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	**)**	**WT Docket No. 02-146**
and 92-95 GHz Bands	**)**	
	)	
Loea Communications Corporation	**)**	**RM-10288**
Petition for Rulemaking	**)**	

REPLY COMMENTS OF TERABEAM CORPORATION

Howard J. Symons
Russell H. Fox
Susan S. Ferrel
MINTZ, LEVIN, COHN, FERRIS,
GLOVSKY AND POPEO, P.C.
701 Pennsylvania Avenue, N.W.
Washington, DC 20004-2608
(202) 434-7300

Its Attorneys

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EXECUTIVE SUMMARY

The majority of commenting parties agree on most of the issues raised in the Notice of Proposed Rulemaking ("NPRM"). For example, the commenters agree that the FCC should adopt its proposal to conform its regulations to recent international allocations, but should refrain from adopting a new footnote to the Table of Allocations. In addition, most commenters agree with the FCC's approach regarding the coordination of the radio astronomy service ("RAS"). With regard to band plan proposals, the commenters urge the FCC to allocate the entire 71-76 GHz and 81-86 GHz band for fixed service use. There was also broad agreement that the Commission should authorize the use of the millimeter wave bands on a site-specific, and not a geographic area, basis.

However, the parties adopted different approaches with regard to the issues concerning the characteristics of equipment that may be used in the millimeter wave bands. All of the parties agree that the Commission should make the full 5 GHz of spectrum available in the 71-76 GHz and 81-86 GHz bands without channelization. Terabeam, however, does not agree that the 71-76 GHz and 81-86 GHz bands be restricted to the use of dual-band frequency division duplex ("FDD") equipment. This approach would impose unnecessary costs on, and delays in the introduction of, 71-76 GHz and 81-86 GHz products. The rationale for the recommended mandate to use dual-band FDD equipment is based on the use of the millimeter wave bands in a hub-and-spoke architecture in an "uncoordinated" environment. However, there is no evidence to suggest that this scenario will be prevalent in the use of the millimeter wave bands and that if it is, that the required use of dual-band FDD will materially ameliorate the anticipated negative effects. A dual-band FDD requirement would also create unnecessary interference near RAS facilities. Finally, the mandated use of dual-band FDD, or any technology, is contrary to Commission practice and precedent.

The Commission should reject recommendations that the FCC mandate a minimum automatic transmitter power control ("ATPC") range and adopt conditions for its use. If any ATPC requirements are adopted, they should be set at a level that is consistent with current manufacturing capabilities. In particular, Terabeam recommends 25 dBW as an appropriate level at which to require ATPC, if such a requirement is necessary at all. In addition, if APTC is mandated, the Commission should adopt the approach to use Power Flux Density as the receiver power limit.

Several parties have addressed the lowest permissible level of antenna gain. Terabeam recommends a minimum antenna gain of 40 dBi and a maximum half-power beamwidth of 2.0 degrees. If the FCC adopts Terabeam's recommended antenna gain and beamwidth limitations, then the radiation suppression table initially proposed by WCA must be modified so that the innermost radiation restriction "L1" would apply only to *sidelobes* in the region of 1.2 degrees to 5 degrees from beam center, not the main lobe.

Finally, the FCC should not require digital modulation in the 71-76 GHz and 81-86 GHz bands. This approach would restrict the type of technology that may be employed in the vast majority of the country. Coordination with the RAS should be within defined exclusion zones, but use of digital technology does not need to be mandated within those zones.

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Terabeam Corporation, by its counsel and pursuant to the provisions of Section 1.415 of the rules and regulations of the Federal Communications Commission ("FCC" or "Commission"), 47 C.F.R. § 1.415 (2002), and the invitation extended by the Commission in the above referenced Notice of Proposed Rule Making ("NPRM"),[1/] hereby submits its reply comments responsive to the comments of others who addressed the FCC's proposals designed to promote the commercial development and growth of the bands 71-76 GHz, 81-86 GHz and 92-95 GHz (the so-called "millimeter wave bands").

I. Introduction

As Terabeam noted in its comments, it designs and manufactures broadband wireless systems that extend and optimize carrier and enterprise networks. Terabeam presently uses 60 GHz technology in its Gigalink series of products. Terabeam also expects to offer equipment using the millimeter wave bands that are the subject of this proceeding.

1/ *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, Notice of Proposed Rulemaking, 17 FCC Rcd 12182 (2002) ("NPRM").

There was significant agreement among commenting parties regarding most of the matters raised in the NPRM. However, on certain issues concerning the characteristics of equipment that will be used in the millimeter wave bands, parties adopted different approaches. In an attempt to reach consensus on some of these issues, the Wireless Communications Association International ("WCA") convened a meeting of its Over 40 GHz Committee on January 29, 2003 at Cisco Systems, Inc.'s Wireless Division Headquarters in San Jose, California (the "WCA Committee Meeting"). Terabeam actively participated in that meeting. Terabeam agrees with many of the positions that it expects certain WCA members will take as a result of those discussions, including positions regarding acceptable limits for out of band emissions, required accuracy of station location information in license applications, the use of digital modulation, protection for Radio Astronomy Service ("RAS") stations and unlicensed operations. However, Terabeam takes the opportunity of these reply comments to present its own views on issues where its positions will diverge from others' and to point out to the FCC the general agreement among the commenting parties on virtually all other issues.[2/]

II. Reply Comments

A. Allocation Proposals

Most other parties, like Terabeam, generally supported the FCC's proposal to conform its regulations to recent international allocations.[3/] Terabeam disagreed with the FCC's proposal to add a new footnote regarding the use of the 71-76 GHz band to the Table of Allocations.[4/] Instead, it recommended that the FCC adopt technical standards that will offer the level of

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2/ Terabeam's reply comments are limited to matters associated with the 71-86 GHz and 81-86 GHz bands.

3/ *See, e.g.*, Comments of the Boeing Company ("Boeing") at 2; Comments of Cisco Systems, Inc. ("Cisco") at 10; Comments of Harris Corporation ("Harris") at 2.

4/ Comments of Terabeam at 2.

protection suggested by the Wireless Communications Association ("WCA"). Others advocated the same approach. For example, Loea Communications Corporation ("Loea") "believes that the adoption of technical standards . . . will provide adequate protection to satellite operations without the need to adopt 5.561."[5/] In addition, Sprint Corporation ("Sprint") urged that the Commission "not adopt the proposed new footnote to the Table of Frequency Allocations . . . but should instead adopt technical standards that . . . provide interference protection to Government satellite operations."[6/] Terabeam also opposed the addition of a secondary allocation for amateur and AMSAT services in the band 81-81.5 GHz. Others agreed with this position, including both Sprint and Cisco, who urged the Commission to refrain from adopting its "proposed new secondary allocation for amateur and AMSAT services at 81-81.5 GHz [because] this will complicate frequency coordination."[7/] Terabeam agreed with the FCC's approach regarding coordination of the use of the 81-86 GHz, 92-94 GHz and 94.1-95 GHz with the radio astronomy service ("RAS"). Many of the other commenters endorsed this position, including Comsearch, who discussed, at length, ways in which the Commission could facilitate this coordination process.[8/]

B. Band Plan

Terabeam supported Loea's proposal to allocate the entire 71-76 GHz and 81-86 GHz band for fixed service use, postponing indefinitely a potential allocation in these band for mobile, or other uses. This position was widely endorsed by others. Both Harris and the Fixed Wireless

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5/ Comments of Loea Corporation ("Loea") at 12.

6/ Comments of Sprint Corporation ("Sprint") at 4.

7/ Comments of Sprint at 4; Comments of Cisco at 10-12 ("Cisco also supports the Commission's decision *not* to propose a secondary Amateur and/or AMSAT allocation at 81-81.5 GHz.").

8/ *See* Comments of Comsearch at 17; *see also* Comments of Fixed Wireless Communications Coalition ("FWCC") at 6-7.

Communications Coalition ("FWCC") urged the Commission to adopt Loea's proposal to allocate the band for fixed use.[9/]

C. Service Rules

Terabeam strongly supported the plan to authorize the use of the millimeter wave bands on a site-specific, and not on a geographic area, basis. As Terabeam demonstrated, the use of the bands can be coordinated by the FCC itself or by a band administrator. There was virtual unanimity on these important issues.

While Terabeam and others generally support the availability of spectrum for unlicensed operations, virtually all parties believe that, in this case, it is in the public interest that the band be authorized on a licensed basis. The majority of commenters agree that unlicensed operations in these bands would greatly complicate coordination and would likely interfere significantly with the ability of licensed providers to offer service guarantees.[10/] Likewise, and as Cisco explains, there is little to be gained from the administrative streamlining that comes from unlicensed use of this spectrum because the equipment that will be used for these bands will require professional installation and environmental assessments.[11/] Finally, as Loea notes, adopting an unlicensed approach would increase the costs for providers, who will, as a result, be required to install more facilities in order to remain competitive with its wireline competitors.[12/]

Virtually all parties agree that the Commission should not adopt geographic area licensing for these bands. For example, Endwave Corporation ("Endwave") strongly opposes geographic area licensing because it does not promote the most efficient use of the spectrum and

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9/ Comments of FWCC at 4, 6; Comments of Harris at 5.

10/ Comments of Cisco at 21; Comments of Loea at 16-19; Comments of Sprint at 6.

11/ Comments of Cisco at 21.

12/ Comments of Loea at 16.

has the potential of placing an entire region in the hands of an entity that may not be competent to administer the spectrum in the most economic way.[13/] As a result, and as Sprint explains, geographic area licensing has the potential to "impede the free and efficient use of the band."[14/] Accordingly, and as the comments demonstrate, geographic area licensing is unsuitable for these frequency bands and has the potential of imposing "additional and unnecessary burdens on the new technologies operating in this band."[15/]

For these reasons, the Commission should adopt a site-specific licensing approach. This sentiment is echoed by the majority of commenters to this proceeding, who agree that, at these frequencies, site-by-site licensing is by far the most efficient means of allocating resources.[16/] As Sprint Corporation explains, a site-specific approach enables an infinite number of providers to be authorized in the spectrum.[17/] This is true "because the frequency reuse capabilities of these wavelengths can support a great deal of users, both individual and economic units and major service providers, even in crowded metropolitan areas.[18/] Further, the potential for interference in these bands is less of a risk because the extremely narrow "pencil beams" used to transmit data ensures that interference can be easily avoided through coordination.[19/]

13/ Comments of Endwave Corporation ("Endwave") at 5.

14/ Comments of Sprint at 6.

15/ Comments of Boeing at 6; Comments of Harris at 8.

16/ Comments of Boeing at 6; Comments of Sprint at 6; Comments of Harris at 5; Comments of FWCC at 10; Comments of Cisco at 17-18.

17/ Comments of Sprint at 6.

18/ Comments of Endwave at 5.

19/ Comments of Boeing at 6; Comments of Sprint at 6.

D. Technical and Operational Rules

1. Pairing and Channelization

Virtually all of the commenting parties agree that the FCC should make the full 5 GHz of spectrum available in the bands 71-76 GHz and 81-86 GHz available without channelization. Terabeam agrees with these parties because the unique potential of these bands to support extremely high data rates, such as 10 Gbps or more, would be compromised or even eliminated were the bands to be channelized.

Nevertheless, Terabeam does not concur with a recommendation by Cisco that the 71-76 GHz and 81-86 GHz bands be restricted to the use of dual-band frequency division duplex ("FDD") equipment, so that two-way communications links would always consist of a transmission path in one of the bands and a reverse path in the other band. Cisco would prohibit the use in these bands of time division duplex ("TDD") equipment or single-band FDD products (i.e. radios that support 2-ways links operating wholly within the 71-76 GHz or 81-86 GHz band); Cisco asserts that these technologies would unduly interfere with operators' ability to easily deploy high-capacity communications links that require the full amount of spectrum in each band.

Terabeam believes that Cisco's approach would impose unnecessary costs on, and delays in the introduction of, 71-76 GHz and 81-86 GHz products, with only speculative advantages for dense deployments of high-bandwidth equipment in the future. The possibility that the use of different duplexing technologies in these bands will increase co-channel interference among users is insignificant where links are randomly distributed in a given market, as will occur in most cases where enterprises and carriers employ these frequencies to connect facilities to each other or establish backhaul links as part of network architectures. The only scenario in which the simultaneous use of TDD, single-band FDD, dual-band FDD equipment will raise the likelihood

of interference is in "uncoordinated" hub-and-spoke deployments, such as those in which multiple end-users are communicating wirelessly with a location (e.g., the rooftop of a carrier hotel or similar network point of presence).[20/] If the various paths converging on the point of presence are uncoordinated, and if different users consequently employ different transmission technologies, the ability of the hub to support multiple incoming links could be diminished – particularly if any of the incoming links seek to use the full breadth of one of the 71-76 GHz or 81-86 GHz bands – because adjacent inbound links may be receiving the same frequencies needed for transmissions on the inbound full band link.[21/]

However, the possibility that dense deployments of high-bandwidth radio links will be discouraged in these settings does not warrant, at this stage, a rule that would restrict *all* 71-76 GHz and 81-86 GHz to dual-band FDD technology. First, there is no evidence that a significant number of 71-76 GHz and 81-86 GHz links will be deployed in the near future in hub-and-spoke settings, as opposed to random placements, or that a significant percentage of 71-76 GHz and 81-86 GHz links will consist – in the near future – of radios that require the full breadth of each band. Further, there is little reason to assume that hub-and-spoke scenarios will be uncoordinated. It is more likely that hub-and-spoke arrangements will occur in coordinated settings. A hub-and-spoke site managed by a carrier will certainly be operated on a coordinated basis, so that the carrier may provide acceptable service to its customers. A site operated as a

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[20/] At the WCA Meeting, all parties agreed that this circumstance is the only one that would likely increase the incidence of co-channel interference. Terabeam's use of the terms "coordinated" and "uncoordinated" in the context of this discussion only refers to restrictions imposed by a site manager or telecom operator, apart from those imposed by the FCC or by a band administrator, to ensure the most efficient use of the spectrum at the hub-and-spoke site. In either case (coordinated or uncoordinated hub-and-spoke configurations) Terabeam envisions the operation of millimeter wave spectrum only after the issuance of a site license, subject to routine interference assessment by the FCC itself or a band administrator.

[21/] Or, conversely, this situation could occur if an adjacent outbound link transmits on the same frequencies needed for reception on the outbound full band link.

"telecom hotel" will also likely be operated on a coordinated basis, so that the "hotel" operator can provide an acceptable grade of service to its customers.[22/] Finally, it has not been shown that compelling the use of dual-band FDD radios will materially enhance the ability to deploy 71-76 GHz and 81-86 GHz links because of the presence of other interference constraints. For example, even with the use of dual-band FDD technology, some spatial diversity between transmitters is required, just as it would be for the use of single band FDD and TDD transmitters

Accordingly, Cisco's proposal would impose the use of dual-band FDD technology on all radios to address a limited circumstance (uncoordinated use of the band in a hub-and-spoke architecture) with uncertain benefit. However, adoption of the proposal would impose several significant burdens. A requirement to use dual-band FDD technology will increase the cost to manufacture transmitters, thereby resulting in higher cost of using the band to the public. While the technology for both 71-76 GHz and 81-86 GHz radios is similar, each band requires individual development of millimeter wave components, in contrast to a single band radio where one set of components could be developed to cover a single band. These common components would benefit from higher volumes (two per radio rather than just one), resulting in lower equipment cost.

Further, Terabeam, among others, already produces equipment for the unlicensed 60 GHz band today. That technology could be adopted comparatively quickly for use in the 71-76 GHz band. If Terabeam and others were permitted to manufacture equipment that allowed single band FDD transmissions in the 71-76 GHz band, that equipment would be available to the public soon after the FCC concludes its rule making proceeding. However, today's 60 GHz technology

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22/ The entity responsible for a coordinated hub and spoke is certainly permitted by the current proposal to install dual-band radios if it believes that doing so will best meet its system requirements.

is not quickly adaptable to the 81-86 GHz band. If the FCC, as Cisco suggests, requires the use of dual-band FDD technology, the introduction of equipment to use the 81-86 GHz band will be delayed and may inhibit adoption. Also, as noted below, a dual-band FDD requirement would impose unnecessary interference near RAS facilities, which seek the use of the 81-86 GHz band on a primary basis. One transmitter in dual-band FDD radio would be forced to occupy this band and cause potential interference, whereas a singleband FDD link operating in the 71-76GHz band would pose no threat to RAS activities.

Finally, restriction of the use of this band to a particular technology is contrary to Commission precedent. In recent decisions, the Commission has demonstrated its commitment to adopting technology-neutral regulatory policies. For example, in the Commission's recent Biennial Review of its Part 22 rules and regulations, it noted that it is moving toward a less regulatory approach with respect to [its] service rules and [is] permitting carriers to deploy technologies that best fit the needs of the market.[23/] Moreover, the Commission recently expressed its commitment to adopting band plans that are technology-neutral and neither favors nor prejudiced one . . . technology over another."[24/] By placing the dual-band FDD restriction on all radios, the FCC would be restricting innovation in these bands by limiting a single radio and system architecture for an industry that has not yet developed.

23/ *Year 2000 Biennial Regulatory Review - Amendment of Part 22 of the Commission's Rules to Modify or Eliminate Outdated Rules Affecting the Cellular Radiotelephone Service and other Commercial Mobile Radio Services*, WT Docket No. 01-108, Report and Order, 17 FCC Rcd 18401 ¶ 45 (2002).

24/ *Amendments to Parts 1, 2, 27, and 90 of the Commission's Rules to License Services in the 216-220 MHz, 1390-1395 MHz, 1427-1429 MHz, 1429-1432 MHz, 1432-1435 MHz, 1670-1675 MHz, and 2385-2390 MHz Government Transfer Bands*, WT Docket No. 02-8, Report and Order, 17 FCC Rcd 9980 ¶ 54.

2. Automatic Transmitter Power Control

Cisco also recommends that the FCC mandate a minimum automatic transmitter power control ("ATPC") range and adopt conditions for its use. In particular, Cisco would require ATPC with equipment with EIRP of 15 dBW or greater. Terabeam disagrees with Cisco's proposal. Like its proposal to mandate the use of FDD technology, Cisco's ATPC proposal is based principally on the use of the 71-76 GHz and 81-86 GHz bands in an uncoordinated environment in a hub-and-spoke configuration. As Terabeam noted above, the extent of the problem Cisco projects is uncertain. Therefore, Cisco would require manufacturers to include ATPC, with additional costs to end users, on far more equipment than may be necessary.

Terabeam is not convinced that the FCC needs to require that users bear the additional cost of ATPC for an uncertain benefit. If any ATPC requirements are adopted, they should be set at a level that is consistent with current manufacturing capabilities. As noted above, Terabeam participated in the WCA Meeting. Based on those discussions, Terabeam understands that others submitting reply comments will recommend that a requirement for ATPC should be limited to installations in which transmitters will be operated at power levels above 23 dBW EIRP. If ATPC will be required in any circumstances, Terabeam agrees that 23 dBW is a reasonably derived limit based on theoretical assumptions. However, instead of adopting these recommendations based on theoretical assumptions, the FCC should set any ATPC threshold at 25 dBW, so that vendors are permitted a reasonable margin for variances that result from manufacturing tolerances and the impact of climate on actual power levels.

Moreover, if ATPC is mandated, Terabeam generally agrees with the approach to use Power Flux Density ("PFD") as the receiver power limit. It is premature, however, to set the limit at 100pW/cm^2 as discussed at the WCA Meeting. Further evaluation of this issue is required to ensure that a variety of modulation schemes and bandwidths are permitted and to

make certain that this limit can both accommodate manufacturing tolerances and environmental impact while still promoting the use of more power-efficient radios.

Finally, while ATPC is permitted by Part 101 of the FCC's rules today, its use is not mandated.[25/] The Commission should adopt the same approach to ATPC in the millimeter wave bands.

3. Restrictions on Beamwidth and Power Limits

In its comments, Terabeam recommended changes to the table proposed by the WCA, which specifies permissible power and antenna beamwidth levels. In particular, Terabeam recommended a change in the proposed formula for maximum allowable EIRP for antennas with less than 50 dBi of gain. This formula has been further refined at the WCA Meeting. Terabeam supports the revised recommendation reached at the WCA Meeting which envisions reducing the maximum EIRP of systems deploying antennas of gain less than 50dBi by a ratio of 2dB EIRP reduction for every dB of gain below 50dBi. Not addressed in Terabeam's comments, but a subject of discussion in Cisco's comments and the WCA Meeting, is the lowest permissible level of antenna gain. In particular, Cisco proposes a minimum gain antenna of 43dB and 1.2 degree beamwidth. Terabeam recommends a minimum antenna gain of 40 dBi and a maximum half-power beamwidth of 2.0 degrees. As Terabeam noted earlier, it expects the millimeter wave bands to be employed by wireless carriers for backhaul purposes. Accordingly, antennas will be mounted on wireless towers (as opposed, for example, to building) subject to moderate wind movement. A gain floor of anything higher than 40 dBi and maximum half power beamwidth of lower than 2.0 degrees will not permit the deployment of antennas capable of fulfilling this need. If the FCC adopts Terabeam's recommended antenna gain and beamwidth limitations, then the

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25/ *See* 47 C.F.R. § 101.113(b) (discussing the power limitations for transmitters that *use* ATPC) (emphasis added); 47 C.F.R. § 101.143(b) (accord).

radiation suppression table initially proposed by WCA must be modified so that the innermost radiation restriction "L1" would apply only to *sidelobes* in the region of 1.2 degrees to 5 degrees from beam center, not the main lobe.

4. Digital Modulation

Cisco recommends that the FCC require digital modulation in the 71-76 GHz and 81-86 GHz bands. Terabeam disagrees that such a blanket requirement is necessary. The basis for Cisco's recommendation is its concern for the interference that may be caused to radio astronomy service ("RAS") operations by the use of analog or unscrambled digital signals. However, Cisco's legitimate concerns for RAS operations may be addressed without unnecessarily restricting the type of technology that may be employed in the vast majority of the country.

All parties recommend coordination with RAS within the defined exclusion zones. However, the use of digital modulation need not be mandated within exclusion zones. Instead, Terabeam agrees with the consensus reached at the WCA Meeting that, based upon description of a proposed millimeter wave system to the RAS coordinator, the RAS coordinator may, based upon an analysis of the proposed system and a determination of likely harmful interference, require the use of digital modulation. In fact, the NPRM proposes deleting the primary RAS allocation in the 71-76 GHz band. Single band FDD or TDD radio in the 71-76 GHz band with any modulation scheme would provide even greater protection than digital modulation within the 81-86 GHz band.

III. CONCLUSION

Based on the foregoing, Terabeam urges the Commission to adopt regulations as described above and to act in a manner consistent with the recommendations made herein.

Respectfully submitted,

TERABEAM CORPORATION

By: */s/ Russell H. Fox*

Howard J. Symons
Russell H. Fox
Susan S. Ferrel
MINTZ, LEVIN, COHN, FERRIS,
GLOVSKY AND POPEO, P.C.
701 Pennsylvania Avenue, N.W.
Washington, DC 20004-2608
(202) 434-7300

Its Attorneys

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