UNITED STATES DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Washington, D.C. 20230

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Richard Smith, Chief
Office of Engineering and Technology
Federal Communications Commission
2000 M Street, N.W., Suite 480
Washington, D.C. 20554

Re: Petitions for Reconsideration to Amend the Commission's Rules to Provide for Operation of Unlicensed NII Devices in the 5 GHz Frequency Range, Report and Order (ET Docket No. 96-102)

Dear Mr. Smith:

This letter regards petitions for reconsideration filed March 3, 1997 by the Wireless Information Networks Forum (WINForum), Apple Computer Inc., and Hewlett Packard to amend the Commission's Rules to Provide for Operation of Unlicensed NII (U-NII) devices in the 5 GHz Frequency Range.[1] This Report and Order permits U-NII devices to operate in three 100 MHz sub-bands subject to different operational and power restrictions. The three sub-bands -- 5150-5250 MHz, 5250-5350 MHz, and 5725-5825 MHz -- are currently allocated on a primary basis for Federal aeronautical radionavigation and radiolocation services. As the agency responsible for Federal radio spectrum management, the National Telecommunications and Information Administration (NTIA), in coordination with the Interdepartment Radio Advisory Committee (IRAC), has reviewed the petitions to determine the impact the requested modifications would have on Federal spectrum operations.

In most cases, the requested modifications will not have an impact on current or future Federal operations in the 5 GHz frequency band. Several proposed modifications may impact Federal spectrum operations, however, and NTIA urges the Commission to deny these requests. NTIA is particularly concerned about proposals to relax the restricted band general limits in the 4500-5150 MHz and 5350-5460 MHz bands, increase by 3 dB the power spectral density limits, use high gain antennas in the 5250-5350 MHz band, and implement impulse (ultra-wideband) systems in the bands designated for U-NII devices. In each of these areas, NTIA urges the Commission to retain the rules it established in the Report and Order without modification. Denying these modifications will not hinder the development of the U-NII devices, yet is essential to protect current and future Federal operations in and adjacent to the bands designat for U-NII device operations.

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[1] See Amendment of the Commission's Rules to Provide for Operation of Unlicensed NII Devic GHz Frequency Range, Report and Order, ET Docket No. 96-102, 12 FCC Rcd 1576 (1997).

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In addition, NTIA supports proposed modifications to the U-NII Order that would permit directional gain antennas for U-NII devices operating in the 5725-5825 MHz band.[2] These modifications will allow longer-distance unlicensed "community networking" uses and thus will help promote the Administration's goal of connecting all the nation's classrooms, libraries, hospitals, and clinics to the National Information Infrastructure by the year 2000.

Furthermore, NTIA continues to strongly recommend, as we did in reply comments submitted earlier in this proceeding,[3] that the Commission make efforts to discourage operation of U-NII devices near military bases and test ranges where high-powered Federal radar systems could be operating. U-NII devices are likely to experience interference from Federal radar systems in these areas.

The enclosed analysis addresses each of the requested modifications to the U-NII Order and discusses the potential impact of the requests on current and future Federal operations. NTIA believes U-NII devices and Federal radio spectrum operations can successfully co-exist if the Commission takes into consideration the concerns described in this analysis. NTIA therefore urges the Commission to adopt the recommendations discussed in the analysis. Thank you for your consideration of these views.

Sincerely,

Richard D. Parlow
Associate Administrator
Office of Spectrum Management

Enclosure

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[2] NTIA notes that the Commission has already decided to allow unlicensed spread spectrum devices to operate in this band. See Amendment of Parts 2 and 15 of the Commission's Rules Regarding Spread Spectrum Transmitters, Report and Order, ET Docket No. 96-8 (1997).

[3] Reply Comments of NTIA filed in response to the Amendment of the Commission's Rules to Provide for Unlicensed NII/SUPERNet Operations in the 5 GHz Frequency Range, Notice of Proposed Rule Making, ET Docket No. 96-102, 11 FCC Rcd 7205 (1996).

ATTACHMENT A

ANALYSIS OF THE IMPACT TO AERONAUTICAL RADIONAVIGATION SYSTEMS FROM THE OUT-OF-BAND EMISSIONS OF U-NII DEVICES

INTRODUCTION

The 5000-5250 MHz and 5350-5460 MHz bands are allocated to the Federal aeronautical radionavigation service on a primary basis. The FAA's Microwave Landing System (MLS) has a frequency allocation in the 5031-5150 MHz band, where 5031-5091 MHz is currently used for existing MLS channel assignments, and 5091-5150 MHz has been designated by the International Civil Aviation Organization (ICAO) for future MLS expansion channels. Besides MLS, other FAA systems of concern include radars and data links which may need to employ spectrum in the 5000-5250 MHz band at some point in the future. One radar system that is currently in the planning stages at the FAA is the Terminal Area Surveillance System (TASS). Early expectations for TASS show a need for large amounts of spectrum in the 5000-5250 MHz band. Another existing radar system that may need to migrate to the 5000-5250 MHz band because of spectrum congestion in the 5600-5650 MHz band is the Terminal Doppler Weather Radar (TDWR). FAA Data Link applications that could use the 5000-5250 MHz band include: Aeronautical Data Link (ADL), Automatic Dependent Surveillance-Broadcast (ADS-B), and Local Area Differential Global Navigation Satellite System (LADGNSS). In addition to these systems the 5350-5470 MHz band is intended to be used by Airborne Weather Radars for weather detection and forward looking wind shear detection[1], however, this band could also be used to satisfy currently defined aeronautical datalink requirements.

On January 6, 1997 the Commission released a Report and Order (R&O) specifying the rules for the Unlicensed National Information Infrastructure (U-NII) devices. As specified in the R&O the U-NII devices are permitted to operate in three bands subject to different transmit power and operational restrictions. The three U-NII bands are: 5150-5250 MHz, 5250-5350 MHz, and 5725-5825 MHz bands. The R&O also specifies the out-of-band emission levels for the U-NII devices. The 5150-5250 MHz and 5250-5350 MHz bands are adjacent to two bands that are on the Part 15 restricted bands list §15.205, namely the 4500-5150 MHz and 5350-5460 MHz bands. Unlicensed devices that operate in the restricted bands must comply with the general limits specified in §15.209 which would supersede the out-of-band emission limits specified in the R&O.

On March 3, 1997 WINForum filed a Petition of Reconsideration, requesting that the Commission modify the out-of-band emission limits for the U-NII devices.[2] Table 1 and Table 2 compare the out-of-band emission limits proposed by WINForum and those specified in the general limits of §15.209 for the 5150-5250 MHz and 5250-5350 MHz bands. As can be seen, there is a significant difference between the values proposed by WINForum and those specified in the general limits.

TABLE 1. Comparison of the Out-of-Band Emission Limits for U-NII Devices Operating in the 5150-5250 MHz Band

Frequency Offset	Out-of-Band Emission Limits Proposed by WINForum*	Out-of-Band Emission Limits Specified in §15.209
5140-5150 MHz and 5350-5360 MHz	-10 dBm	-41 dBm[h]
5130-5140 MHz and 5360-5370 MHz	-20 dBm	-41 dBm
* All emissions below 5130 MHz and above 5370 MHz must comply with the general limits of §15.209		

TABLE 2. Comparison of the Out-of-Band Emission Limits for U-NII Devices Operating in the 5250-5350 MHz Band

Frequency Offset	Out-of-Band Emission Limits Proposed by WINForum*	Out-of-Band Emission Limits Specified in §15.209
from the band edge to 10 MHz outside the band edge	-10 dBm	-41 dBm
from 10 MHz outside the band edge to 20 MHz outside the band edge	-20 dBm	-41 dBm
* All emissions below 5230 MHz and above 5370 MHz must comply with the general limits of §15.209		

The MLS, ADL, ADS-B, and the LADGNSS are felt to be more susceptible to interference from U-NII out-of-band emissions. Therefore, this analysis will examine the impact to these systems from the out-of-band emissions of U-NII devices using the limits proposed by WINForum.

[h] In the bands 4500-5150 MHz and 5350-5470 MHz the general emission limits are specified in §15.209 as limited to 500 μV/m @ 3 meters. This results in an EIRP = -104.8 + E_o (dBμV/m) + 20 log D_o = -41.4 dBm.

MICROWAVE LANDING SYSTEM (MLS)

The MLS provides precision approach and landing guidance for all types of aircraft during weather conditions of reduced ceiling and visibility. The MLS has been adopted by ICAO as the precision guidance standard to replace the Instrument Landing System (ILS) to meet evolving aviation user needs and to address specific operational and technical requirements.

The MLS is a Time-Reference Scanning Beam (TRSB) system which allows airborne stations to determine bearing and elevation angle relative to a ground transmitter. This is done by measuring the time duration between pulses of energy associated with the sweep of a high gain, electronically-scanned antenna beam across the host aircraft. Digital preambles are used to differentiate between azimuth and elevation scans, as well as other auxiliary functions of MLS.

Susceptibility of MLS Aircraft Receivers to Interference

The MLS outputs of concern are angle guidance (azimuth and elevation) and data. The criteria for acceptable performance must ensure the integrity of the following:

Guidance accuracy
Data accuracy
Receiver acquisition time
Receiver loss-of-lock

Interference arising from both within and outside the 5031-5091 MHz and 5091-5150 MHz bands are of interest.

For in-band interference (within ± 1.2 MHz of the desired MLS signal), the ICAO All Weather Operations Panel (AWOP), at its 15th annual meeting (AWOP/15), reaffirmed that MLS receivers should meet their performance requirements when interference from an undesired signal is received at a level not exceeding -124.5 dBW/m^2 at the MLS receiver antenna. This power density is equivalent to an allowable interference power level of -130 dBm (-160 dBW), referenced to the antenna port.[3] The interference criteria for MLS is a fixed signal criteria, which means that the criteria is the same for all distances along the aircraft glide slope.

Aggregate Effects of U-NII Device Out-of Band Emissions on MLS Receiver Performance

The aggregate interference power level from U-NII out-of-band emissions at the input of the MLS airborne receiver is determined from the following equation:

$$I = P_{agg} + 10 \log(D) - L_B + 10 \log(BW_{MLS}/BW_{NII}) \qquad (1)$$

where

I is the interference power level from U-NII out-of-band emissions at the input of the MLS

airborne receiver (dBm);
P_{agg} is the aggregate U-NII out-of-band emission power (dBm);
D is the average transmit duty cycle of a U-NII device;
L_B is the mean building attenuation losses (dB);
BW_{MLS} is the MLS receiver bandwidth (Hz);
BW_{NII} is the U-NII emission bandwidth (Hz);

The MLS and U-NII nominal technical characteristics used in the analysis are given in Tables 3 and 4 respectively.

TABLE 3. Nominal Technical Characteristics for MLS[4]

PARAMETER	NOMINAL VALUE
Frequency	5031-5091 MHz 5091-5150 MHz
Receiver Bandwidth	150 kHz
Antenna Gain	6 dBi
Frequency Selectivity	> 40 dB
Data Service Availability	0.99999

TABLE 4. Nominal Technical Characteristics of U-NII Devices Operating in the 5150-5250 MHz and 5250-5350 MHz Band

PARAMETER	NOMINAL VALUE
Frequency	5150-5250 MHz 5250-5350 MHz
EIRP	200 mW (5150-5250 MHz) 1 W (5250-5350 MHz)
Bandwidth	20 MHz
Attenuation of Out-of-Band Emissions	See Tables 1 and 2
Mean Building Attenuation	17 dB (airborne systems) 10 dB (ground-based systems)
Average Transmit Duty Cycle	50%
Mean Density of U-NII Devices	32 devices/km^2

The High Performance Radio Local Area Networks (HIPERLANs) mean density over Europe is estimated to be 32 devices/km^2. It is expected that the density in a metropolitan and densely inhabited area will be higher than the mean.[5]

NTIA has developed a program to estimate the power-sum aggregation into an aircraft receiver.[6] The program computes the power-sum aggregate interference at an airborne receiver by modeling the emitter distribution and integrating their collective effect under free-space propagation conditions. The user specifies the aircraft altitude, the emitter density, the emission level, and the emission frequency. Using these values, the program determines the number of emitters in the field-of-view of the aircraft and computes the aggregate power-sum into the aircraft receiver. The aircraft altitude used in the aggregate analysis is 100 feet, which represents the decision height for Category II precision landings.

To determine the impact to a MLS receiver resulting from the aggregate out-of-band emissions of U-NII devices, the analysis will consider the effects of both in-band aggregate spurious emissions and adjacent channel aggregate interference from the U-NII devices. For the aggregate in-band spurious emissions the out-of-band emission levels for the U-NII devices given in Table 4 will be used. For adjacent channel aggregate interference the MLS receiver off-frequency rejection of 40 dB will be used. The results of the aggregate interference analysis are presented in Table 5.

TABLE 5. Aggregate Interference Levels at the Input of a MLS Receiver from Adjacent Band U-NII Devices

	Aggregate Interference Level	**MLS Interference Threshold**	**Margin**
In-Band Spurious Emission (5140-5150 MHz Band)	-112 dBm	-130 dBm	-18 dB
In-Band Spurious Emission (5130-5140 MHz Band)	-122 dBm	-130 dBm	-8 dB
Adjacent Channel	-124 dBm	-130 dBm	-6 dB

As shown in Table 5, the levels of aggregate interference from adjacent band U-NII devices with the out-of-band emission limits proposed by WINForum exceed the MLS interference threshold by as much as 18 dB. This analysis assumes that all the U-NII devices are located indoors; however, if devices are employed outdoors (e.g., Ad-hoc configuration[i]), the aggregate interference levels computed will be higher.

[i] An Ad-hoc configuration is where two or more computers are exchanging information (e.g., files) with each other, without the use of a fixed base station (access point).

C-BAND DATA LINK

The aviation community has been investigating developing viable data links for high integrity precision approach and flight management operations. Figure 1 illustrates the typical architecture of the Local Area Differential Global Navigation Satellite System (LADGNSS) for precision approach operations. Three primary frequency bands have been proposed to the ICAO Global Navigation Satellite Systems Panel (GNSSP) for the local DGPS data link: VHF, L-Band, and C-Band. Some studies have shown that because of the inherent propagation characteristics the only viable approach capable of achieving the stringent requirements demanded by these operations appears to be a C-Band data link.

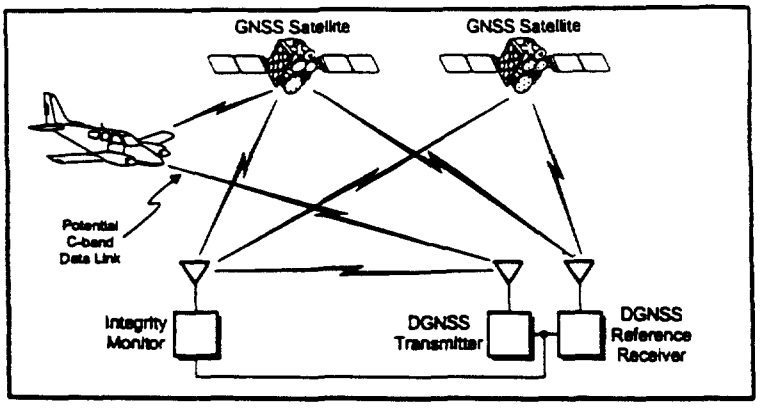

Figure 1 LADGNSS Architecture

The data links to support flight management would be used to transmit dynamic aircraft position information and include the Aeronautical Data Link (ADL) and Automatic Dependent Surveillance-Broadcast (ADS-B). For ADL and ADS-B, the data would be computed by an aircraft's navigation or flight management system and provided by the data link to service ground stations, and then to an aircraft control terminal. The data link would also support the dissemination of weather, Air Traffic Control (ATC), flight planning and maintenance, and operations information. The data link would be used to respond to a pilot's request for information by retrieving the data from embedded databases, reformatting the information, and sending it to the requesting aircraft. Unlike the ground station for the precision approach landings, which would be located at the airport terminal area, the ground stations for the flight management data links must be across the U.S. to provide continuing aircraft communications for en-route flights.

The term "C-Band Data Link" will be used to represent the LADGNSS, ADL, and ADS-B systems in this analysis. There are two components of the C-Band Data Link: the airborne segment

and the ground segment. The ground segment of the C-Band Data Link can be located at the airport terminal area for approach/landings, or anywhere throughout the country to provide location information for flight management of en-route aircraft. Nominal technical characteristics of the C-Band Data Link are provided in Table 6.[7]

TABLE 6. Nominal Technical Characteristics of the C-Band Data Link[j]

PARAMETER	NOMINAL VALUE
Frequency Band	5090-5150 MHz
Data Rate	800 kbps
Maximum Range	20 nmi
Receiver Bandwidth	1 MHz
Receiver Noise Figure	3 dB
Antenna Gain	Airborne Segment: 0 dBi Ground Segment: 6 dBi
Data Service Availability	0.99999

Of particular concern for the precision approach/landings and flight management data links is their susceptibility to out-of-band emissions of U-NII devices operating in the 5150-5250 MHz band.[k] Potential interference from U-NII devices may occur in both the ground-to-air (airborne segment) and air-to-ground (ground segment) links.

Susceptibility of C-Band Data Link Receivers to Interference

The C-Band Data Link receiver noise power is calculated using the following equation:

$$N = -114 + 10\,\mathrm{Log}(BW) + NF \qquad (2)$$

where

N is the C-Band Data Link receiver noise power (dBm);
BW is the C-Band Data Link receiver bandwidth (MHz);
NF is the C-Band Data Link receiver noise figure (dB)

Using the receiver bandwidth and noise figure given in Table 6, a receiver noise power for the

[j] The values of antenna gain and receiver noise figure are assumed for this analysis.

[k] Data links that updating flight information every few seconds will not have the same redundancy that an air traffic control radar would have.

C-Band Data Link of -111 dBm was computed. The interference protection criteria for the C-Band Data Link is defined as 10 dB below the receiver noise level and thus is set at -121 dBm.

Aggregate Effects of U-NII Out-of-Band Emissions on C-Band Data Link (Airborne Segment) Receiver Performance

The aggregate interference power level from U-NII out-of-band emissions at the input of the C-Band Data Link airborne receiver is determined from the following equation:

$$I = P_{agg} + 10 \log(D) - L_B + 10 \log(BW_{DL}/BW_{NII}) \quad (3)$$

where

I is the interference power level from U-NII out-of-band emissions at the input of the C-Band Data Link airborne segment receiver (dBm);
P_{agg} is the aggregate U-NII out-of-band emission power (dBm);
D is the average transmit duty cycle of a U-NII device;
L_B is the mean building attenuation losses (dB);
BW_{DL} is the C-Band Data Link receiver bandwidth (Hz);
BW_{NII} is the U-NII emission bandwidth (Hz).

The aircraft altitude used in the aggregate interference analysis is 1000 feet. The U-NII and C-Band Data Link characteristics used in the analysis are given in Tables 4 and 6. The results of the aggregate interference analysis are given in Table 7.

TABLE 7. Aggregate Interference Levels at the Input of a C-Band Data Link Receiver (Airborne Segment) from Adjacent Band U-NII Device Emissions

	Aggregate Interference Level	**C-Band Data Link Interference Threshold**	**Margin**
In-Band Spurious Emission (5140-5150 MHz Band)	-113 dBm	-121 dBm	-8 dB
In-Band Spurious Emission (5130-5140 MHz Band)	-123 dBm	-121 dBm	2 dB

As shown in Table 7, the levels of aggregate interference from adjacent band U-NII devices with the out-of-band emission limits proposed by WINForum exceed the specified C-Band Data Link interference threshold in the 5140-5150 MHz band segment. Three of the variables used to compute the aggregate interference levels are represented by average values: building attenuation, transmit duty cycle, and device density. If the difference between the mean value of these variables and the 0.99999 value is 2 dB then an interference situation would also exist in the 5130-5140 MHz

band segment.[1] This analysis assumes that all the U-NII devices are located indoors, however, if devices are employed outdoors (e.g., Ad-hoc configurations) the aggregate interference levels computed will be higher.

Aggregate Effects of U-NII Out-of Band Emissions on C-Band Data Link (Ground Segment) Receiver Performance

As stated earlier, there are two configurations for the ground segment of the C-Band Data Link: (1) located at an airport for approach/landings and (2) located anywhere throughout the U.S. for flight management. For the ground segment of the C-Band Data Link located at an airport there is some control of how close U-NII devices can be. In this analysis it is assumed that the closest a U-NII devices can be to a C-Band Data Link ground segment receiver located at an airport is 1 km. However, for the ground segments of the C-Band Data Link that can be located anywhere throughout the country U-NII devices can be located as close as 100 meters. In this analysis it is assumed that the closest a U-NII device can be to a ground segment C-Band Data Link used for flight management is 100 m.

NTIA has developed a computer program to estimate the power-sum aggregation at a terrestrial receiver from a distribution of terrestrial transmitters.[8] Using this capability the power-sum aggregate out-of-band emission level of U-NII devices at the ground segment of C-Band Data Link was computed. The aggregate interference power level from U-NII out-of-band emissions at the input of the C-Band Data Link ground segment receiver is determined from Equation 3. The results of the aggregate interference analysis are given in Table 8.

As shown in Table 8, the levels of aggregate interference from adjacent band U-NII devices with the out-of-band emission limits proposed by WINForum exceed the specified C-Band Data Link interference threshold by as much as 19 dB. This analysis assumes that all the U-NII devices are located indoors; however, if devices are employed outdoors (e.g., Ad-hoc configuration) the aggregate interference levels computed will be higher.

[1] The standard of deviation for many of the building penetration loss measurements reviewed for this analysis was found to be 6 dB.

TABLE 8. Aggregate Interference Levels at the Input of a C-Band Data Link Receiver (Ground Segment) from Adjacent Band U-NII Device Emissions

	Aggregate Interference Level	C-Band Data Link Interference Threshold	Margin
Ground Segment (Approach/Landings)			
In-Band Spurious Emission (5140-5150 MHz Band)	-105 dBm	-121 dBm	-16 dB
In-Band Spurious Emission (5130-5140 MHz Band)	-115 dBm	-121 dBm	-6 dB
Ground Segment (Flight Management)			
In-Band Spurious Emission (5140-5150 MHz Band)	-102 dBm	-121 dBm	-19 dB
In-Band Spurious Emission (5130-5140 MHz Band)	-112 dBm	-121 dBm	-9 dB

Single-Entry Interference to the Ground Segment of the C-Band Data Link Receiver

Since the ground segment of the C-band data link can be used for flight management, it will be located throughout the country (e.g., not limited to airports). Since the locations for the ground segment are essentially unknown, there is no practical way to limit the distance separation between them and a U-NII device. This inability to restrict how close a U-NII device can be from a ground segment receiver makes them more susceptible to out-of-band interference from U-NII devices. For the single-entry analysis it will be assumed that the U-NII devices are connected to lap top computers and are operating in an Ad-hoc configuration (e.g., a base station or access point is not required to transfer information between computers) the distance separation required to preclude interference from a single U-NII will then be calculated. The following equation will be used to calculate the required propagation loss between a U-NII device and the ground segment receiver of the C-Band Data Link:

$$L_{REQ} = EIRP_{NII} - A_{OOB} + G_{DL} + 10 \log (BW_{DL}/BW_{NII}) - I_{DL} + 10 \log (D) \quad (4)$$

where

L_{REQ} is the required propagation loss between a single U-NII device and the ground segment of the C-Band Data Link receiver (dB);
$EIRP_{NII}$ is the EIRP of the U-NII device operating in the 5150-5250 MHz band (dBm);
A_{OOB} is the attenuation of U-NII out-of-band emissions (dB);
G_{DL} is the antenna gain of the ground segment of the C-Band Data Link (dBi);
BW_{DL} is the receiver bandwidth of the ground segment of the C-Band Data Link receiver

(MHz);
BW_{NII} is the emission bandwidth of the U-NII device (MHz);
I_{DL} is the interference threshold for the ground segment of the C-Band Data Link receiver (dBm);
D is the duty cycle of the U-NII device.

Equation 4 gives the propagation loss that is required to preclude interference between a single U-NII device and the ground segment of the C-Band Data Link receiver. Assuming free-space propagation loss yields the following equation:

$$L_{REQ} = 20 \log F + 20 \log D_{REQ} - 27.55 \qquad (5)$$

where
F is the frequency of the U-NII device (MHz);
D_{REQ} is the required distance separation (meters)

Solving Equation 5 for D_{REQ} gives the distance separation that is required between a single U-NII device and the ground segment of the C-Band Data Link receiver to preclude interference. A comparison of the distance separations resulting from the single-entry interference analysis for U-NII devices with out-of-band emission limits proposed by WINForum and those in conformance with §15.209 is given in Table 9.

TABLE 9. A Comparison of the Required Distance Separations Between a U-NII Device and the Ground Segment of the C-Band Data Link

	Out-of-Band Emission Limits Proposed by WINForum	**Out-of-Band Emission Limits Specified in §15.209**
In-Band Spurious Emissions (5140-5150 MHz)	1 km	15 m
In-Band Spurious Emissions (5130-5140 MHz)	330 m	15 m

As stated earlier, the ground-segment of the C-Band Data Link providing flight management functions will be located throughout the U.S. to provide continued location and status information to en-route aircraft. Distance separations between the C-Band Data Link and the U-NII devices on the order of 1 km are not practical because this would require the FAA to purchase large parcels of land to assure protection of the data link receiver.

SUMMARY

The following aeronautical radionavigation systems have been identified as possibly requiring spectrum resources in the 5000-5250 MHz and 5350-5460 MHz bands: Microwave Landing System (MLS); Terminal Area Surveillance System (TASS); Terminal Doppler Weather Radar (TDWR); Aeronautical Data Link (ADL); Automatic Dependent Surveillance-Broadcast (ADS-B); Local Area Differential Global Navigation Satellite System (LADGNSS); and Airborne Weather Radar.

The MLS, ADL, ADS-B, and LADGNSS will be more susceptible to interference from the U-NII devices and will be considered in this analysis. The ADL, ADS-B, and LADGNSS will be considered under the broad category of C-Band Data Link.

The results indicate that the aggregate levels of interference computed in this analysis resulting from the out-of-band emission limits proposed by WINForum for U-NII devices operating in the 5150-5250 MHz and 5250-5350 MHz bands exceed the protection criteria for MLS, the airborne segment of the C-Band Data Link, and the ground segment of the C-Band Data Link.

The results of the aggregate interference analysis are based on mean values for the following U-NII device parameters: average transmit duty cycle; mean device density; and median building attenuation. Any difference between the mean value of these variables and the 0.99999 value required for aeronautical radionavigation systems will increase the levels of interference calculated in this analysis.

In the 5150-5250 MHz band this analysis assumes that all the U-NII devices are located indoors; however, if devices are employed outdoors (e.g., Ad-hoc configurations) the aggregate interference levels computed in this analysis will increase.

The technical characteristics for many of the aeronautical radionavigation systems included in this analysis reflect preliminary conceptual design, and not firm specifications and design. Accordingly, some of the design parameters are subject to changes, which could make the aeronautical radionavigation receivers more susceptible to out-of-band interference from U-NII devices operating in the 5150-5250 MHz and 5250-5350 MHz bands.

For the out-of-band emission limits proposed by WINForum, single-entry interference to the C-Band Data Link ground segment can be precluded if the distance separation is greater than 1 km. However, if the general limits in §15.209 are used single-entry interference can be precluded with distance separations of approximately 15 m. Distance separations on the order of 1 km are not considered practical, because the FAA would be required to purchase large parcels of land in order to protect the ground segment of the C-Band Data Link from interfering U-NII devices.

REFERENCES

1. Federal Systems Integration and Management Center, Analysis of Sharing C-Band Spectrum Between FAA Systems and MSS Feeder Links Summary Report, 90070TND-02, October 1995, page 1-1.

2. Wireless Information Networks Forum Petition for Reconsideration and Clarification, filed on March 3, 1997, pages 5-7.

3. Kelly, R. J., ICAO/Annex 10, MLS Channel Plan Protection Criteria Rationale, January 12, 1992.

4. Federal Systems Integration and Management Center, Analysis of Sharing C-Band Spectrum Between FAA Systems and MSS Feeder Links Summary Report, 90070TND-02, October 1995, page 5-11.

5. USWP 7C/121 (Rev 1), Analysis of Potential Interference to Space borne SARs from Wireless High Speed Local Area Networks Around 5.3 GHz, February 21, 1997, page 6.

6. National Telecommunications and Information Administration, NTIA TM-89-139, Single and Aggregate Emission Level Models for Interference Analysis, March 1989, Section 4.

7. Federal Systems Integration and Management Center, Analysis of Sharing C-Band Spectrum Between FAA Systems and MSS Feeder Links Summary Report, 90070TND-02, October 1995

8. National Telecommunications and Information Administration, NTIA TM-89-139, Single and Aggregate Emission Level Models for Interference Analysis, March 1989, Section 3.

OVERVIEW OF WINForum's PETITION FOR RECONSIDERATION

On March 3, 1997, WINForum filed a Petition for Reconsideration and Clarification of the Commission's Report and Order (R&O) for U-NII devices.[1] WINForum proposes nine clarifications and modifications to the R&O, many of which NTIA supports. There are, however, several WINForum proposals that NTIA opposes because of potential adverse affects on Federal spectrum operations.

ITEM 1 U-NII Devices Should be Permitted to Operate Across the 5250 MHz Boundary

Discussion

The R&O allows U-NII devices to operate in three bands: 5150-5250 MHz; 5250-5350 MHz; and 5725-5825 MHz. The 5150-5250 MHz and 5250-5350 MHz bands are adjacent to each other, but have different power limits and operational requirements. In the 5150-5250 MHz band, the Commission requires a maximum power limit of 50 mW and restricts U-NII devices to indoor operation. In the 5250-5350 MHz band, the Commission requires a maximum power limit of 250 mW and U-NII devices may operate either indoors or outdoors.

WINForum believes that the R&O is unclear regarding whether the U-NII devices may have channels that span the two bands. WINForum is, therefore, requesting that U-NII devices be permitted to have channels that span the 5150-5250 MHz and 5250-5350 MHz bands. U-NII devices whose channels span the two bands would be required to meet the more restrictive lower band power limit and the indoor operating restrictions.

Findings

NTIA supports WINForum's proposal, as stated above, because the proposed modification will not impact Federal operations.

ITEM 2 Clarify and Harmonize the Out-of-Band Emission Limits in the R&O with the General Limits in 47 CFR §15.209

Discussion

The R&O allows U-NII devices to operate in the 5150-5250 MHz and 5250-5350 MHz bands. The bands adjacent to these bands, the 4500-5150 MHz and 5350-5460 MHz bands, are on a list of restricted bands specified in 47 CFR §15.205, which requires emissions in these bands to

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[1] See Amendment of the Commission's Rules to Provide for Operation of Unlicensed NII Devices in the 5 GHz Frequency Range, Report and Order, ET Docket No. 96-102, 12 FCC Rcd 1576 (1997).

on a list of restricted bands specified in 47 CFR §15.205, which requires emissions in these bands to comply with the general limits of 47 CFR §15.209. WINForum maintains that it is unclear whether the limits for out-of-band emissions specified in the R&O or the general limits of §15.209 apply outside of the U-NII bands. During discussions between NTIA and WINForum, NTIA has taken the position that, in the restricted bands, the more restrictive general limits of §15.209 would supersede the out-of-band emission limits specified in the R&O.WINForum is therefore requesting that the following changes be made to the out-of-band emission limits for the U-NII devices in the 5150-5250 MHz and 5250-5350 MHz bands:

WINForum's Proposed Out-of Band Emission Limits for U-NII Devices Operating in the 5150-5250 MHz Band

Frequency Offset	Attenuation of U-NII Emissions
5140-5150 MHz and 5350-5360 MHz	27 dB
5130-5140 MHz and 5360-5370 MHz	37 dB
All emissions below 5130 MHz and above 5370 MHz must comply with the general limits of §15.209.	

WINForum's Proposed Out-of-Band Emission Limits for U-NII Devices Operating in the 5250-5350 MHz Band

Frequency Offset	Attenuation of U-NII Emissions
from band edge to 10 MHz outside the band edge	34 dB
from 10 MHz outside the band edge to 20 MHz outside the band edge	44 dB
All emissions more than 20 MHz outside the band edge must comply with the general limits of §15.209.	

The out-of-band emission limits in the 5725-5825 MHz band would remain the same as specified in the R&O.

Impact to Federal Operations

WINForum proposes to relax the general limits in 47 CFR §15.209 in the 20 MHz below

5150 MHz and the 20 MHz above 5350 MHz. The bands 4500-5150 MHz and 5350-5460 MHz are on the restricted bands list because they are allocated for the Federal aeronautical radionavigation service. The International Civil Aviation Organization (ICAO) has designated the 5091-5150 MHz band for future Microwave Landing System (MLS) expansion channels. In addition a study for the Federal Aviation Administration (FAA)[2] identified several aeronautical radionavigation systems that may require spectrum in these bands. These systems include: Terminal Area Surveillance System (TASS), Terminal Doppler Weather Radar (TDWR), Automatic Dependent Surveillance-Broadcast (ADS-B) data link, Aeronautical Data Link (ADL), and a Precision Landing data link to support the Global Navigation Satellite System (GNSS). It should be noted that some of these systems are only conceptual in nature and none of them (except MLS) currently occupy this spectrum.

In discussions between NTIA and WINForum, NTIA has stressed the importance of the restricted band limits for providing protection to aeronautical radionavigation systems. NTIA has also discussed the restricted band limits with FAA personnel. The FAA maintains that the general limits in §15.209 were established to provide the protection necessary for aeronautical radionavigation systems performing critical safety-of-life functions. For example, a data link supporting precision approach operations is providing information for navigation avionics. The navigation avionics receive input information from other sources (e.g., GPS satellites) and carry out complex computations to provide the required output information. The avionics are required to provide alert information if the output is determined to be hazardous or misleading. The time to alert specification (time from when the event happened until the pilot alert including computational time) can be as short as one second. Thus, interference that occurs for even a fraction of a second can cause false alerts that could cause the pilot to perform unnecessary evasive actions (e.g., abort the landing), which is unacceptable.

NTIA, in coordination with the FAA, performed an analysis to assess the impact to current and future aeronautical radionavigation systems from the out-band emission limits for U-NII devices proposed by WINForum. This analysis is presented in Attachment A. The results of the analysis show that the out-of-band emission limits proposed by WINForum will result in interfering signal levels that exceed the established protection thresholds for the aeronautical radionavigation systems considered in the analysis, which include MLS, air-to-ground data links, and ground-to-air data links.

Since the U-NII devices are unlicensed, it is impossible to know where they will be located or the number of devices active in a given area at any specific time. This makes predicting interference from U-NII devices extremely difficult. The only way to control the interference in the adjacent aeronautical radionavigation bands is through limits on the out-of-band emissions of the U-NII devices. Any proposed increase in the out-of-band emissions of the U-NII devices must be viewed in the context of its potential impact upon interference. Based on the above discussions,

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[2] Federal Systems Integration and Management Center, Analysis of Sharing C-Band Spectrum Between FAA Systems and MSS Feeder Links Summary Report, 90070TND-02, October 1995.

NTIA opposes WINForum's proposed increase in the out-of-band emission limits for the U-NII devices, and supports the limits proposed by the Commission in the R&O.

ITEM 3 The Frequency Stability Requirements Should be Deleted as Unnecessary Because No Channelization has been Mandated

Discussion

WINForum is proposing to delete §15.407(g) in the R&O, which specifies limitations on the variability of the carrier frequency of a U-NII device. WINForum argues that carrier frequency stability is only relevant for channelized systems where devices with imprecise carrier frequency tolerances could drift into other channels, causing adjacent channel interference. WINForum maintains that, since the FCC has not adopted a channelization scheme for the U-NII bands, no carrier frequency stability is needed.

Impact to Federal Operations

This modification will not impact Federal systems. Even in the absence of carrier frequency stability requirements, the out-of-band emission limitations will govern any potential interference to Federal systems. Therefore, NTIA supports the proposal made by WINForum.

ITEM 4 The Output Power and Power Spectral Density Rules Should Not Advantage Narrowband Systems

Discussion

WINForum is proposing that the total power output be specified as:

$$X \text{ dBm} + 10 \log B$$

where B is the 26-dB bandwidth in MHz;
X is 4 dBm for the 5150-5250 MHz band;
X is 11 dBm for the 5250-5350 MHz band; and
X is 17 dBm for the 5725-5825 MHz band.

If transmitting antennas of gain greater than 6 dBi are used, both the peak transmit power and peak power spectral density would be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

The maximum power output levels would be the same as those currently specified in the R&O. WINForum is making this proposal because they are concerned that, since the R&O specifies that the measurements are to be made with a 1 MHz resolution bandwidth, devices with an emission bandwidth less than 1 MHz would be allowed the same output power as a device with a 1 MHz

bandwidth. The narrowband systems would then gain a signal-to-noise advantage over wideband systems. Moreover, a number of such narrowband devices could be clustered in a small region of the spectrum, thereby generating more interference than a single device with a bandwidth of 1 MHz or greater.

WINForum is also proposing that allowance be made for the fact that most signals are not spectrally flat across their emission band. WINForum believes that this could be accomplished by allowing a 3 dB tolerance in any given 1 MHz band, while maintaining the total output power as a function of bandwidth as specified above.

Impact to Federal Systems

The R&O currently specifies the total output power independent of the bandwidth. For wider bandwidth systems (e.g., 20 MHz) this is not an issue, because, the power will be spread over a large enough bandwidth to reduce the potential for interference. If narrow bandwidths are employed, however, the power levels per unit bandwidth will be much higher resulting in greater potential for interference to Federal systems. The rules proposed by WINForum that specify the total power output as a function of bandwidth will prevent this from occurring (e.g., narrower bandwidth systems will have lower power levels). Since the rules proposed by WINForum do not increase the maximum power output levels that are currently specified in the R&O, the interference potential to Federal systems remains unchanged. Therefore, NTIA supports the proposal made by WINForum.

WINForum also proposes a 3 dB increase or tolerance in the peak power spectral density limits to allow for spectral peaking. The spectral peaking is based on the fact that the power spectral densities for most digital modulation schemes follow a sin X/X relationship, resulting in a higher level of power spectral density at the center frequency that falls-off as one moves away from the center frequency. NTIA realizes that most digital signals have some degree of variability in the power spectral density across their emission bands. An increase of 3 dB in the power spectral density limits, however, could effectively raise the output power by 3 dB. This would, in turn, double the interference power to Federal aeronautical radionavigation and radiolocation systems. This increase is for a single U-NII device; the Commission must also take into consideration what such an increase will have on the aggregation of interference to Federal systems operating in the band. NTIA thus opposes the proposed 3 dB increase for the power spectral density limits of the U-NII devices, and supports the limits proposed by the Commission in the R&O.

ITEM 5 The Out-of-Band Limits Should be Stated Relative to In-Band Limits Rather than Actual In-Band Power

Discussion

WINForum proposes that the out-of-band emission limits in the R&O be revised to state the out-of-band limits relative to the in-band power limits, including the required power reduction for systems with more than 6 dBi of antenna gain, rather than as relative to the actual transmitted power.

WINForum argues that under the current rules, if a U-NII device cannot meet the out-of-band emission limits stated in the R&O, reduction of power is not an option, because attenuation from the maximum peak power density contained within the band of operation is required. It is unclear from WINForum's proposal whether or not the 3 dB increase of the power spectral density limits would also apply to the U-NII device out-of-band emission limits.

Impact to Federal Systems

NTIA agrees that, by stating the out-of-band emission limits as a function of the maximum permitted in-band power, rather than as a function of the actual in-band power, equipment designers will be able to utilize in-band power reduction to meet the out-of-band limitations. NTIA is concerned, however, that absolute levels for out-of-band emission limits could result in high out-of-band effective isotropic radiated power (EIRP) if a high-gain antenna is used. This concern will be alleviated, if it is made clear that the maximum allowed in-band power spectral density used as a reference point is included the specified power reductions for systems with more than 6 dBi of antenna gain. If the power reduction for high gain antennas is included in the absolute limits, specifying the out-of-band emissions in terms of absolute versus relative levels would not alter the magnitude of the power transmitted into adjacent bands and there is no expected impact on Federal systems. Based on the discussion above, NTIA supports the proposal made by WINForum.

WINForum is not entirely clear when it addresses the 3 dB increase for out-of-band emissions. Increasing the out-of-band emission limits by 3 dB could increase the out-of-band emissions from the U-NII devices in the adjacent Federal aeronautical radionavigation band 5090-5150 MHz resulting in additional interference. Any proposed change in the out-of-band emission limits for the U-NII devices must be viewed in the context of the potential impact upon aggregate interference to current and future adjacent band Federal aeronautical radionavigation systems. Based on the potential increase of adjacent band interference, NTIA opposes the proposed 3 dB increase in the out-of-band emission limits for the U-NII devices, and supports the limits proposed by the Commission in the R&O.

ITEM 6 The Commission Should Specify the Total Power Output in a Manner that Accurately Represents the Interference Potential of U-NII Devices

Discussion

The out-of-band emission limits in the R&O are specified in terms of the attenuation of the peak envelope power in a 1 MHz band relative to the maximum value in the band. WINForum is recommending that the out-of-band emission limits be measured in terms of average power during a burst instead of peak envelope power. WINForum requests that rules specifying the total power output be clarified and modified to accurately represent the interference potential of the U-NII devices. WINForum maintains that symbol-to-symbol variations due to modulation are unimportant from the perspective of interference potential. WINForum proposes a series of definitions and modifications to existing definitions, consistent with those adopted by ANSI C63.17 for unlicensed

personal communications devices, that compensates for short-term envelope variations which they believe neither understates nor overstates the actual power of the device from the perspective of its interference potential.

WINForum proposes that the power measurement interval be the transmission duration when the duration is less than 30/B and equal to 30/B when the transmission duration exceeds this value where B is the emission bandwidth of the signal.

WINForum also requests that the Commission adopt the following definitions:

Average Symbol Envelope Power:	The average, taken over all symbols in the signaling alphabet, of the envelope power for each symbol.
Pulse:	Continuous transmission of a sequence of modulation symbols, during which the average symbol envelope power is constant.
Transmit Power:	The total energy transmitted over a time interval of at most 30/B or the duration of the transmission pulse, whichever is less, divided by the interval duration.

WINForum also proposes editorial modifications to the definition of peak transmit power.

Impact on Federal Operations

In Attachment A of WINForum's filing, an experiment was performed to demonstrate the relationship between the measurement bandwidth, the signal bandwidth, the actual power spectral density, and the measured power spectral density. In this experiment, $\pi/4$ DQPSK modulation (differential quadrature phase shift keying with a $\pi/4$ radian shift between successive symbols) was used with a data rate of 384 kbps. The signal spectrum was measured using a 10 kHz resolution bandwidth and a 1 MHz video bandwidth. This represents the case where the measurement bandwidth is significantly less than the signal bandwidth (the same situation occurs for U-NII devices with data rates of 20 Mbps when a measurement bandwidth of 1 MHz is used). The results of the experiment were as expected: The output of the resolution filter looks much like Gaussian noise. The same argument can be applied to other "well behaved" digital modulation schemes with known peak-to-average ratios such as: BPSK, QPSK, QAM, FSK, MSK, and GMSK. Under the R&O, however, nothing guarantees that these modulation techniques will be employed by U-NII devices. A manufacturer could develop some new type of modulation that violates the peak-to-average relationship of the digital modulation techniques listed above. In such a case, the peak levels

could be much higher than the average levels, and, if the measurement technique is based on average power level, interference to Federal systems could be greatly understated.

NTIA has been discussing the problem with WINForum. Possible solutions could be to develop a list of modulation schemes that are permissible for U-NII devices, or to specify a peak-to-average ratio to which U-NII devices must adhere. NTIA will continue to discuss these matters with WINForum.

NTIA agrees with WINForum that the measurements be made over bursts that are transmitted at the maximum power control level so that power measurements accurately reflect interference potential. Any averaging must not include time intervals during which the transmitter is off or transmitting at a reduced power level (e.g., employing power control to minimize co-channel interference).

While NTIA does not oppose the definitions proposed by WINForum, it appears that most of the definitions are related to the symbol duration, but there is no proposed definition for a symbol. WINForum defines symbol duration of 1.5/B in a footnote, but this definition applies only to certain classes of modulation. NTIA agrees that the definitions proposed by WINForum can be adopted, but believes that a definition of symbol duration should also be developed and included in the rules.

ITEM 7 The Commission Should Clarify the Definition and Measurement of Power Spectral Density and Peak Power Spectral Density

Discussion

WINForum urges the Commission to clarify the definition and measurement of power spectral density and peak power spectral density. As detailed extensively in Attachments A and B of WINForum's petition, experimental and theoretical research demonstrates that using peak measurement techniques (e.g., spectrum analyzer's peak detection or max hold mode) will significantly overstate the interference potential of the U-NII devices due to the inherent randomness of a wideband signal measured with a narrowband filter. WINForum adds that, from an interference perspective, it is the true power spectral density, rather than the peak power output of a 1 MHz resolution filter, that should be limited, because it is the true power spectral density over the victim receiver bandwidth that will determine the effect of the interference on the victim receiver.

WINForum requests that the Commission adopt the following definitions:

Power Spectral Density: The total energy output per unit bandwidth from a pulse or sequence of pulses for which the transmit power is at its peak or maximum level, divided by the total duration of the pulses. This total time does not include the time between pulses during which the transmit power is off or below its maximum level.

Peak Power Spectral Density: The maximum power spectral density, with the specified measurement bandwidth, within the U-NII device operating band.

WINForum also states that maximum resolution bandwidth must be limited in order to accurately isolate the power within the bandwidth of a potential victim receiver.

Impact to Federal Operations

The argument made by WINForum to use average versus peak power for the power spectral density measurements of the U-NII devices is based on the discussion in Attachments A and B of its petition. In Attachments A and B, it is demonstrated both theoretically and with experimental results, that power output of the resolution filter is noise-like when the resolution bandwidth of the spectrum analyzer is significantly less than the emission bandwidth. The results given in Attachments A and B are based on well known digital modulation techniques (e.g., known peak-to-average ratios). NTIA agrees with the results presented by WINForum and believes that the same conclusion would apply to other constant-envelope and linear digital modulation techniques. Therefore, if the U-NII devices were limited to using these types of digital modulation techniques, measuring the power spectral density in terms of average power instead of peak power, as the R&O requires, would not increase the effects of interference to Federal systems operating in or adjacent to the bands permitted for U-NII device operation.

The R&O, however, does not limit the U-NII devices to the classes of digital modulation used by WINForum in their theoretical and experimental discussions. Unless the rules specify or limit the modulation techniques that can or cannot be employed by the U-NII devices, NTIA cannot, therefore, support specifying the power spectral density limits in terms of average power, unless the Commission's rules specify or limit the modulation techniques that may be employed by the U-NII devices. Otherwise, the interference potential to Federal systems operating in or adjacent to the U-NII devices would be significantly understated.

ITEM 8 Provisions are Necessary to Control the Power Output of Very Short Duration Impulse Emissions

Discussion

As WINForum indicates, the R&O would not limit the use of devices that can transmit isolated "impulse" signals that are very short in duration (e.g., 5-10 nanoseconds). Impulse transmission systems of this type are characterized by a wide bandwidth (one that may span several hundred megahertz) and extremely high peak power levels.[3] WINForum acknowledges that a

[3] Such a system, called an ultra-wideband system, has an instantaneous bandwidth greater than 25 percent of its center frequency.

measurement instrument with a maximum resolution bandwidth on the order of 1 to 3 MHz (typical for most spectrum analyzers) will not be adequate to determine the power of the impulse signal. On this basis, WINForum concludes that different measurement techniques are needed to accommodate impulse transmission systems. WINForum therefore plans to continue to discuss this issue with NTIA, with a goal of jointly developing suitable test procedures for measuring the total output and power spectral density of impulse transmissions.

WINForum also believes that it will be necessary to specify in the Commission's Rules that the manufacturer is required to disclose, in its application for Part 15 Certification, details such as the modulation format, minimum pulse duration, minimum and maximum pulse repetition rate, and spectral characteristics under expected conditions.

Impact on Federal Operations

WINForum suggests that separate test procedures should be developed to measure the output power and power spectral density of impulse type systems. In discussions with WINForum, NTIA has stated that, if the power spectral density is stated in terms of average power, as requested by WINForum, ultra-wideband (impulse) transmission systems should not be permitted to operate in the U-NII bands. If the power spectral density and out-of-band emission limits for ultra-wide systems are specified in terms of average power, the interference potential to Federal systems will be significantly understated. Therefore, NTIA opposes the implementation of ultra-wideband systems in the bands designated for U-NII devices, unless the power spectral density and out-of-band emission limits are specified in terms of peak power as proposed by the Commission in the R&O.

ITEM 9 The Definition of U-NII Devices Should be Clarified to Require Digital Modulation

Discussion

WINForum proposes that the definition of U-NII devices be modified to specifically state that the use of this spectrum is restricted to systems using digital modulation techniques.

Impact on Federal Systems

Specifying the type of modulation in the definition of U-NII devices would help the development of future Federal systems in the band. Specifying the allowable modulation schemes would even be better for defining the interference environment. It may also be useful to include a minimum bandwidth in the definition of the U-NII devices in order to preserve the true purpose of opening these bands for unlicensed devices -- that is, to provide spectrum for unlicensed broadband data applications that could not be supported by the current unlicensed frequency allocations. Therefore, NTIA supports this proposal.