on how the needed information could be obtained and how the analysis could be accomplished.

The proposal consists of two major parts:

1 Develop a report based on existing information in the literature and from private companies to provide a consistent and comprehensive base of knowledge on the current noise environment.

2 Develop simulation tools and models of noise sources that enable the evaluation of the future noise environment. Noise models should be developed for major current sources of noise and sources that may be significant in the future. The noise models and models of communications systems should then be incorporated into simulations that will evaluate the impact of the noise sources on communications systems.

Simulation and modeling was chosen as the method of evaluation of the noise environment since a key element of the FCC request is related to the future noise environment. Simulation is believed to be the most effective means of evaluating the future noise environment.

Direct and detailed field measurements were also considered as a method of evaluating the noise environment. However, this approach was not considered to be very efficient or very effective due to a number of factors. The first factor is that the environment can vary significantly from one location to another and from one time to another. A direct measurement approach would force the choice of a set of 'typical environments' or the establishment of a massive measurement program. Even if this approach were taken, it would be difficult to identify the impact of a specific source of noise through direct measurement. The result of direct measurement is usually a composite noise level rather than the contribution of a specific source. In many cases, the accurate measurement of noise is also very difficult due to the low signal levels being measured. With direct measurement, desired signals or large signals that are close in frequency to the noise being measured often mask the noise level. Further, direct measurements of the noise environment do not allow easy exploration of the impact of different scenarios, or possible solutions to noise problems. Simulation can eliminate many of these measurement issues and has been used extensively in industry.

The items in the charter would be specifically addressed as follows.

#### Item 1: The state of knowledge of electromagnetic noise levels

This item should be assessed through the literature search as well as through additional information that private companies, public institutions, and government agencies might have gathered through internal research. There is a large volume of information available on the noise environment, however, it needs to be evaluated and consolidated into a single, consistent source of information on the current state of knowledge of the noise environment. A consultant familiar with noise measurement and the impact of noise on communication systems may be the best way to consolidate the information. The literature search should attempt to identify specific noise sources, their frequency characteristics and their level of impact on the noise environment. Review of this material by members of the sub-committee or their appointees would ensure meaningful analysis of the gathered information.

#### Item 2: Man-made causes of noise affecting wireless communications

This item should be addressed by measurement of the major current or projected causes of man-made noise identified from the literature search and other inputs. Broadband models of the noise emitted by these sources should be developed. The level of noise as a function of distance from the source should also be determined.

#### Item 3: The effects of noise on current and future communications systems

The minimum distance (or minimum attenuation) from potential noise sources to several different types of communications systems should be determined. This information along with the noise models generated above should be used in a simulation to identify the impact of particular noise sources on the different types of communication systems. In situations where multiple noise sources need to be taken into account, a statistical analysis using Monte Carlo techniques should be done.

Future environments can be evaluated by deploying potential noise sources as they would be deployed in the future and assessing their impact through simulation.

#### Item 4: Issues and causes of interference that justify FCC attention

This item can also be assessed via modeling and simulation as discussed above. The simulations in item 3 will identify sources that can cause issues. It is also expected that inputs from manufacturers and operators of communications systems (see item1) will identify FCC regulations with the potential to cause noise issues.

New noise models should also be defined based on these FCC regulations (e.g. part 15). The impact of equipment emitting at the maximum level allowed by the regulations should be evaluated through simulation.

Item 5: Types of noise causing concern and approaches for gaining sufficient information on them

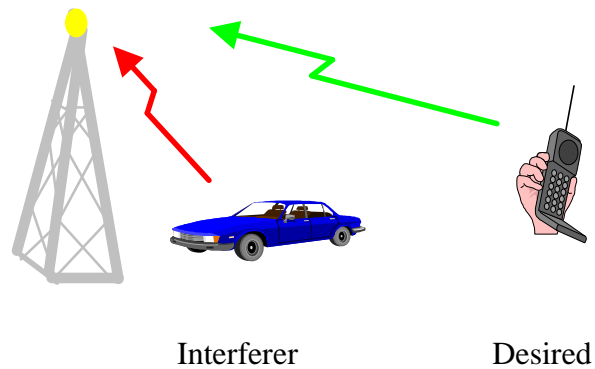
This item can be addressed through item 4 and verification of the models and simulation through measurements. Although the simulations should give representative values for the noise due to particular sources, it is desirable to verify the impact of the major sources through measurement and to provide documentation on the accuracy of the models.

### Measurement Proposal

The following is a more detailed proposal for a first phase of measurements of the noise environment and its impact of communication systems.

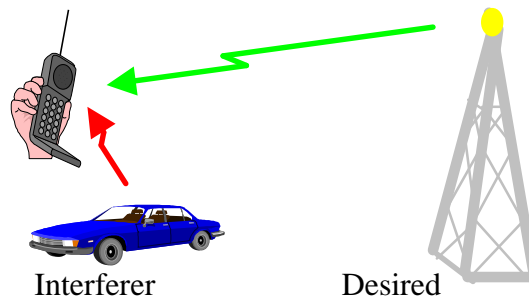
#### *Background: Evaluation of the Impact of Noise Sources*

Noise sources generally impact wireless communication systems by increasing the noise in a receiver. This reduces the range of the system. Two types of interference cases are relatively common; base station and subscriber interference. A base station case is shown below.



In this case, an interferer that is close to a base station has enough noise in the base stations receive band that it effectively increases the noise floor of the base station receiver. This reduces the ability of other subscriber units to communicate with the base station and thus reduces the range of the system. Since the base station antenna is usually mounted on a tower or building, interferers are limited in how close they can get to the antenna, so there is a significant minimum path loss.

The second type of interference is subscriber interference as shown below.



Although the mechanism for range reduction is the same (increase in the subscriber's receiver noise floor), there is a significant difference in the minimum path loss since a subscriber unit can be very close to the interferer.

Although all radio systems do not have exactly these configurations, the interference mechanism is still the loss of range due to a noise floor rise and the key parameters are the interferer's noise power spectral density and the minimum path loss.

From this analysis, two types of information are necessary: 1) the noise generated by the interferers and 2) the minimum path loss between the noise source and the receiver that is receiving the interference.

### ***Measurement Details & Analysis***

In order to adequately characterize noise sources and their impact on current and future communication systems, measurements of noise sources and communications systems will be necessary. The measurements of noise sources will be used to develop broadband noise models of the significant sources of noise. Measurements of the propagation loss as a function of the distance from a particular receiving system are also necessary. These measurements will then be combined in a simulator that calculates the noise floor rise of the receiving system as a function of the distance to the noise sources. Worst case noise floor rise (now or in the future) can be obtained by identifying and simulating worst case placements of one or more noise sources. Alternately, Monte Carlo analysis can take into account noise sources that are moving or intermittent.

The ability of FCC regulations to protect communication systems can also be evaluated. This could be done by first developing a noise model based on FCC regulations (e.g. part 15). This model together with worst case placements of the noise sources, can predict the impact of a worst case noise source on communications systems.

#### **Noise Source Measurements**

As a first step, the most significant sources of noise should be measured. We propose measuring the 4-5 most significant sources. These sources should be determined based on the results of the literature search and other inputs.

Spectral characteristics of the emission from each noise source should be captured and characterized (discrete spectra and their levels and the noise spectra shape).

Noise field strength in a 1Hz bandwidth as a function of distance from the source should be measured at bands of interest (typically from 400MHz to 60Ghz).

Units from several manufacturers should be characterized to account for manufacturer variations when possible.

#### **Communication Systems Measurements**

Various systems that might be interfered with should be measured to determine the loss

versus the distance to the noise source.

Some specific systems and frequency bands that should be considered as having potential to be interfered with are as follows.

1. Current & future cellular and land mobile systems (e.g. @ 700, 800MHz, 2 & 3.5GHz)
2. Navigational satellite systems (approximately 1600 MHz, and other known future satellite bands).
3. Fixed point to point and point to multipoint microwave systems (microwave bands including 2.5, 5.5, 30, and 60 GHz should be measured).
4. Wireless LAN -current and proposed bands

#### Analysis

Given the transmitted noise, the path loss versus distance to the noise source and the placement of specific noise sources, the maximum expected noise floor degradation for specific communication systems can be calculated. For situations where it is expected that multiple non-continuous sources could be significant, a Monte Carlo simulation of a distribution of noise sources should be done.

The noise floor impact on the above systems should also be analyzed assuming the noise sources are radiating at a level equal to the FCC limit on noise assuming a single source and also assuming a worst case distribution for multiple sources. These measurements should help assess the ability of current FCC rules to protect various types of communication systems.

#### Additional Efforts

After the initial measurements and analyses are completed, additional potential noise contributors should be measured and analyzed to capture a broader range of potential noise sources.

Field measurement of a worst case situation would be desirable to verify the accuracy of the modeling and simulation. This should be done particularly where further regulation appears to be desirable based on simulations.

The basic information and approach used in this assessment of the noise environment would also be available for analyses of other situations as other noise issues arise.