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Magalie Roman Salas
Office of the Secretary
Federal Communications Commission
The Portals
445 Twelfth Street, SW - Room TW-A325
Washington, DC 20554

Re: *In the Matter of Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range* and *Amendment of the Commission's Rules to Authorize Subsidiary Terrestrial Use of the 12.2-12.7 GHz Band by Direct Broadcast Satellite Licensees and Their Affiliates*; ET Docket No. 98-206, RM-9147, and RM-9245

Dear Ms. Salas:

Enclosed for filing are (1) and original and eight copies of QUALCOMM Incorporated's ("QUALCOMM's") Comments regarding the above-referenced dockets (an original and four copies, plus two copies for each of the two additional dockets), and (2) a 3.5-inch diskette containing QUALCOMM's Comments that is formatted in WordPerfect 5.1. We are also enclosing an additional copy to be stamped and returned to us with the courier (marked as such).

Please call if you have any questions or comments.

Sincerely,

J. Breck Blalock

Enclosures

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Before the
Federal Communication Commission
Washington, D.C. 20554

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In the Matter of	)	
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Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range	)	ET Docket No. 98-206 RM-9147 RM-9245
	)	
and	)	
	)	
Amendment of the Commission's Rules to Authorize Subsidiary Terrestrial Use of the 12.2-12.7 GHz Band by Direct Broadcast Satellite Licensees and Their Affiliates	)	

COMMENTS OF QUALCOMM INCORPORATED

QUALCOMM Incorporated ("QUALCOMM"), by its attorneys, hereby submits its comments to the Commission in the above-captioned proceeding.[1] QUALCOMM owns and operates the OmniTRACS® system, a two-way messaging and position tracking system operating in the Ku-band.[2] OmniTRACS® is used primarily by the commercial long-haul trucking industry, although QUALCOMM is also authorized to provide OmniTRACS® services

1 *Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range, et al.*, ET Docket No. 98-206, *Notice of Proposed Rulemaking,* FCC 98-310 (rel. November 24, 1998) ("NPRM").

2 *QUALCOMM Inc.*, Order, 4 FCC Rcd 1543 (1989).

in the maritime environment.[3] QUALCOMM currently provides service to over 200,000 OmniTRACS® units and offers similar services in approximately 33 countries other than the United States.

I. THE COMMISSION SHOULD DEFER IMPLEMENTING AN NGSO/GSO SHARING PLAN IN THE KU-BAND PENDING THE CONCLUSION OF WRC-2000

QUALCOMM is concerned that the introduction of non-geostationary orbit satellite ("NGSO") fixed-satellite services ("FSS") in the Ku-band may interfere with the use and growth of incumbent services, particularly under the spectrum sharing criteria developed at the 1997 International Telecommunications Union ("ITU") World Radio Conference ("WRC-97"). Although QUALCOMM does not object to spectrum sharing between geostationary satellite orbit ("GSO") and NGSO systems in general, QUALCOMM is concerned that basing such spectrum sharing criteria on the provisional power flux density limits adopted at WRC-97 is premature.

QUALCOMM notes that the provisional limits adopted at WRC-97, and the justifications for the limits, have not been fully studied in the usual matter by the ITU Radiocommunications Sector. Currently, Joint Task Group 4-9-11, in which the U.S. participates, is conducting technical analysis of these sharing issues in preparation for WRC-2000. The outcome of this analysis is crucial in determining whether incumbent GSO satellite system operators will be adequately protected from NGSO interference, particularly where multiple NGSO systems may be deployed.

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[3] *Mobile Satellite-Based Communications Services By Crescomm Transmission Services, Inc. and QUALCOMM, Inc.*, 11 FCC Rcd 10944, 10950 (1996).

Because of the foregoing, the Commission should refrain from implementing the proposed power limits until such time as the ITU process, including WRC-2000, has been completed.

II. THE COMMISSION SHOULD TREAT QUALCOMM AS AN INCUMBENT GSO KU-BAND OPERATOR FOR PURPOSES OF ESTABLISHING NGSO/GSO KU-BAND SHARING CRITERIA

Although QUALCOMM provides OmniTRACS® services as a secondary service in the Ku Band, the public interest justifies the Commission treating QUALCOMM as an incumbent, primary Ku-band GSO service provider for purposes of sharing analysis. QUALCOMM has provided OmniTRACS® services in the Ku-band for more than 10 years during which time OmniTRACS® has become one of the most important VSAT services in the United States.

The long-haul trucking industry, which OmniTRACS® primarily serves, is the primary means by which goods are delivered to market in the United States. OmniTRACS® contributes substantially to the long-haul trucking market's competitiveness and ability to efficiently distribute goods throughout the United States. Considering the importance of this distribution system to the U.S. economy and to the public welfare, the Commission should give the OmniTRACS® system equal weight with other incumbent Ku-band GSO VSAT operations for the limited purpose of developing spectrum sharing criteria between NGSO and GSO Ku-band systems.

III. ANY POWER FLUX DENSITY LIMITATIONS ADOPTED BY THE COMMISSION FOR NGSO KU-BAND SYSTEMS SHOULD INCLUDE LIMITATIONS TO ACCOUNT FOR THE OMNITRACS® ANTENNA

QUALCOMM has performed a preliminary technical analysis ("Technical Analysis"), attached hereto as Attachment 1, of the sharing proposals listed in the NPRM as they may impact the OmniTRACS® system. QUALCOMM's analysis indicates that a single NGSO system operating within the proposed power flux density limits will not significantly impact

OmniTRACS® operations, provided that the Commission adopt a -153.8 dBW/m^2/4kHz equivalent power flux density ("epfd") limit at 100 percent of NGSO operating time for VSAT units similar to QUALCOMM's OmniTRACS® VSAT units.[4]

The Commission has listed the provisional epfd (downlink) limits for various GSO receiver reference antenna diameter and patterns in Table 1 of the NPRM. The Commission has asked for comment on whether the proposed limits adequately protect incumbent GSO Ku-band operations.[5] The Commission has also asked for comments on whether the epfd limits in Table 1 adequately protect all GSO Ku-band earth stations.[6]

As outlined in the Technical Analysis, QUALCOMM has determined that the satellite to OmniTRACS® VSAT terminal downlink, the predominant link in the OmniTRACS® forward link, is susceptible to unacceptable signal degradation at epfd of more than -153.8 dBW/m^2/4kHz. While this epfd level is higher than the levels identified generally in Table 1, the limits in the table have been calculated for standard rotationally symmetrical reference antennas. Because QUALCOMM's OmniTRACS® antenna has a gain pattern that is dramatically different from the typical rotationally symmetrical antenna, QUALCOMM is concerned that the epfd limits referenced in Table 1 may not be sufficient to adequately protect the OmniTRACS® forward downlink from unacceptable interference from NGSO operations.

To address this concern, the FCC should only adopt sharing criteria that account for QUALCOMM's OmniTRACS® VSAT terminals. Because of the unusual pattern of the OmniTRACS® VSAT antenna, any such sharing criteria must include an epfd limit of not more

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4 Technical Analysis at 3-4.

5 NPRM at ¶ 26.

6 NPRM at ¶ 27.

than -153.8 dBW/m^2/4kHz for 100 percent of the time of NGSO operation for antennas similar to OmniTRACS® VSAT terminals.

QUALCOMM has also analyzed the Commission's proposed epfd limits with respect to the OmniTRACS® 9 meter hub downlink. This analysis indicates that the OmniTRACS® satellite to hub downlink can tolerate an epfd of -197.0 dBW/m^2/4kHz without unacceptable interference. Although this figure is slightly lower than the Commission's proposed limit for a 10 meter reference antenna, QUALCOMM does not believe that this difference requires revised epfd limits to address QUALCOMM's 9 meter hub downlink.[7]

IV. IF THE COMMISSION ADOPTS THE PROPOSED POWER FLUX DENSITY LIMITS, THEN THOSE LIMITS SHOULD APPLY TO ALL NGSO SYSTEMS IN THE AGGREGATE

The provisional power flux density limits adopted by WRC-97 and proposed by the Commission apply only to a single NGSO FSS system and do not consider the impact of multiple NGSO systems. However, in January of this year Boeing, Hughes Communications, Virtual Geosatellite, LLC, and Teledesic LLC, each submitted applications for NGSO systems operating in the Ku-band. The now substantial likelihood that multiple NGSO systems operating in the Ku-band will be deployed weighs against the FCC adopting final sharing rules until the conclusion of the ITU review process.

Moreover, the interference analysis presented herein by QUALCOMM represents the total interference the OmniTRACS® system can accept from all sources. For the conclusions QUALCOMM has reached to be valid in a multiple entry NGSO environment, the power flux density limits adopted by the Commission must apply to all NGSO systems in the aggregate.

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[7] Technical Analysis at 4. QUALCOMM's analysis also indicates that the Commission's proposed single system aggregate power flux density limit of -170 dB (W/m^2) would not cause unacceptable degradation of OmniTRACS® 14.0-14.5 GHz uplinks. *Id.* at 5.

Accordingly, if the Commission adopts sharing rules based on power flux density limits at this time, the Commission should require that all NGSO systems in the aggregate meet the proposed limits.

Respectfully submitted,

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Attorneys for QUALCOMM Incorporated

March 2, 1999

ATTACHMENT 1

TECHNICAL ANALYSIS

Non Geo-stationary Satellite Orbit (NGSO) Interference to OmniTRACS

The FCC is in the progress of approving NGSO Ku-band service. As part of this approval, the FCC has proposed a Ku-band spectrum-sharing plan for a single NGSO Ku-band system. The intent of the plan is to allow both an NGSO service (like SkyBridge) and GSO services (like OmniTRACS) to use the Ku-band such that the interference between the two is minimal. Specifically, the FCC would be opening the 11.7 – 12.2 GHz band for satellite to ground links and the 14.0 – 14.5 GHz band for ground to satellite links for NGSO services. Because these are the bands used by OmniTRACS, there is potential for NGSO services to interfere with OmniTRACS.

The FCC is seeking comments on their proposed spectrum-sharing plan. The gist of the plan is to limit the power flux density (pfd) that the NGSO satellites and earth stations can produce. The FCC has proposed pfd limits on the NGSO services that are believed by them to be low enough so that they have no noticeable affect on geostationary services like OmniTRACS.

It should be noted that the FCC is proposing granting NGSO services primary access to the band. OmniTRACS was granted access to this band as a secondary user. However, QUALCOMM has nearly 200,000 existing OmniTRACS mobile terminals operating throughout CONUS providing an extremely very valuable service to the domestic long distance trucking industry (among other industries). Accordingly, OmniTRACS should be given the same interference protection from new NGSO services as are primary users of the Ku-band.

To evaluate the effect the NGSO interference may have on the OmniTRACS system, one should look at the individual OmniTRACS links.

OmniTRACS Link	Space Link	
Forward (Hub-to-Mobile)	Uplink	Downlink
Return (Mobile-to-Hub)	Uplink	Downlink

The two shaded entries in the table above are the predominate links for the combined E_b/N_0 (U/L plus D/L) calculations. The predominate links are between the satellite and the mobile. These links are predominant because the combined E_b/N_0 for the forward and return links is essentially the same as the E_b/N_0 for the relevant predominant link. Any degradation in these predominate links E_b/N_0s affect the combined E_b/N_0 for that link, essentially on a dB-for-dB basis. Thus, these two predominate links need the most interference protection.

To measure the effect the NGSO interference has on the individual (U/L or D/L) and combined links the E_b/N_0 degradation is analyzed.

Forward and Return Downlink Interference Analysis

The ITU has made a recommendation (ITU-R Recommendation S.1323) for the level of NGSO interference a GSO system should accept (6% of total system noise). The following analysis

evaluates the E_b/N_0 degradation this level of interference produces. Then the resultant NGSO power flux density is calculated.

The following terms are used in the analysis:

N_0 = receiver thermal noise power density.
I_{g0} = interference power density from GSO systems.
I_{n0} = interference power density from any one NGSO system.

First, the mobile terminal and hub N_0 is calculated.[1]

	Mobile Terminal (Forward Link)	**Hub (Return Link)**
System Noise Temperature	25.7 dB-°K	21.7 dB-°K
K	-228.6 dBW/°K-Hz	-228.6 dBW/°K-Hz
N_0	-202.9 dBW/Hz	-206.9 dBW/Hz

Next, the existing level of GSO interference (I_{n0}) seen by the mobile terminal and hub is calculated. Assuming the majority of the GSO interference comes from the two adjacent satellites in the geo-stationary arc, a calculation of the existing I_{g0} is in the following table.

	Forward Downlink (Mobile Terminal)	**Return Downlink (Hub)**
Adjacent Satellite EIRP (typical)	48 dBW	
Slant Range (typical)	37209 Km	
Adjacent Satellite Interference PFD	-114.4 dBW/m^2	
Adjacent Satellite Interference BW	36 MHz	
Adjacent Satellite Interference PFD (1 Hz)	-190.0 dBW/m^2/KHz	
Number of Adjacent Satellites	2	
Total Adjacent Satellite Interference	-187.0 dBW/m^2/4KHz	
Receive Antenna Ae (11.7 GHz)	-24.8 dB-m^2 (G=18dBi towards interferer)	-22.8 dB-m^2 (G=20dBi towards interferer)
Adjacent Satellite (I_{g0})	-211.8 dBW/Hz	-209.8 dBW/Hz
N_0/I_{g0}	8.9 dB	2.9 dB

Next, the level of NGSO interference (I_{n0}) is calculated. ITU-R Recommendation S.1323 recommends that GSO systems be designed to accept an interference level from any one NGSO system up to 6% of the total system noise power (N_0+I_{g0}). From this, one can calculate N_0/I_{n0}.

[1] The system noise temperatures are taken from the mobile terminal and earth station FCC Radio Station Authorizations.

	Forward Downlink	Return Downlink
$(N_0+I_{g0})/I_{n0}$	12.2 dB	
N_0/I_{g0}	8.9 dB	2.9 dB
N_0/I_{n0}	11.7 dB	10.4 dB

The downlink degradation caused by NGSO interference can now be calculated.

	Forward Downlink	Return Downlink
E_b/N_0	0 dB	0 dB
N_0/I_{g0}	8.9 dB	2.9 dB
$E_b/(N_0+I_{g0})$	-0.5 dB	-1.8 dB
N_0/I_{n0}	11.7 dB	10.4 dB
$E_b/(N_0+I_{g0}+I_{n0})$	-0.8 dB	-2.0 dB

These calculations show that NGSO interference degrades the forward downlink by 0.3 dB and the return downlink by 0.2 dB. Because the downlink is the predominant link on the forward link, the forward link will be degraded by 0.3 dB. A return downlink degradation of 0.2 dB will have virtually no effect on the return link.

Next, the following calculations derive the NGSO interference levels that produce the aforementioned E_b/N_0 degradations.

	Forward Downlink (MCT)	Return Downlink (Hub)
N_0 (dBW/Hz)	-202.9	-206.9
Target N_0/I_{n0} (dB)	11.7	10.4
I_{n0} (dBW/Hz)	-214.6	-217.3
I_{n0} (dBW/4KHz)	-178.6	-181.3
ET Antenna Ae (m^2) (11.7 GHz)	0.00328 (G=18dBi)	36.8 (G=58.5dBi)
ET Ae (dB-m^2)	-24.8	15.7
Acceptable I_{n0} pfd (dBW/m^2/4KHz)	**-153.8**	**-197.0**

As part of the FCC NGSO spectrum sharing plan, the FCC has defined "effective power flux density (epfd)" as, "*Epfd is the sum of the power levels of all possible interfering transmissions from all satellites in a particular NGSO constellation into a particular GSO earth station receiver.*" [1]. The equation that defines epfd appears in [1] and is shown at the end of the analysis for reference.

The FCC has defined epfd limits for a variety of reference antennas; 60 cm, 3m and 10m as defined in ITU-R S.465-5. (See [1], page 18.) The reference antennas all have the same assumed pattern of $G = 32 - 25 \log\Theta$ for $\Theta > \Theta_{min}$ and the pattern is rotationally symmetrical. The FCC recognizes that they have not addressed all antenna types and has asked for comments on others.

QUALCOMM's OmniTRACS mobile antenna has a pattern that is quite different from any of these reference antennas in that it is fan shaped with a broad elevation angle and even a relatively broad azimuth pattern.[2] Consequently, the epfd limits do not sufficiently address the needs of the OmniTRACS system. NGSO services should consider the affect that their space stations have on OmniTRACS mobile terminals.

The above calculation shows that OmniTRACS mobile terminals can tolerate an interference level of –153.8 dBW/m^2/4KHz with small affect when the NGSO satellite is in line with the OmniTRACS MCT victim antenna and the GSO satellite it is receiving from. Because of the definition of epfd, this value is also the epfd limits that can be accepted for the reference antenna where the gain of the antenna at an angle Θ must consider the fact that the antenna is not rotationally symmetric. Likewise, the OmniTRACS hub can tolerate an interference level of –197.0 dBW/m^2/4KHz.

Because the analysis results for the 9 meter OmniTRACS hub antenna are very close to the epfd limits already defined for a 10 meter reference antenna, OmniTRACS most likely can accept the 10 meter epfd limits (as opposed to requesting new limits be defined for a 9 meter antenna).

However, because the OmniTRACS mobile terminal has a unique antenna, QUALCOMM requests that the FCC add epfd limits that address the OmniTRACS antenna. Specifically, QUALCOMM would like to see an epfd limit of –153.8 dBW/m^2/4KHz not be exceeded 100% of the time for an OmniTRACS reference antenna.[3] QUALCOMM's justification for the 100% time limit is that since the OmniTRACS antenna pattern is wide, any interfering signal received by the mobile terminal is likely to remain within the 3dB points of the antenna for a significant time period. Thus, QUALCOMM would like to see the level of –153.8 dBW/m^2/4KHz not be exceeded. It should be noted that this epfd level is significantly higher than other epfd values specified by the FCC for other reference antennas.

Because QUALCOMM requests this epfd limit 100% of the time, QUALCOMM would be willing to coordinate with the potentially interfering NGSO system the frequencies and GSO satellites OmniTRACS are using. Although OmniTRACS uses multiple frequencies and satellites, they do not change often, so it should not be too difficult to prevent intersystem interference.

Forward and Return Uplink Interference Analysis

The FCC has defined apfd as, *"Apfd is the sum of the power levels at a location on the GSO arc created by all visible earth station transmitters in an NGSO system."* Refer to [1] for the equation defining apfd and it is shown at the end of the analysis for reference. The FCC has

[2] The OmniTRACS mobile terminal pattern is fan-shaped. In the US, the boresight elevation is approximately 40° with a 40° beamwidth. The azimuth beamwidth is relatively narrow (about 7°). The MCT steers the beam in azimuth, but the beam remains fixed in elevation.

[3] An OmniTRACS reference antenna pattern is approximately sinx/x shaped in both elevation and azimuth. The elevation 3dB beamwidth is 40 degrees with a boresight of 40 degrees. The azimuth 3 dB beamwidth is approximately 7 degrees. Maximum gain is approximately 18 dBi.

proposed an apfd limit of –170 dBW/m^2/4KHz[4]. The NGSO apfd may potentially interfere with the OmniTRACS uplinks.

The following calculations measure the affect this level of uplink interference has on OmniTRACS. It compares E_b/N_0 to $E_b/(N_0+I_{n0})$ where I_{n0} represents the interference effect of the apfd sources.

	Forward Uplink (Hub)	**Return Uplink (MCT)**
ET EIRP (typical)	71.0 dBW	13.0 dBW
Slant Range (typical)	37209 Km	37209 Km
PFD at GSO arc	-91.41 dBW/m^2	-149.41 dBW/m^2
Bit Rate	36.96 dB-Hz	20.42 dB-Hz
E_b (per square meter)	-128.37 dBW/m^2/Hz	-169.83 dBW/m^2/Hz
NGSO I_{n0} PFD (4KHz)	-170 dBW/m^2/4KHz	-170 dBW/m^2/4KHz
NGSO I_{n0} PFD (1Hz)	-206.02 dBW/m^2/Hz	-206.02 dBW/m^2/Hz
E_b/I_{n0}	77.65 dB	36.19 dB
ET EIRP (typical)	71.0 dBW	13.0 dBW
Path Loss (typical)	207.08	207.08
Spacecraft G/T (typical)	-5	-5
Bit Rate	36.96 dB-Hz	20.42 dB-Hz
E_b/N_0	50.56	9.10
$E_b/(N_0+I_{n0})$	50.56	9.09

From this calculation, one can see that E_b/N_0 is essentially equal to $E_b/(N_0+I_{n0})$. The result will be that the return $E_b/(N_0+I_{n0})$ is degraded only by 0.01 dB. The OmniTRACS forward link is not degraded at all. OmniTRACS can tolerate an apfd level of –170 dBW/m^2/4KHz well.

Summary

This analysis evaluated the expected E_b/N_0 degradation due to NGSO interference and the acceptable power flux density levels from NGSO space stations. A recommended epfd limit for OmniTRACS mobile antennas was calculated. It was also shown that the FCC's proposed limit of NGSO space station interference (apfd) has minimal impact on OmniTRACS.

The pfd limits used and calculated in this analysis are those that OmniTRACS can tolerate from **all** sources. The FCC NGSO limits refer to the interference produced by any one NGSO system. The FCC recognizes that existing Ku-band users must be protected from all such systems. Thus, interference limits must be defined that apply to NGSO systems in the aggregate. QUALCOMM realizes that simply reducing the limits by 10log(N) (N being the number of NGSO systems in

[4] In the reference document the FCC proposes an apfd limit of –170 dB(w/m^2) in the 12.75-13.25 GHz band. It is not clear whether this limit also applies to the 14.0-14.5 GHz band. This analysis assumes it does apply. It is also assumed the reference bandwidth for the apfd is 4KHz.

operation) may be overly precautionary, but recommends that approach until a more rigorous analysis is performed.

Reference:

[1] Notice of Proposed Rule Making, FCC 98-310
[2] Recommendation ITU-R S.1323

EPFD and APFD Definitions

$$apfd = 10 \times \log\left[\sum_{i=1}^{N} 10^{P(i)/10} \times \frac{G_t(\Theta_i)}{4\pi d_i^2}\right]$$

where:

- N is the number of earth stations in the NGSO system with an elevation angle greater than or equal to 0, from which the point considered in the GSO is visible.
- i is the index of the earth station considered in the NGSO system.
- $P(i)$ is the RF power flux density at the input of the transmitting antenna of the earth station considered in the NGSO system in dBW in the reference bandwidth
- Θ_i is the off-axis angle between the boresight of the earth station considered in the NGSO system and the direction of the point considered in the GSO.
- $G_t(\Theta_i)$ is the transmit antenna gain (as a ratio) of the earth station considered in the NGSO system.
- *d_i is the distance from transmit antenna i to the GSO arc.*

$$epfd = 10 \times \log\left[\sum_{i=1}^{N} 10^{pfd(i)/10} \times \frac{G_r(\Theta_i)}{G_{\max}}\right]$$

where:

- N is the number of NGSO space stations to be considered with elevation angle ≥ 0.
- i is the index of the NGSO space station considered.
- $pfd(i)$ is the power flux density at the earth's surface at the point considered in the reference bandwidth (4 KHz).
- Θ_i is the angle between the direction considered towards the GSO and the direction towards the interfering NGSO space station.
- $G_r(\Theta_i)$ is the gain (as a ratio) of the receive reference antenna to be considered as part of the GSO network.
- G_{max} is the maximum gain (as a ratio) of the above reference antenna.

CERTIFICATE OF SERVICE

I, Susanne M. Gyldenvand, hereby certify that a copy of the foregoing Comments of QUALCOMM Incorporated was sent by hand delivery (when marked by an "*"), or by U.S. Mail, postage prepaid, on this 2nd day of March 1999 to the following:

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Attachment A

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