Regulations Affecting 802.11 Deployment

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Disclaimer

I am not a lawyer. Do not use my presentation to run your life, hobby, or business. The following is my interpretation. Although I ran this by a number of telecommunications lawyers and experts in the field,[1] it doesn't mean that my advice will hold up with the Federal Communications Commission (FCC) or in a court of law. Its purpose is to alert you to issues you may need to consider for your deployment and possibly suggest some solutions. You may want to bring up these issues with your attorney or research them yourself to see how they will impact you.

I am a long-time broadcast engineer and a member of the Society of Broadcast Engineers. I am also an active member of the Bay Area Wireless Users Group (BAWUG - http://www.bawug.org), so I have one foot in the camp of "conservative old-timer" and one in "excited newcomer." With BAWUG I am promoting the use of unlicensed spectrum to create and bridge communities and also what the FCC calls "good engineering practice" in the deployment of these networks.

As regulations change, you may want to refer back to my web site (http://www.lns.com) for updates to this paper. Also, please send any comments, additions, or corrections concerning this paper to the e-mail address shown above. Thanks in advance.

Abstract and Objectives

Many companies are jumping onto the wireless bandwagon, trying to create new "first mile" infrastructure and hoping to link to customers not yet served or to bypass the current wired solutions. They see it as a quicker and possibly cheaper way of providing high-speed data to these customers.

Although these are all good ideas, most of these companies have little or no clue about the ramifications of using unlicensed spectrum. My purpose in writing this is to shed a little light on the law, policy, rules and regulations, and future developments that will impact wireless deployment.

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1 - Many thanks to Mike Newman, Dewayne Hendricks, Dane Ericksen, Jim Thompson, Phil Kane and all the others that reviewed this document!

1 - INTRODUCTION TO THE TECHNOLOGY

802.11 is a standards group under the IEEE that develops standards related to wireless and wired Ethernet transmission. This includes the actual physical layer such as 802.11a and 802.11b modulation schemes.

802.11b is a Direct Sequence Spread Spectrum technology that in the United States occupies 11 channels. These channels center on frequencies in the Industrial, Scientific, and Medical (ISM) band from 2.412 to 2.462 MHz in 5 MHz steps. The spectrum used by 802.11b is 22 MHz wide. As the channels are smaller than the occupied bandwidth, really only three channels (1, 6, and 11) can be used in a small area without running into interference.

802.11a doesn't use Direct Sequence. Instead it uses a modulation scheme called Orthogonal Frequency Division Multiplexing (OFDM). OFDM uses 52 300 KHz–wide carriers grouped into one channel 20 MHz wide. With the slower symbol speed of OFDM and the forward error correction incorporated into 802.11a, it is more resilient to multi-path and interference. However, because 802.11a is at more than double the frequency of 802.11b, it has greater free space loss. 802.11a will only have about 18% of the signal that 802.11b will have with the same gain antennas and transmitter power.

Where 802.11b occupies the portion of the ISM band at 2.4 GHz, 802.11a can occupy either the ISM band at 5.8 GHz (5.725–5.850 GHz) or a section of spectrum known as Unlicensed National Information Infrastructure (U-NII) band. This band was approved in 1997 and was promoted by the group WINForum, which was made up of individuals and companies such as Apple Computer.

The band takes up 300 MHz of spectrum and is divided into three 100 MHz sections. The first two are next to each other and the third is 375 MHz up from the top of the second band. The "low" band runs from 5.15 GHz to 5.25 GHz, the "middle" band runs from 5.25 GHz to 5.35 GHz, and the "high" band runs from 5.725 GHz to 5.825 GHz.[2, 3]

2 - REGULATIONS AND LAWS THAT WILL AFFECT DEPLOYMENT OF 802.11 WIRELESS NETWORKS

2.1 - The Civilian Spectrum Regulations

The spectrum is managed by a number of different organizations. The most visible to the general public is the Federal Communications Commission (FCC). The FCC manages "civilian" and state and local government usage of the radio spectrum. This is the regulatory organization that you will be directly affected by.

The FCC has a set of Rules and Regulations that define the use of spectrum, as well as policies and procedures for working with the FCC. You can read these in "hard copy" by ordering the "Code of Federal Regulations, Title 47" from the Government Printing Office (GPO) at:

2The FCC currently has an NPRM (RM-10371) to add 5.470 to 5.725GHz to the U-NII band.
3Notice that the ISM band actually goes another 25 MHz higher than the "high" portion of the U-NII band.

http://bookstore.gpo.gov

Companies such as Pike and Fischer (http://www.pf.com) offer subscription services to the updated FCC regulations and other policies and proposed rules. There are also free, although slightly dated, versions of the FCC rules such as the "Hypertext FCC Rules Project" run by Harold Hallikainen at:

http://www.hallikainen.com/FccRules

Harold's site actually indexes the GPO's on-line version of the rules. You can go directly to the GPO's on-line access of the rules at:

http://www.access.gpo.gov/nara/cfr/cfr-table-search.html

As the GPO's site points to all of the Code of Federal Regulations (CFR), you want the section known as "Title 47 – Telecommunications."

2.2 - Enforcement

The Commission has the authority to investigate any user of the band. In fact they can actually come on site and inspect the operation of the equipment:

> *15.29(a) Any equipment or device subject to the provisions of this part, together with any certificate, notice of registration or any technical data required to be kept on file by the operator, supplier or party responsible for compliance of the device shall be made available for inspection by a Commission representative upon reasonable request.*

The FCC currently has very limited resources for enforcement, as the trend for the last couple of decades is toward deregulating the industry and reducing the level of staffing in the enforcement bureaus. The FCC will likely only visit you if they receive a complaint. There have been rare reports of the FCC going after Wireless Internet Service Providers (WISPs) when they interfered with Part 97 (amateur radio) users. Working with the co-users of these bands is in your best interest, as they will be the ones complaining.

There is also the National Telecommunications and Information Administration (NTIA), who works with the Interdepartmental Radio Advisory Committee (IRAC) that manages federal use of the spectrum. You likely won't hear from them unless you do something really wrong.

3 - POWER LIMITS

As 802.11 is designed for short-range use, such as in offices and homes, it is limited to very low power. Ideally, a well-engineered path will have just the amount of power required to get from point "A" to point "B" with good reliability. Good engineering will limit the signal to only the area being served, which both reduces interference and provides a more efficient use of the spectrum. Using too much power would cover more area than is needed, and also has the potential to wreak havoc on other users of the band.

3.1 - 802.11b - FCC 15.247

3.1.1 - Point to Multi-point

For 802.11b point to multi-point uses, you are allowed up to 30 dBm or 1 watt of Transmitter Power Output (TPO) with a 6 dBi antenna or 36 dBm or 4 watts Effective Radiated Power over an isotropic antenna (EIRP). The TPO needs to be reduced 1 dB for every dB of antenna gain over 6 dBi.

3.1.2 – Point to Point

For 802.11b point-to-point uses, the FCC encourages directional antennas to minimize interference to other users. The FCC in fact is more lenient with point-to-point links, as it only requires the TPO to be reduced by 1/3 of a dB as compared to a full dB for point to multipoint.

More specifically, for every 3 dB of antenna gain over a 6 dBi antenna, you need to reduce the TPO 1 dB below 1 watt. For example, a 24 dBi antenna is 18 dB over a 6 dBi antenna. You would have to lower a 1 watt (30 dBm) transmitter 18/3 or 6 dB to 24 dBm or ¼ watt.

3.2 - 802.11a - FCC 15.407

3.2.1 - Point to Multi-point

As described before, the U-NII band, which is used for 802.11a point to multi-point, is chopped into three sections. The "low" band runs from 5.15 GHz to 5.25 GHz, and has a maximum power of 50 mW (TPO). This band is meant to be in-building only, as defined by the FCC's Rules and Regulations Part 15.407 (d) and (e):

> *(d) Any U-NII device that operates in the 5.15-5.25 GHz band shall use a transmitting antenna that is an integral part of the device.*
>
> *(e) Within the 5.15-5.25 GHz band, U-NII devices will be restricted to indoor operations to reduce any potential for harmful interference to co-channel MSS operations.*

The "middle" band runs from 5.25 GHz to 5.35 GHz, with a maximum power limit of 250 mW. Finally the "high" band runs from 5.725 GHz to 5.825 GHz, with a maximum transmitter power of 1 watt and antenna gain of 6 dBi or 36 dBm or 4 watts EIRP.

3.2.2 - Point to Point

As with 802.11b, the FCC does give some latitude to 802.11a point-to-point links in Regulation 15.407(a)(3). For the 5.725 GHz to 5.825 GHz band, the FCC allows a TPO of 1 watt and up to a 23 dBi gain antenna without reducing the TPO 1 dB for every 1 dB of gain over 23 dBi.

Regulation 15.247(b)(3)(ii) does allow the use of any gain antenna for point-to-point operations without reducing the TPO for the 5.725 GHz to 5.825 GHz band. You should look at the part your equipment is

certified under to see what restrictions you have for EIRP.

4 - EQUIPMENT LIMITATIONS AND CERTIFICATION

4.1 - Certification

Part 15 devices are designed to be installed and used by the general public. With this in mind, the Commission wants them to be as "idiot proof" as possible. They have severe limitations on what you can do with this gear. For instance, the Rules states:

> *15.203 - An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.*

A bit further the Rules repeats the same sentiment:

> *15.204(c) - Only the antenna with which an intentional radiator is authorized may be used with the intentional radiator.*

The basics of certification can be found in FCC 2.901 through 2.1093. The requirement for Part 15 devices can be found at 15.201.

Equipment can be certified a couple of ways, as a component or as a "system." For a component, you can have a piece of equipment known as a transmitter, an amplifier, or an antenna. All of these components can be mixed and matched with each other. If you have equipment certified as a system, it can't be used with other equipment. See 15.203 and 15.204:

> *15.204(b) - A transmission system consisting of an intentional radiator, an external radio frequency power amplifier, and an antenna, may be authorized, marketed and used under this part.* ***However, when a transmission system is authorized as a system, it must always be marketed as a complete system and must always be used in the configuration in which it was authorized. An external radio frequency power amplifier shall be marketed only in the system configuration with which the amplifier is authorized and shall not be marketed as a separate product.*** [Boldface added by author for emphasis]

In other words, you can't take an Access Point that is certified as a "system" and attach an antenna that isn't a part of the certification for the Access Point.

You can however, re-certify equipment. If you go out and purchase gear on the street, there isn't anything to stop you from reselling this gear at a profit or loss. In fact, you could re-certify this equipment too. However, there has been some discussion about whether you need approval from the manufacturer to do this. One communications law attorney I talked to said approval is not needed.

The process of certification is involved and can be costly. You should contract with one of the many

consultants in this field for guidance.

4.2 - Temporary Options to Certification

4.2.1 - Experimental Licenses (Part 5) and Special Temporary Authorities (STA) (Parts 15.7 and 5.61)

Experimental licenses are used for temporary experimentation. STAs are used to make urgent requests for use of the spectrum when you can't go through the traditional paperwork process imposed by the FCC to get your equipment license. STAs and experimental licenses can only be used for very specific purposes such as legitimate educational research. For instance, they can't be used to "determine customer acceptance of the product or marketing strategy."

STAs actually have a lower priority for interference than experimental licenses do, but since you have a Part 15 device, this doesn't matter much. The authorization conferred by STAs is also limited to 6 months, while experimental licenses can be good for up to two years.

For more information you can visit the FCC's web pages detailing STAs and experimental licenses at:

http://www.fcc.gov/oet/info/filing/elb

5 - INTERFERENCE

> *This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause **harmful interference**, and (2) this device must accept any interference received, including interference that may cause undesired operation.*
>
> [Labeling requirement in Part 15.19]

5.1 - Description

Of course, interference is the signal you're *not* interested in that is overpowering the signal you *are* interested in. The FCC has a specific definition of "harmful interference:"

> *Part 2.1(c) **Harmful interference** - Interference which endangers the functioning of a radio-navigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radio-communication service operating in accordance with these [International Radio] Regulations.*

In Part 15 it is repeated as:

> *Part 15.3(m) **Harmful interference**.*
> *Any emission, radiation or induction that endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radiocommunications service operating in accordance with this chapter.*

As there are other users of this band, interference will be a factor in your deployment. The 2.4 GHz band is a bit more congested than the 5.8 GHz band, but both have co-users that you'll need to watch out for (see Table 1).

The following subsections describe the co-users you may encounter while deploying 802.11 devices, and how you may be able to mitigate that interference for each.

Part / Use	Start Ghz	End Ghz
Part 87	0.4700	10.5000
Part 97	2.3900	2.4500
Part 15	2.4000	2.4830
FusionLighting	2.4000	2.4835
Part 18	2.4000	2.5000
Part 80	2.4000	9.6000
ISM - 802.11b/g	2.4010	2.4730
Part 74	2.4500	2.4835
Part 101	2.4500	2.5000
Part 90	2.4500	2.8350
Part 25	5.0910	5.2500
U-NII Low	5.1500	5.2500
U-NII Middle	5.2500	5.3500
Part 97	5.6500	5.9250
U-NII High	5.7250	5.8250
ISM	5.7250	5.8500
Part 18	5.7250	5.8750

Table 1 - Spectrum Allocations for 802.11 and Co-users

5.2 - Devices That Fall into Part 15 of the ISM Band (2400–2483 MHz)

These devices include unlicensed telecommunications devices such as cordless phones, home spy cameras, and Frequency Hopping (FHSS) and Direct Sequence (DSSS) Spread Spectrum LAN transceivers.

You have no priority over or parity with any of these users, and any device that falls into Part 15 must not cause harmful interference to any other licensed and legally operating Part 15 user and in fact must accept interference from all licensed and legally operating Part 15 users. A friend of mine who used to be in the enforcement division with the FCC said, "You have as much right to the band as a garage door opener does."

> *15.5(b) Operation of an intentional, unintentional, or incidental radiator is subject to the conditions that no harmful interference is caused and that interference must be accepted that may be caused by the operation of an authorized radio station, by another intentional or unintentional radiator, by industrial, scientific and medical (ISM) equipment, or by an incidental radiator.*

(Or basically everything.)

15.5(c) The operator of a radio frequency device shall be required to cease operating the device upon notification by a Commission representative that the device is causing harmful interference. Operation shall not resume until the condition causing the harmful interference has been corrected.

Operators of other licensed and non-licensed devices can inform you of interference and require that you terminate operation. This message doesn't have to come from a "commission representative."

Channel	Bottom (GHz)	Center (GHz)	Top (GHz)
1	2.4010	2.4120	2.4230
2	2.4060	2.4170	2.4280
3	2.4110	2.4220	2.4330
4	2.4160	2.4270	2.4380
5	2.4210	2.4320	2.4430
6	2.4260	2.4370	2.4480
7	2.4310	2.4420	2.4530
8	2.4360	2.4470	2.4580
9	2.4410	2.4520	2.4630
10	2.4460	2.4570	2.4680
11	2.4510	2.4620	2.4730

Table 2 - United States 802.11b Channel Allocations

Using 802.11b you can cause interference even if you are on different channels, as the channels are 22 MHz wide and are only spaced 5 MHz apart. Channels 1, 6, and 11 are the only channels that don't interfere with each other (see Table 2).

5.3 - Devices That Fall into the U-NII Band

Unlike the 2.4 GHz band, this band doesn't have overlapping channels. The lower 200 MHz of the U-NII band has eight 20 MHz wide channels. You can use any of the channels without interfering with other radios on other channels that are within "earshot."

Ideally, it would be good to know what other Part 15 users are out there. Looking into groups under the banner of "Freenetworks" is a good place to start.

5.4 - Industrial, Scientific, and Medical (ISM) - Part 18

This is also an unlicensed service. Typical ISM applications are the production of physical, biological, or chemical effects such as heating, ionization of gases, mechanical vibrations, hair removal, and acceleration of charged particles.

Users are ultrasonic devices such as jewelry cleaners and ultrasonic humidifiers, microwave ovens, medical devices such as diathermy equipment and magnetic resonance imaging (MRI) equipment, and industrial uses such as paint dryers (18.107). RF should be contained within the devices, but other users

must accept interference from these devices.

Part 18 frequencies that could affect 802.11 devices are 2.400 to 2.500 GHz and 5.725 GHz to 5.875 GHz.

As Part 18 devices are unlicensed and operators are likely clueless on the impact, it will be difficult to coordinate with them.

5.5 - Satellite Communications - Part 25

This part of the FCC's rules is used for the uplink or downlink of data, video, etc. to and from satellites in Earth orbit. One band that overlaps the U-NII band is reserved for Earth-to-space communications at 5.091–5.25 GHz. Within this spectrum, 5.091–5.150 GHz is also allocated to the fixed-satellite service (Earth-to-space) for non-geostationary satellites on a primary basis. The FCC is trying to decommission this band for "feeder" use to satellites as "after 1 January 2010, the fixed-satellite service will become secondary to the aeronautical radionavigation service." See Part 87 below.

As this use involves very narrow aperture antennas pointing into the sky at relatively high power, you will likely not interfere with them. If you are near one of these installations, there is a very slight chance they could interfere with you.

A note in Part 2.106 [S5.446] also allocates 5.150–5.216 GHz for a similar use, except for space-to-Earth communications. You have a higher chance of interfering with these installations, as Earth stations are dealing with very low signal levels from distance satellites.

5.6 - Broadcast Auxiliary - Part 74

Normally the traffic on Part 74 is from Electronic News Gathering (ENG) video links going back to studios or television transmitters. These remote vehicles such as helicopters and trucks need to be licensed. Only Part 74 eligible users such as TV stations, networks, etc. can hold these licenses (see 74.600).

Typically these transmitters are scattered all around an area, as TV remote trucks can go anywhere. This can cause interference to 802.11 gear such as access points deployed with omni-directional antennas servicing a particular area.

Also the "receive" points for ENG are often mountaintops and towers. Depending on how 802.11 transmitters are deployed at these same locations, they could cause interference to these links. Wireless providers should consider contacting a local frequency coordinator for Part 74 frequencies that would be affected. Going to the Society of Broadcast Engineers website (http://www.sbe.org) will give you a listing of coordinators for your area.

At this point, there have been reports of FHSS devices interfering with these transmissions, as the dwell time for this FHSS tends to punch holes in the video links. DHSS is less likely to cause interference to ENG users, but their links can cause problems with your 802.11 deployment.

ENG frequencies that overlap 802.11 devices are 2.450–2.467 GHz (channel A08) and 2.467–2.4835 GHz (channel A09) (see Part 74.602).

5.7 - Stations in the Maritime Services - Part 80

2.4–9.6 GHz is used for "Radiodetermination" such as RADAR. As with the other RADAR users, it is unlikely you will interfere with them. They can interfere with you.

5.8 - Aviation Services - Part 87

The frequencies used by this part are for "radio navigation stations" or RADAR. They span the frequencies from 470 MHz to 2.450 GHz to overlap the channels used by 802.11b and 2.450 to 10.500 GHz to overlap the channels used by 802.11a. It is unlikely you will ever cause any problems for them; it is far more likely they will be a nuisance to you.

5.9 - Land Mobile Radio Services - Part 90

For subpart C of this part, users can be anyone engaged in a commercial activity. They can use from 2.450–2.835 GHz, but can only license 2.450–2.483 GHz. (90.35(a)(3))

Users in subpart B would be local government. This would include organizations such as law enforcement, fire departments, etc. Some uses may be video downlinks for flying platforms such as helicopters, also known as terrestrial surveillance.

"Even if you are in the right, never argue with someone with a badge and a gun."

Even if they are not licensed, they can put you in jail for interfering with a peace officer in the performance of his or her duties.

Depending on the commercial or government agency, coordination goes through different groups such as "Association of Public Safety Communications Officials" (APCO). Consider going to their conferences. You can also try to network with engineering companies that the government has approved for frequency coordination.

5.10 - Amateur Radio - Part 97

Amateur radio frequencies that overlap 802.11b are 2.390–2.450 GHz and 5.650–5.925 GHz for 802.11a. They are primary from 2.402–2.417 GHz and secondary from 2.400–2.402 GHz. A Notice of Proposed Rule Making (NPRM) has been submitted to the FCC to change the 2.400–2.402 to primary.

Amateurs are very protective of their spectrum. The American Radio Relay League (ARRL) is a powerful lobbying force in Washington, D.C. They are very concerned about any unlicensed devices.

They think the original authorization of the FCC doesn't give it the right to hand out the spectrum in this manner. You may find that the local groups of amateurs agree and are helping with the ARRL's efforts. Getting involved with these local groups to establish a dialogue will make it easier to coordinate to minimize inference and conflicts.

5.11 - Fixed Microwave Services - Part 101

Users are known as Local Television Transmission Service (LTTS) and Private Operational Fixed Point-to-Point Microwave Service (POFS). This band is used to transport video. They are allocated from 2.450 to 2.500 GHz.

Coordination is done through engineering companies (like CSI Telecommunications) that use frequency search companies like ComSearch.

5.11 - Federal Usage (NTIA/IRAC)

The Federal government uses this band for "radiolocation" or "radionavigation." There are several warnings in the FCC's Rules and Regulations that disclose this fact.

In the case of 802.11b, a note in the Rules warns:

> *15.247(h) Spread spectrum systems are sharing these bands on a noninterference basis with systems supporting critical Government requirements that have been allocated the usage of these bands, secondary only to ISM equipment operated under the provisions of Part 18 of this chapter. Many of these Government systems are airborne radiolocation systems that emit a high EIRP which can cause interference to other users.[...]*

In the case of 802.11a, the FCC has a note in Part 15.407 stating that:

> *Commission strongly recommends that parties employing U-NII devices to provide critical communications services should determine if there are any nearby Government radar systems that could affect their operation.*

...if they will even tell you.

Coordination is just not available, as it is managed by the NTIA/IRAC. You will need to sniff around and see what the conditions are with non-802.11 devices like a spectrum analyzer.

6 - BROADBAND APPROPRIATE USE POLICIES (AUP)

If you are an individual or group that depends on cheap broadband connections, you need to consider the appropriate use policies of broadband providers.

6.1 - Cable

There are already laws on the books restricting the sharing of cable bandwidth, as the cable companies have been dealing with this since the start of the industry in the 1960's. AUPs may not need to spell out restrictions on sharing Internet access with the neighbors. Also, the cable industry specifically has 802.11 on their radar:

http://www.spectrum.ieee.org/WEBONLY/resource/apr02/webs.html

Cable providers are scared of Network Address Translation (NAT). NAT gives Internet access customers the ability to add more computers than the number of IP addresses that are given to the customer. Cable providers are proposing an alternative to NAT that will feed back to them the actual number of users behind a NAT box so that they can determine (and bill for) the customer's actual usage of their network.

6.2 - Digital Subscriber Line (DSL)

DSL providers are also getting concerned about over-subscription to their low-cost services. Bandwidth is expensive and the charge of $50 a month or so will not cover the cost of a 1.5 Mb/s DSL going flat-out 24 hours a day. There is a very good chance that broadband providers will start to charge for extra bandwidth, or they will cap the bandwidth or put time limits on usage.

Some Internet providers make no limitations and actually encourage "reselling" of the connection. Normally you will have to pay a premium for this service. Check with the provider for restrictions.

A sample of an AUP with no restrictions is as follows:

> TLGNet's TERMS AND CONDITIONS
>
> *TLGnet exercises no control whatsoever over the content of the information passing through TLGnet. You are free to communicate commercial, noncommercial, personal, questionable, obnoxious, annoying, or any other kind of information, misinformation, or disinformation through our service. You are fully responsible for the privacy of, content of, and liability for your own communications.*
>
> *TLGnet exercises no control whatsoever over the content of the information passing through TLGnet. TLGnet makes no warranties of any kind, whether expressed or implied, for the service it is providing. TLGnet also disclaims any warranty of merchantability or fitness for any particular purpose. TLGnet will not be responsible for any damages you suffer or inflict on others. This includes loss resulting from delays, non-deliveries, misdeliveries, or service interruptions caused by its own negligence or your errors or omissions. Use of any information obtained via TLGnet is at your own risk. You are responsible for determining whether or not the traffic you originate will end up being carried on another network, and for following the rules of any such networks. TLGnet specifically denies any responsibility for the accuracy or quality of information obtained through its services.*

Any access to other networks connected to TLGnet must comply with the rules appropriate with the other network. Use of TLGnet itself may be for any purpose. Use of TLGnet for commercial purposes is both permitted and encouraged.

7 - HUMAN EXPOSURE TO RADIO FREQUENCY RADIATION

I am not going to cover the pseudo-scientific arguments of human exposure to radio frequency radiation. I am only addressing the current ANSI limits on human exposure to radio frequency fields. However, keep in mind that cellular telephone companies have run into groups that are using this pseudo-science to delay or stop deployment of cell phone installations via city and county governments.

Once 802.11 deployment gets more popular, these groups may have an impact on your deployment—after all, they know what "microwave ovens can do" and 802.11b runs at the same frequency.

The FCC's concern is:

> *At the present time there is no federally-mandated radio frequency (RF) exposure standard. However, several non-government organizations, such as the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers Inc. (IEEE), and the National Council on Radiation Protection and Measurements (NCRP) have issued recommendations for human exposure to RF electromagnetic fields.*
>
> [...]
>
> *On August 1, 1996, the Commission adopted the NCRP's recommended Maximum Permissible Exposure limits for field strength and power density for the transmitters operating at frequencies of 300 KHz to 100 GHz. In addition, the Commission adopted the specific absorption rate (SAR) limits for devices operating within close proximity to the body as specified within the ANSI/IEEE C95.1-1992 guidelines.(See Report and Order, FCC 96-326) The Commission's requirements are detailed in Parts 1 and 2 of the FCC's Rules and Regulations [47 C.F.R. 1.1307(b), 1.1310, 2.1091, 2.1093].*
>
> - From http://www.fcc.gov/oet/rfsafety

This breaks down to exposure limits for workers around the RF equipment and for the general public. At 2.45 GHz, the exposure limit is 4.08 mW/cm^2 for an unlimited time for workers and 1.63 mW/cm^2 for 30 minutes for the general public. As this is energy absorbed over time, you can raise or lower the mW/cm^2 for a controlled situation like workers by decreasing or increasing the time exposed. As this would be hard to regulate for the general public, you shouldn't apply this "time vs. exposure" calculation for the public.

The Office of Engineering and Technology (OET) Bulletin number 65 (August 1997) "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields" at:

http://www.fcc.gov/oet/info/documents/bulletins/#65

shows how to calculate these fields.

As an example, a near-field calculation of a 2 foot aperture dish (24 dBi) with ¼ watt of power applied (maximum EIRP for point-to-point) has almost a 1 foot area in front of the dish that would be

considered "controlled" and 2 feet in front of the dish with limited exposure for the general public.

To take these concerns into account, just place your dishes out of the way, say above "head height."

The FCC has a page that covers many of these issues at:

http://www.fcc.gov/oet/rfsafety

The FCC also has a page with the FDA on "Cell Phone Facts." The site is designed for the "end-user" of such equipment. It tried to demystify some of the concerns many have about RF exposure. You will find the site at:

http://www.fda.gov/cellphones/

8 - LAWS ON ANTENNAS AND TOWERS

8.1 - FCC Preemption of Local Law

In installing antennas for clients, you may run into local ordinances and homeowner agreements that would prevent installations. Thanks to the kind folks such as those at the Satellite Broadcasting and Communications Association (SBCA) who lobbied the FCC, the FCC has stepped in and overruled these ordinances and agreements.

For a good introduction to this topic, please read Roy Trumbell's paper at:

http://www.lns.com/sbe/antenna_mounts.html

This rule should only apply to broadcast signals such as TV, DBS, or MMDS. The provision for MMDS could arguably cover wireless data deployment, as...

> *1.4000 Restrictions impairing reception of television broadcast signals, direct broadcast satellite services, or multichannel multipoint distribution services:*
>
> *1.4000(a)(1)(i) An antenna that is:*
>
> *(A) Used to receive direct broadcast satellite service, including direct-to-home satellite service, or to receive or transmit fixed wireless signals via satellite, and*
>
> *(B) One meter or less in diameter or is located in Alaska;*
>
> *[...]*
>
> *1.4000(a)(2) For purposes of this section, "fixed wireless signals" means any commercial non-broadcast communications signals transmitted via wireless technology to and/or from a fixed customer location. Fixed wireless signals do not include, among other things, AM radio, FM radio, amateur (HAM) radio, Citizen's Band (CB) radio, and Digital Audio Radio Service (DARS) signals.*

There are conditions:

1.400(c) In the case of an antenna that is used to transmit fixed wireless signals, the provisions of this section shall apply only if a label is affixed to the antenna that:

(1) Provides adequate notice regarding potential radiofrequency safety hazards, e.g., information regarding the safe minimum separation distance required between users and transceiver antennas; and

(2) References the applicable FCC-adopted limits for radiofrequency exposure specified in 1.1310 of this chapter.

Issues such as "can traffic such as Multicast IP fall into these rules" and "what percentage of traffic must be broadcast" need to be resolved before you can use this section of the FCC rules.

8.2 - Height Limitations

8.2.1 - Local Ordinances

Most if not all cities regulate the construction of towers. There will be maximum height (e.g., 300 feet in Oakland, or 10 feet for a mast on a residence in Fremont), zoning of the antenna or tower (residential or commercial), construction (no antennas 15 feet above the tower in Oakland or a 300-foot setback in Fremont) and aesthetic (e.g., what color, how hidden) regulations. Depending on these factors, you will have to jump over various hurdles with each city and installation.

8.2.2 - FAA and the FCC Tower Registration

For obvious reasons, the FAA is very concerned about things that airplanes might bump into. Part 17.7(a) of the FCC R&R describes:

"*Any construction or alteration of more than 60.96 meters (200 feet) in height above ground level at its site."*

The next sections go into detail of what towers need marking if they are in a glide slope of a runway and have any "*extraordinary hazard potentials"*.

Details can also be found in the U.S. Department of Transportation Advisory Circular AC70/7460-1K.

If your tower falls into this category, then it is necessary to register it with the FCC as per Part 17.4.

9 - THE FUTURE - GOOD NEWS / BAD NEWS

What can we look forward to, and what do we need to be on the lookout for?

9.1 - The Good News: New Standards to Help

Standards are being developed to help the current and upcoming protocols coexist.

9.1.1 - 802.11h

This IEEE group (802.11h) is developing transmission power control (TPC) and dynamic frequency selection (DFS) protocols. These protocols will use the band more efficiently and be required for European deployment.

The standard is expected to be available the second half of this year, with equipment on the street in 2003. Already Atheros Communications, Inc. is starting to ship 802.11a chipsets with these features.

9.1.2 - 802.15 - WPAN (a.k.a. Bluetooth) TG2

This IEEE task group (802.15) is developing a set of "Coexistence Mechanisms" to facilitate the coexistence of WLAN and WPAN devices with methods like "Data Rate Scaling".

9.1.3 - 802.16.2

The subgroup of "Working Group on Broadband Wireless Access Standards" for Metropolitan Area Networks (MANs) is called "Coexistence of Fixed Broadband Wireless Access Systems". This group is researching what it takes to deploy a MAN and to solve interference issues.

9.2 - The Bad News

9.2.1 - RF [Radio Frequency] Lighting

RF lighting is a new industrial lighting technology made by Fusion Lighting Inc. -

http://www.fusionlighting.com

This excited sodium lamp uses RF energy from 2.4–2.4835 GHz. It has a broader and more contiguous spectrum than mercury vapor. It is also four times more efficient.

ISM users are concerned that it may add considerable noise to the 2.4 GHz band. Short- and long-range 802.11b could be crippled, as it operates right in the middle of the lamp's spectrum.

9.2.2 - Sirius' Application for an NPRM for Power Restrictions

Sirius uses 2.32–2.345 GHz and is interested in limiting signals in this band to 8.6 μV per meter at 3 meters. This may require filtering for cards that use the lower end of the 802.11b channels. Therefore, it could limit the use of the lower 802.11b channels.

[UPDATE: Rumor has it that this petition was withdrawn by Sirius. This may not be an issue. More to come... - Tim June 6th 2002]

9.2.3 - Will Other Folks Try to Shut Down 802.11 or Accept It?

The ARRL is very active in commenting on proposed rules that would give more spectrum to unlicensed users. They are particularly concerned about spectrum that is currently used by amateurs. Some insight can be gained at the ARRL's page on Part 15 devices at:

http://www.arrl.org/tis/info/part15.html

The NTIA/IRAC is also concerned about this spectrum, as they also use it. However, their exact use may be "secret," as it isn't really defined anymore than "radionavigation" (read: RADAR). They are also very concerned about future Ultra-Wide Band developments and have sent out a number of "hand slaps" to the FCC for their recent rule making on UWB. They probably see the ISM and U-NII bands for what they are, and have given up on this spectrum and moved any low EIRP communications from it.

In addition, license holders of 3G may be actively working against 802.11 use, as they can see it as very cheap competition to the very expensive 3G spectrum and deployment. We haven't seen anything definitive from them, but it is worth watching.

10 - WHAT CAN YOU DO?

If any group or individual wants to shut down long distance 802.11 use, they could do it via the FCC's Rules and Regulations, by creating new rules or encouraging the FCC to enforce the current rules on owner restrictions and equipment certification requirements. If you are concerned about this you should be subscribing to the emailed "daily reports" from the FCC at:

http://www.fcc.gov/Daily_Releases/Daily_Digest

You will also need to know how to comment on Notices of Inquiry (NOI) or proposed rules such as Notices of Proposed Rule Making. The FCC will have public comment periods on both of these. It is up to you to find out about ones that will impact you and submit a good argument why you want or don't want the NPRM to become a new rule. A good page that covers NOIs and NPRMs and the process of commenting to the FCC can be found in the "**How Do I...**" section at the FCC's site at:

http://wireless.fcc.gov/csinfo

11 - CONCLUSIONS

- Building a business on Part 15 spectrum has risks, as you have no priority over anyone else.
- Coordination with other users (i.e., Parts 15, 74, 90, and 101) can extend the life of a network.
- A properly engineered and designed network will be useful longer than one that isn't properly designed, but it still may have a limited lifetime, as noise or interference from other users will increase.
- Other forces may be trying to shut down this option via changes in the FCC Rules and Regulations. A coordinated effort to track and respond to rules that would be detrimental to Part 15 users is needed. This could be done, for example, by WISP organizations or by the loosely coordinated networks of Freenetworks.org.