

**Before the
Federal Communications Commission
Washington, D.C. 20554**

In the Matter of)	
)	
Allocations and Service Rules)	
for the 71-76 GHz, 81-86 GHz)	
and 92-95 GHz Bands)	WT Docket No. 02-146
81-86 GHz and 92-95 GHz Bands)	
)	
Loea Communications Corporation)	RM-10288
Petition for Rulemaking)	
)	

JOINT REPLY COMMENTS

LOEA COMMUNICATIONS
CORPORATION

CISCO SYSTEMS, INC.

CERAGON NETWORKS

ENDWAVE CORPORATION

STRATEX NETWORKS

BRIDGEWAVE
COMMUNICATIONS, INC.

February 3, 2003

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EXECUTIVE SUMMARY

The Joint Parties are submitting these reply comments to report that they have reached consensus on a number of unresolved issues that were raised in the initial round of comments for the *Notice of Proposed Rulemaking* in this proceeding (the “*NPRM*”). Those comments already reflect substantial agreement with the initial comments filed by The Wireless Communications Association International, Inc. (“WCA”) – among other things, the Joint Parties (each of whom are members of WCA’s Over 40 GHz Committee”) have concurred that (1) there should be no spectral segmentation of the 71-76 and 81-86 GHz bands and only minimal segmentation of the 92-95 GHz band where necessary to protect the 94.0-94.1 GHz cloud radar band; (2) the Commission should utilize point-to-point licensing for the 71-76, 81-86 and 92-95 GHz bands (the “Upper Millimeter Wave” or “UMW” bands); and (3) for UMW spectrum, the Commission should adopt a “narrowbeam” restriction on the physical extent of the radiation pattern.

As of the close of the initial round of comments, however, the record included a variety of different proposals on more specific technical issues. Accordingly, to obtain a final consensus on these matters, the Joint Parties convened on January 29th, 2003 at Cisco Systems, Inc.’s Wireless Division Headquarters in San Jose, California. As a result of those discussions, the Joint Parties have reached agreement on the following issues: (1) the extent to which the Commission’s UMW rules should permit full-duplex transmission; (2) use of Adaptive Transmitter Power Control (“ATPC”); (3) transmitter power limits in relation to antenna gain and the radiation suppression mask; (4) out-of-band emission limits; (5) required accuracy of end-point location in filings for UMW licenses; (6) digital modulation; and (7) unlicensed operations. Having resolved these matters independently, the Joint Parties believe there is now sufficient agreement in the record to permit the issuance of final UMW rules in accordance with WCA’s initial comments and the further consensus discussed herein. The Joint Parties urge the Commission to adopt such rules on an expedited basis and thereby unleash the enormous potential of UMW spectrum as a vehicle for delivering new broadband service to the marketplace.

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JOINT REPLY COMMENTS

Loea Communications Corporation (“Loea”), Cisco Systems, Inc. (“Cisco”), Endwave Corporation, Ceragon Networks, BridgeWave Communications, Inc., and Stratex Networks (collectively hereinafter referred to as the “Joint Parties”) hereby submit their reply comments with respect to the *Notice of Proposed Rulemaking* (“*NPRM*”)¹ issued in this proceeding to allocate spectrum and adopt service and technical rules for the 71-76 GHz, 81-86 GHz and 92-95 GHz bands (the “Upper Millimeter Wave” bands).

I. INTRODUCTION

The Joint Parties are service providers, equipment manufacturers and consultants interested in the domestic deployment of the Upper Millimeter Wave or “UMW” bands for broadband service. As the Commission is aware, several of the Joint Parties have already filed initial comments that are highly supportive of the initial comments filed in

¹ *Allocations and Service Rules for the 71-76 GHz, 81-86 GHz and 92-95 GHz Bands; Loea Communications Corporation Petition for Rulemaking*, 17 FCC Rcd 12182 (2002).

this proceeding by The Wireless Communications Association International, Inc. (“WCA”).² Those filings reflect substantial agreement on the following critical issues:

- There should be no spectral segmentation of the 71-76 and 81-86 GHz bands and only minimal segmentation of the 92-95 GHz band where necessary to protect the 94.0-94.1 GHz cloud radar band.
- The Commission should utilize point-to-point licensing for the UMW spectrum; band managers and geographic-area licensing would stifle investment in and deployment of UMW facilities for broadband service.
- For UMW spectrum, the Commission should adopt a “narrowbeam” restriction on the physical extent of the radiation pattern (although opinions varied as to precise envelope definition).

At the same time, however, each of the Joint Parties also proposed one or more specific rules that differ from those proposed by WCA with respect to the following:

- Permitting full-duplex transmission within a band.
- Regulating the use of Adaptive Transmitter Power Control (ATPC).
- Transmitter power limits versus antenna gain and radiation suppression mask.
- Acceptable limits for out-of-band emissions.
- Required accuracy of end-point location in filings for licenses.
- Digital modulation.
- Unlicensed operations.

To obtain a final consensus on these issues, the Joint Parties convened on January 29th, 2003 at Cisco’s Wireless Division Headquarters in San Jose, California. The Joint Parties are pleased to report that they have reached agreement on a variety of key points,

² Each of the Joint Parties is a member of the Over 40 GHz Committee of The Wireless Communications Association International, Inc. (“WCA”). Through WCA, the Committee submitted extensive initial comments addressing the various legal, technical and logistical issues raised in the *NPRM*. See Comments of The Wireless Communications Association International, Inc., WT Docket No. 02-146 (filed Nov. 1, 2002).

and that there is now sufficient consensus in the record to permit the issuance of final rules on an expedited basis.

II. DISCUSSION.

A. Dual Band FDD vs. Single-Band FDD or TDD.

The propagation characteristics of the UMW frequencies permit a new paradigm for managing interference – one based upon geographical (as opposed to spectral) parceling, but which also offers nearly unlimited reuse of spectrum and thus eliminates the need for wide-area spectrum auctions. Generally, there are two ways to coordinate spectrum for maximum reuse: (1) placing strict limits on the extent of the radiation envelope emitted from an antenna, or (2) limiting the spectral content of the radiated energy. In its original Petition for Rulemaking in this docket, Loea proposed a set of technical rules which relied entirely on the first means of coordination – more specifically, the proposal advocated very high antenna gain minima and extreme limits to off-axis radiation suppression. In return, the proposal permitted complete flexibility in spectrum use, thereby maximizing potential applications of the spectrum. Several respondents to the *NPRM* pointed out the practical difficulties of attaining such performance from antennas currently used in the marketplace, and suggested alternative proposals that would relax constraints on gain and off-axis suppression.

In its initial comments, Cisco attempted to balance the two methods of spectrum coordination by advocating some relaxation of the gain and suppression requirements, but also recommending that the Commission restrict radiation within a beam to a single propagation direction in each of the 71-76 and 81-86 GHz bands. This proposal would leave the 92-95 GHz band open for full-duplex applications such as single-band

Frequency Division Duplex (FDD) or Time Division Duplex (TDD).³ Under the Cisco approach, each building or tower acting as a wireless node would be assigned an “East” or “West” designation. All radios transmitting from a building or tower with a specific designation (*e.g.*, “East”) would operate as outgoing half-duplex in one band (*e.g.*, 71-76 GHz), and incoming half-duplex in the other (81-86 GHz). This type of “paired channel” assignment (which is used in other spectrum licensed under Part 101), provides a spectrum coordinator with a useful tool for managing hub-and-spoke deployments, while relaxing constraints on radiation suppression masks for large off-axis angles.

Having reviewed and discussed Cisco’s proposal at length, the Joint Parties have concluded that the proposal will mitigate interference without imposing undue hardware performance constraints that could preclude cost-effective deployment of UMW technology. The Joint Parties therefore recommend the following:

For full-duplex and other two-way radios, the 71-76 and 81-86 GHz bands should be designated as paired channels, such that transceivers operating in these bands will transmit in one channel only and receive in the other channel.

B. ATPC.

An immediate consequence of Cisco’s proposal is that in hub-and-spoke deployments all of the beams incident on a specific tower or building will reside within a single spectral band. Absent spectral segmentation (which the Joint Parties have already agreed is not necessary or desirable), restrictions on power and the physical extent of the incident beams are the only means of managing interference. However, Cisco and Terabeam Networks (“Terabeam”) have proposed *relaxation* of the near-in suppression

³ As to those commenting parties who have expressed concern about preserving UMW spectrum for TDD radio development, it should be noted that the 92-95 GHz band fully accommodates that technology.

mask proposed by Loea, and Cisco, Terabeam, Comsearch, and the Fixed Wireless Communications Coalition (“FWCC”) each proposed relaxation of proposed power penalties for wider antenna beams, all as a means of mitigating hardware and installation costs. If the Commission permits such enlargement of the physical envelope of the radiation pattern, then the use of incident power management is much more than a simple matter of good design practice – it is a prerequisite for frequency coordination of hub-and-spoke deployments.

During the discussions among the Joint Parties, several options were suggested as possible ways to impose mandatory ATPC. One common proposal is based upon the TSB-10 formalism of defining carrier-to-noise ratios (C/N) necessary for error-free operation with different modulation schemes, with an appropriate overhead for setting ATPC levels. Unfortunately, at UMW frequencies TSB-10 is more relevant to multi-path fading than rain fade. Moreover, this form of regulation does not reward users for developing power-efficient and spatially efficient radios. An alternative proposal, more appropriate to this end, would establish a limit on the absolute power flux density (PFD) originating from a specific transmitter as measured at the location of its associated receiver antenna. A maximum authorized PFD of 100 pW/cm² provides a 10 dB cushion above the required C/N level for 10⁻¹⁰ BER with an 8PSK receiver with an 8-dB noise figure, using a 1-foot dish antenna.

Furthermore, a radio using ATPC will operate at minimum output power in good weather and at maximum power during heavy rain events that define its availability threshold. For “four nines” performance in “extreme” U.S. rain zones such as the Gulf Coast, operation through this range of weather conditions demands a dynamic range in

output power of up to 45 dB. Assuming a 13-dB cushion for clear-weather operation, a receiver operating at maximum EIRP must accommodate 32 dB of ATPC dynamic range. A receiver operating at lower maximum power correspondingly needs less ATPC range to operate within clear-weather power limits - consequently the appropriate requirement on ATPC dynamic range (in dB) is $32 - \{55 - \text{EIRP}_{[\text{dBW}]}\}$, or $\text{EIRP}_{[\text{dBW}]} - 23$. For radios with EIRP below +23 dBW, no ATPC is required.

Subject to an exception taken by Cisco in its individual reply comments, the Joint Parties recommend the following:

Transmitters operating in the 71-76 and 81-86 GHz bands with EIRP in excess of +23 dBW must possess capability for Adaptive Transmitter Power Control over a dynamic range in dB of at least the numerical value $\text{EIRP} - 23$, with EIRP expressed in dBW. When pointed at a remote cooperative receiver, the ATPC must operate to maintain the power flux density at the receiver antenna below 100 pW/cm², subject only to the dynamic range limitation of the ATPC.⁴

C. Antenna Gain and Radiation Suppression Mask.

The above-proposed combination of mandatory dual band FDD and mandatory APTC will permit relaxation of the antenna gain limits originally proposed by Loea and endorsed in WCA's initial comments. Loea originally had proposed a minimum antenna gain requirement of 50 dBi, with a waiver for lower gain antennas at an EIRP power penalty of 3 dB per dB of reduced antenna gain, relative to a +55 dBW EIRP. Cisco, however, has concluded that incidents of mutual interference are negligible in high-density deployments (*i.e.*, more than 10 links per square kilometer) even with beamwidths as large as 20 milliradians (1.2 degrees), using a lesser EIRP power penalty of only 2 dB per dB of reduced antenna gain relative to a +55 dBW EIRP. Under this

⁴ Cisco supports a TSB-10 based criterion for authorized receive power, in lieu of a fixed PFD limit.

model, a 12-inch antenna with a nominal gain of 43 dB would permit a transmitter EIRP of $+55-2(50-43)$ or 41 dBW, or a transmitter power level of 630 milliwatts, subject to health and safety approvals. This model would require a minimum antenna gain of 43 dB, and a maximum half-power beamwidth (HPBW) of 1.2 degrees.

Furthermore, hub-and-spoke deployments require radiation suppression requirements close to the main beam, which in turn are typically a function of receiver antenna gain. Mandatory ATPC thus would ease the required suppression levels originally specified in Loea's proposal - assuming ATPC regulations specify a maximum incident PFD level, the interference threshold will be fixed for a given receiver, such that the product of antenna gain and relative off-axis suppression becomes constant, *i.e.*, the tradeoff between suppression required and antenna gain is -1 dBc per +1 dBi. Cisco's modeling of dense deployments has assumed a suppression level of 15 dBc for an antenna with 43 dB gain; consequently, the scaled suppression requirement would restrict power between 1.2 and 5 degrees away from centerline to $(G-28)$ dBc relative to the main beam, for an antenna of gain G . Calculated beam patterns for dish antennas of varying aperture function suggest that such suppression is easily achievable using simple, cost-effective antenna designs.

In view of the above, the Joint Parties have reviewed and approved the following modifications to WCA's proposed Antenna Standards table for the 71-76 and 81-86 GHz bands:

Frequency (MHz)	Cat	Max BW to 3 dB points (Included angle in degrees)	Minimum radiation suppression to angle in degrees from centerline of main beam in decibels							
			Min gain (dBi)	5° to 10°*	10° to 15°*	15° to 20°*	20° to 30°*	30° to 100°*	100° to 140°*	140° to 180°*
932.5 to 935	A B	14.0 20.0	n/a n/a	n/a n/a	6 n/a	11 6	14 10	17 13	20 15	24 20
...										
38,600 to 40,000	A B	n/a n/a	38 38	25 20	29 24	33 28	36 32	42 35	55 36	55 36
71,000 to 76,000	A B	1.20 1.20	43‡*L ₁ 43‡	35 35	40 40	45 45	50 50	50 50	55 55	55 55
81,000 to 86,000	A B	1.20 1.20	43‡*L ₁ 43‡	35 35	40 40	45 45	50 50	50 50	55 55	55 55

‡ Antenna gain less than 50 dBi (but greater than 43 dBi) is permitted with a proportional reduction in maximum authorized EIRP in a ratio of 2 dB of power per 1 dB of gain, so that the maximum allowable EIRP (in dBW) for antennas of less than 50 dBi gain becomes $+55 - 2 (50 - G)$, where G is the antenna gain in dBi.

* For the bands 71-76 GHz and 81-86 GHz, the following specification is included for minimum radiation suppression L₁ at angles from 1.2° to 5° from centerline of main beam in dB: $L_1 = G - 28$.

D. Cross-Polarized Antenna Radiation Suppression Mask.

The Joint Parties agree that mandatory linear polarization provides a frequency coordinator with a valuable tool for managing potential interference, and thus should be incorporated into the Commission's UMW rules. Cisco, however, has also proposed a cross-polarized suppression mask for antennas operating in the 71-76 and 81-86 GHz spectral bands. As to this point, the Joint Parties have agreed to the following proposal:

Frequency (MHz)	Category	Minimum cross-pol radiation suppression to angle in degrees from centerline of main beam in decibels								
		0° to 1.2°	1.2° to 5°	5° to 10°*	10° to 15°*	15° to 20°*	20° to 30°*	30° to 100°*	100° to 140°*	140° to 180°*
71,000 to 76,000	A B	25 25	25 25	45 45	50 50	50 50	55 55	55 55	55 55	55 55
81,000 to 86,000	A B	25 25	25 25	45 45	50 50	50 50	55 55	55 55	55 55	55 55

E. In-Band Power Spectral Density.

Loea's Petition for Rulemaking originally proposed an EIRP limit of +55 dBW for antennas with gain of 50 dBi or higher, but made no proposal with respect to power spectral density in the band. This omission was an oversight on Loea's part, resulting from Loea's focus on applications that spread information broadly across the available bandwidth. Cisco, however, has pointed out that limits on power spectral density are necessary to ensure that potential sources of interference can be predicted and managed. Loea's Petition sets the maximum output power from a fixed point-to-point radio transmitter at 3 Watts - uniformly distributed across a 5 GHz channel, this represents a power spectral density of 60 mW/100 MHz. To account for natural differences in modulation spectra and inevitable amplifier gain variation across the authorized bands, the Joint Parties propose the following:

Transmissions in the 71-76 and 81-86 GHz bands shall be subject to a maximum power spectral density limit of 150 mW per 100 MHz.

F. Out-of-Band Emissions.

Loea initially proposed that the Commission apply the out-of-band emission limits in Section 101.111(2)(ii) to the UMW bands. Cisco has suggested an alternative plan, under which out-of-band emission limits would be based upon absolute power rather than power relative to the transmitter output power. The Joint Parties have reviewed both proposals and elected to support the existing Part 101.111(2)(ii) out-of-band emission limits without revision.

G. Site Survey Precision

Loea's initial comments on the *NPRM* emphasized that accurate transceiver installation coordinates are necessary for management of potential interference (Comsearch, for example, has suggested that a level of accuracy equal to one-tenth of an arc-second). One means of attaining 3-meter or better accuracy in 3 dimensions is the use of GPS with a Wide-Area Augmentation System (WAAS) along with a laser rangefinder for determining height above ground level (AGL). Cisco, however, has questioned the need for 3-meter accuracy in endpoint location, out of concern that (WAAS) is not currently deployed nationwide, and that laser rangefinding equipment may be expensive and impractical.

Having discussed the matter at length, the Joint Parties concur that conventional GPS accuracy will be sufficient for site coordination in almost all cases, and that in special cases where further coordination is required, the coordinator may require an applicant to provide a higher level of accuracy for his endpoints and those of a potential interferer.

H. Digital Modulation.

Cisco has proposed that the Commission restrict modulation types in the 71-76 and 81-86 GHz bands to digital modulation only. This proposal attempts to facilitate coordination with radio astronomy services ("RAS") and thus would only apply to the RAS coordination zones listed under footnote USzzz. The Joint Parties therefore recommend the following:

Within the RAS protection zones specified in footnote USzzz, the Coordinator may require a fixed-services operator to employ a scrambled digital modulation technique, so as to spread radiated energy as uniformly as possible across the 81-86 GHz band.

I. Unlicensed Uses.

Comsearch’s initial comments propose language that would permit unlicensed facilities to operate “underneath” licensed UMW spectrum. Comsearch and the other Joint Parties have since agreed that no unlicensed operations should be permitted in the 71-76 and 81-86 GHz bands.

III. CONCLUSION

In sum, the Joint Parties reiterate that the *NPRM* establishes a viable, comprehensive blueprint for regulation and deployment of broadband facilities in the 71-76, 81-86 and 92-95 GHz bands. The Joint Parties therefore urges the Commission to proceed without further delay and adopt the rules proposed in the *NPRM*, subject to the recommendations made herein and in the initial comments submitted by WCA.

Respectfully submitted,

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