

**Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, D.C. 20554**

In the Matter of

Petition for Rulemaking of the Wireless Ethernet  
Compatibility Alliance To Permit Unlicensed  
National Information Infrastructure Devices To  
Operate in the 5.470-5.725 GHz Band

RM-10371

To: The Commission

**COMMENTS OF LINCOM WIRELESS INC.**

**INTRODUCTION**

LinCom Wireless Inc. hereby submits comments in the above captioned proceeding to encourage the Federal Communications Commission (FCC) to approve the Petition to allocate the 5.470-5.725 GHz band for use by radio local area network (RLAN) and other unlicensed service devices.

LinCom Wireless Inc. (LCW) is a fabless chipset company based in Los Angeles, CA, and is currently developing an innovative chipset for use in Wireless Local Area Network (WLAN) products. Our WLAN chipsets will be used in products such as laptop and desktop PCs, in next generation TV set top boxes and ultimately in advanced network solutions for ad hoc mesh networks. The products incorporating our chipsets will be marketed in the United States as well as Europe. In addition to our chipset design and manufacturing capabilities, LCW also provides systems engineering services to a number of telecommunications companies in the United States. Our marketing and system engineering studies have demonstrated that the 300 MHz (currently provided in the upper and lower UNI bands) of spectrum allocated in the 5GHz

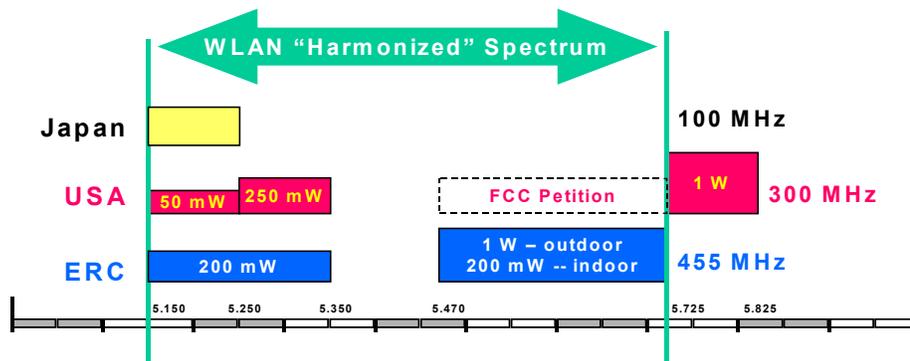
band is not adequate to meet and support WLAN users with the throughput requirements, system capacity and coverage that are predicted to occur in the forthcoming WLAN and wireless home area network (WHAN) market space.

Currently, our WLAN radio/network chipsets transport information at peak data transmission rates of 54 Mbps per channel in the 5 GHz U-NII band. However, this throughput can be significantly degraded. Section II of this document demonstrates the limitations and the problems associated with the lack of spectrum allocated to meet both the technical and product requirements.

Allocation of the additional 255 MHz of bandwidth, viz., the 5.470-5.725 MHz spectrum block, provides two needed attributes attractive from both economic and technical viewpoints. First, this additional spectrum allocation will enable the United States WLAN technologies to be marketed in Europe. This is because the same European frequency band allocation will be congruent with the frequency bands allocated in Europe for WLAN applications. Second, we shall demonstrate in Section II that the Shannon's channel capacity will approximately double the number of bits per second per Hertz (spectral efficiency) achievable when compared with that achievable with the spectral bandwidth currently allocated. In this regard, this will not only allow for the doubling of channel throughput in bits per second per Hertz but it will also enable WLAN chipsets and product sales directly to Europe, i.e., good techno-economics. Additionally, this will provide start up high tech companies, like LinCom Wireless, the ability to export its technology to the European market place thereby increasing expected revenue streams and strengthen business cases.

## DISCUSSION

This petition highly recommends that the FCC allocate the additional 5.470-5.725 GHz band for use by RLAN and other unlicensed service devices. The proposed bandwidth change together with the assigned RLAN bandwidth is illustrated in Figure 1.



**Figure 1.** Illustrating the 5 GHz ISM Band

The rest of this document provides supporting evidence for this recommendation.

### **ALLOCATING ADDITIONAL SPECTRUM IS NEEDED TO MAKE WLAN PRACTICAL**

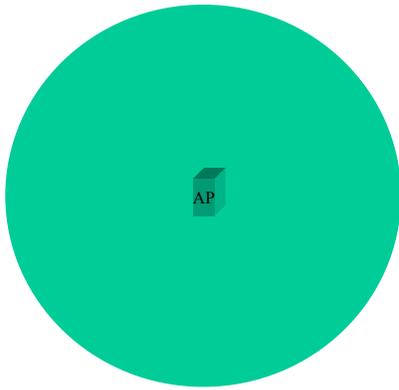
WLAN has been proven to be an essential media for broadband multimedia information transmission. The spectrum allocation, maximum output power and application that are presently assigned for WLANs are summarized in Table 1 below.

**Table 1** Current Spectrum Allocation, Power Constraints and Applications

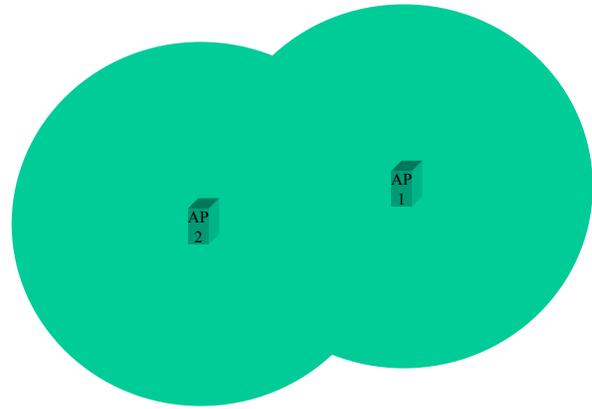
| Spectrum       | Maximum output power with up to 6 dBi antenna gain | Application       |
|----------------|--|-------------------|
| 5.150-5.250GHz | 50mW   | In-door use only  |
| 5.250-5.350GHz | 250mW  | In-door use       |
| 5.725-5.825GHz | 1W   | Out-door use only |

For outdoor applications, the output power enables WLANs to provide for larger coverage areas than achievable with the indoor power levels specified while not interfering with users attached to indoor WLAN applications. However, with the current spectrum assignment, it is best to deploy and architect a WLAN network using isolated and spatially separated access points (APs).

When a new AP is added to a network to achieve a larger communications coverage area (see Figures 2 and 3 below) by using the same frequency band, the newly deployed AP introduces mutual interference between the APs. Such interference forces one or both of these APs to reduce the user throughput thereby degrading the user Quality of Service (QoS) relative to that which can be supported by a single AP.



**Figure 2.** A single AP service coverage area supporting a maximum data transmission rate of 54Mbps for users in the green coverage area.

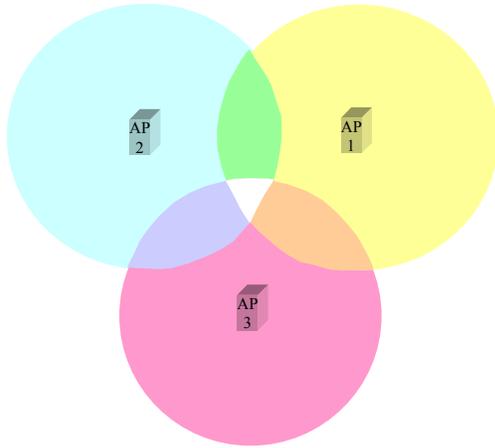


**Figure 3.** A dual AP service enhanced coverage area. Assuming the same spectrum is used, each AP data rate is less than 54Mbps

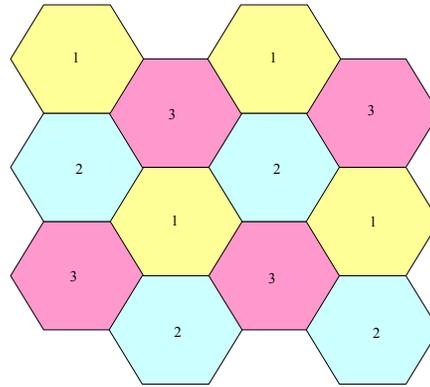
Consider further transmission from the single coverage area of Figure 2. For a single transmission channel, the data transmission rate per channel in the single coverage area is 54Mbps. When the second AP is deployed, the communications coverage area increases, see Figure 3. However, if we require a maximum throughput of 54 Mbps, one must assign the second AP another portion of the spectrum such that the mutual interference is essentially eliminated. By continuing to add APs to increase the network coverage area, one ultimately runs out of allocated spectrum. Therefore to optimize network capacity and coverage area while minimizing mutual interference to acceptable levels, one must introduce the notion of frequency reuse (spectrum re-farming). Thus limited spectrum results in reducing the maximum number of users that can operate within a given coverage area without severely degrading performance or limiting the number of network users who desire to achieve a certain QoS. From a market perspective, network operators potentially cannot make a sound business case for their products if the network capacity is not sufficient. In essence, such performance degradations are attributed

to the lack of spectrum allocation. One readily concludes that the desire to offer a maximum data rate to all users of the network results in the design requirement of breaking up the assigned spectrum into blocks and assigning a block to each AP. Such a concept implies introducing the notion of frequency reuse. This design methodology allows network operators to deploy optimized networks in support of a certain maximum number of users per coverage area. Current demographic predictions for the required number of users of WLAN networks is such that current spectrum allocations are not sufficient to support the QoS requirements when large number of expected users operate in the 5GHz band. If the bandwidth allocation is not sufficient, as is the case based upon current demographic surveys, then network performance metrics cannot be met. Assuming that the data transmission rate of 54Mbps is to be maintained in the entire coverage area, the current spectrum allocation greatly limits the maximum number of users per coverage area and hence deployment of WLANs and their applications.

Further discussion of the concept of spectrum re-farming (or frequency reuse) and spectral limitations seems of interest to further demonstrate why the maximum number of users per coverage area of a WLAN is limited by lack of spectrum for indoor deployments. Assume that each coverage cell is assigned a portion of the allocation frequency spectrum in support of its users so as to minimize the mutual interference among users while maximizing the number of users per coverage area. Figure 4 illustrates a scenario where three APs are deployed. In Figure 4, APs 1, 2, and 3 are assigned different portions of the allocated bandwidth. Such an assignment increases the size of the outdoor coverage area and the data transmission rate can be maintained at its peak value for each area. However, the maximum number of users that can be supported for the required QoS is reduced per coverage area.



**Figure 4.** An example of three AP assigned different portions of the allocated spectrum. The coverage area increases without sacrificing individual AP data transmission rate

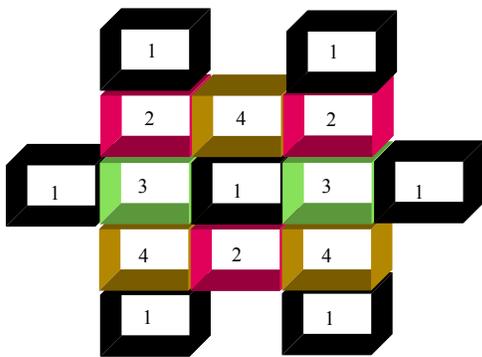


**Figure 5.** An extension of the example provided in 4. Note the same spectrum bandwidth can be reused in different locations without producing intolerable interference levels

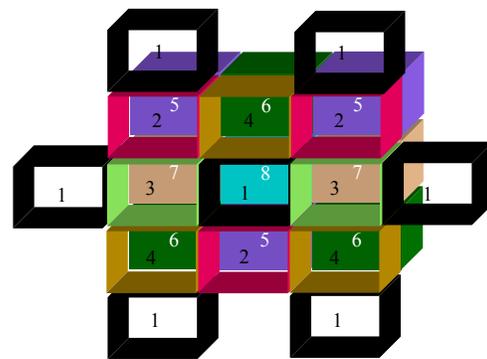
For example, as illustrated in Figure 5, the spectrum allocated has been broken into three disjointed bands and each band is assigned to each of the three coverage areas. A maximum number of users can be supported with the desired QoS in each coverage area. Since all APs are assumed to be individually owned and operated, the well-organized allocation of the coverage areas provides optimum allocation of the restricted spectrum. Figure 5 demonstrates the optimum frequency assignment scenario for the partitioning of the allocated spectrum. Any arrangement other than the best deployment scenario leads to the need for more spectrum when more users than the maximum number that can be supported for the given allocated spectrum is exceeded. Of course, one can go to higher orders of frequency reuse at the expense of smaller cell sizes and the need to deploy more APs. Obviously, there is a limit to doing this as the cost may become prohibitive from the operators profit and revenues perspectives.

Wireless APs are designed for indoor use as well as outdoor usage. For indoor use, the frequency reuse plan used for outdoor deployment may not be the same for indoor deployment of buildings having more than one floor. Thus the network deployment problem becomes three-dimensional. To illustrate this problem and the need for more spectrum for indoor deployment, consider now the following sphere packing problem. Figure 6 provides an example of a two-dimensional cell layout required for one-story buildings. For purposes of demonstrating deployment in an apartment or office building complex containing more than one floor, Figure 7 provides the deployment scenario. The numbering inside the three-dimensional cell blocks serves to characterize frequency channel assignments. For the optimum frequency reuse choice, four frequency channels are required.

In practice, it is rare to have a building with only a two dimensional (one floor) structure. Figure 7 adds another layer behind the two dimensional view of Figure 6. The background layer needs a completely different set of 4 incongruent frequency band allocations from the assigned frequency band in order to avoid direct interference to the foreground layer.



**Figure 6.** An example of indoor wireless bandwidth channel assignment for one floor buildings, i.e., two dimensional view



**Figure 7.** An example of indoor wireless bandwidth channel assignment case with three-dimensional view for two story buildings.

Figures 6 and 7 provide an example of an optimum frequency assignment for spectrum allocation. Note from Figure 7 that the minimum number of channels needed in this example is eight. This uses all of the indoor spectrum channels assigned for WLAN usage (four channels in 5.150-5.250GHz bandwidth and four channels in 5.250-5.350GHz bandwidth). For typical building floor plans, the spectrum channel assignment cannot be expected to be used as demonstrated in Figures 6 and 7; in other words, more bandwidth is needed in order to maximize the number of users per coverage cell.

In addition, in the case where deployment in Figure 7 uses a single AP, one cannot support the required number of users in any one of the coverage cells. The three-dimensional cell layout demonstrated in Figure 7 would be inadequate. Thus the conclusion from this discussion is that more spectrum bandwidth is needed from a practical WLAN deployment perspective.

### **Allocating additional spectrum bandwidth would increase the WLAN throughput**

According to Shannon's information theory, the transmission capacity  $C$  for a bandwidth limited to  $B$  Hertz is

$$C \cong B \cdot \log_2 \left( 1 + \frac{P}{N_0 B} \right) \text{ bits/sec.}$$

Here  $P$  is the received signal power,  $N_0$  is the noise and interference level. Given the new bandwidth,  $B_{new}$ , allocation of 250 MHz (which includes the 5.470-5.725 bandwidth) and the current allocated bandwidth,  $B_{exist}$  Hz, then the ratio of the new achievable transmission capacity  $C_{new}$  and the capacity  $C_{exist}$  is given by

$$\frac{C_{new}}{C_{exist}} \cong \frac{B_{new} \cdot \log_2 \left( 1 + \frac{P}{N_0 B_{new}} \right)}{B_{exist} \cdot \log_2 \left( 1 + \frac{P}{N_0 B_{exist}} \right)} \leq \frac{B_{new}}{B_{exist}}$$

Using the bandwidth data in the equation readily concludes that  $\frac{C_{new}}{C_{exist}} \leq 1.85$ . This result indicates that by allocating the new spectrum to the 5 GHz band one can support approximately twice as many users when compared with the current spectrum allocation! Again, based upon user demographics found in the need for WLANs, the number of users is expected to exceed the number that can be presently supported using the current bandwidth allocations without severely degrading user QoS.

**Allocating spectrum in the 5.470-5.725 band would allow LCW as well as all other corporations in the United States to provide products for multiple markets without modification.**

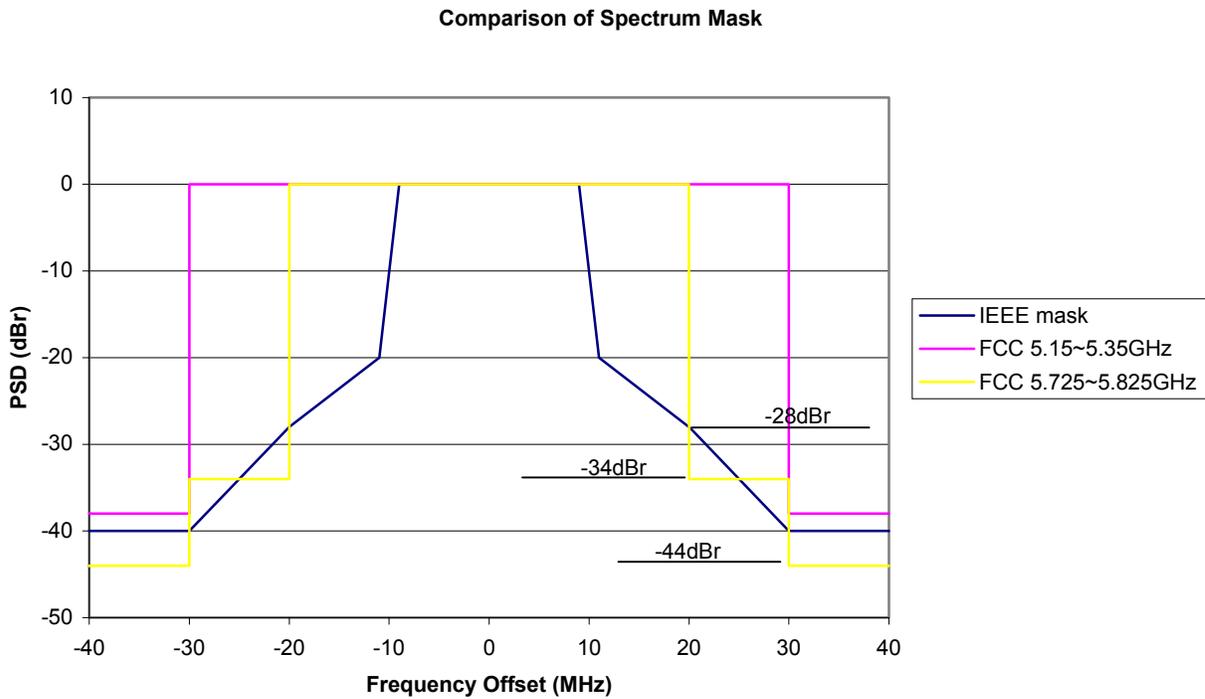
It is with no doubt that state of the art technology development in the United States is ahead of that in other countries worldwide. However, wireless WLAN products made in the United States have not shown a great advantage over similar products made in the world. According to LinCom Wireless research, one of the major reasons is due to the differences in the frequency assignments made by the United States relative to those for other countries. Once a product is out for market in the United States, it has to be modified according to the regulation and specifications required by the targeted country. The time required to modify the product to support foreign frequency band assignments usually takes a minimum of one-half to one year not to mention the costs and economics involved. This time delay represents a great disadvantage to United States vendors who wish to export WLAN product to a foreign country like Europe. It is well known that the WLAN market place is going to be highly competitive. This will provide a major deterrent for USA vendors entering the market one year later than European vendors of WLAN products. By harmonizing use of the 5.470-5.725GHz bands with the 5 GHz band

allocations in Europe one provides approximately twice the network capacity achievable relative to the current frequency assignment in the USA. Additionally, the marketplace in Europe is immediately opened up for USA providers of WLAN products. This additional bandwidth allocation would allow LinCom Wireless (as well as all of the others providing WLAN products) more immediate entry into this marketplace and allow for the opportunity to be more competitive domestically and internationally.

### **802.11a Compatible Products will not cause harmful interference**

LinCom Wireless is developing an IEEE 802.11 combo a/b chipset for use in the deployment of WLAN and WHAN products. LinCom Wireless products will be developed in accordance with the FCC regulations and IEEE standards. Figure 8 illustrates the spectral mask requirements of the FCC and the IEEE. The mask shows that the adjacent channel interference is minimized. Also, demonstrated in Figures 5, 6, and 7 is the frequency reuse plan methodology that will be used in the deployment of the WLAN. By employing frequency reuse methods, the interference to a distanced neighbor can be managed and thereby minimized. Such interference limitations will not only benefit WLAN network deployment, it will also benefit all other systems potentially sharing the spectrum bandwidth with the WLAN.

In addition, the 5.470-5.725 GHz band shall be used only for indoor applications. The building structure will shelter the majority of the emissions generated by WLAN applications.



**Figure 8.** Bandwidth Interference Masks

The current rules for the 5.25-5.35 GHz band should be extended to the 5.470-5.725 GHz band. The current regulation to the 5GHz has partitioned the allocated bandwidth into different bands and assigned different power levels for operation within these bands, see Table 1. It is therefore from an adjacent channel interference perspective to have the band segment 5.470-5.725 GHz regulated the same way as required in the 5.250-5.350 GHz band. In this way, all systems operating in this new frequency band can operate in accordance with the same specifications as those that operate in the 5.250-5.350GHz bands. The recommended harmonization of the petitioned spectrum and its relation to the other adjacent allocations are shown in Figure 1.

There are additional technical details that must be worked out. These include AP initialization and selection of the overall spectrum usage and specifications of the tolerable

interference levels between APs sharing the same spectrum. Such technical details are currently being addressed in the IEEE 802.11h working group.

## **CONCLUSION**

For reasons provided in Section II of this response, LinCom Wireless Inc. respectfully requests that the Commission grant the Petition for Rulemaking and correspondingly amend Part 15 of the rules thereby authorizing the use of the 5.470-5.725 GHz band by all U-NII devices. The proposed rules should merely extend the current rules governing operation of U-NII devices in the 5.725-5.825 GHz band to the newly authorized band.

Respectfully submitted,

LINCOM WIRELESS INC.

By: \_\_\_\_\_

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