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April 14, 1999

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Federal Communications Commission
The Portals
445 Twelth Street, S.W.
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RE: Reply Comments of the Boeing Company
ET Docket No. 98-206

Dear Roman Salas:

Please find attached an electronic copy of the Reply Comments of the Boeing Company in ET Docket No. 98-206. Also included on the disk is Attachment 1 to the Reply Comments of the Boeing Company. The printed original of Boeing's Reply Comments were also submitted to your office on this date accompanying this submission.

Thank you for your attention to this matter. Please let me know if you have any questions.

Sincerely,

Bruce A. Olcott
Counsel for The Boeing Company

BAO/ar

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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

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	)	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	)	

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REPLY COMMENTS OF THE BOEING COMPANY

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April 14, 1999

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REPLY COMMENTS OF THE BOEING COMPANY

The Boeing Company ("Boeing"), by its attorneys and pursuant to Section 1.415 of the Commission's Rules, 47 C.F.R. § 1.415, hereby submits reply comments in response to the above referenced Notice of Proposed Rule Making ("*NPRM*").

I. INTRODUCTORY SUMMARY

This proceeding marks an important milestone in the global development of the commercial satellite communications industry. The Commission is proposing in the instant *NPRM* to establish rules and licensing procedures for non-geostationary ("NGSO") satellite system providing broadband communication services in the fixed satellite service ("FSS") in the Ku-band.

The licensing of Ku-band NGSO FSS systems raises numerous public policy and technical issues – the most important of which is protecting co-frequency geostationary ("GSO") and terrestrial services in the Ku-band. Fortunately, the International Telecommunications Union ("ITU"), Radiocommunications Sector ("ITU-R") has taken an aggressive role in studying and resolving technical and public policy questions. Experts from around the world have been meeting regularly in a number of study groups to devise the most efficient means to permit NGSO FSS entry into the Ku-band on a shared basis with existing operators.

Obviously, there are still outstanding issues that must be resolved by international technical committees. Importantly, however, the comments filed in this proceeding evidence a remarkable level of concurrence and confidence in the ongoing ITU-R study process – generally acknowledging that the FCC should give substantial deference to the findings of ITU-R technical committees and should rely heavily on their expertise in establishing rules for NGSO FSS systems authorized to serve the United States.

Boeing agrees with other commentors in this proceeding that whenever possible the Commission should utilize the outputs of the ITU-R study process as a model for U.S. licensing rules. Boeing also believes, however, that the FCC and the United States delegation to the various ITU technical committees should continue to take a lead role in shaping the international regulatory structure that is expected to be adopted by WRC-00 for NGSO FSS systems.

As a part of this leadership role, Boeing urges the Commission to issue a First Report and Order in this proceeding prior to the start of the Conference Preparatory Meeting ("CPM"), scheduled for November 15, 1999 in Geneva. Issuance of a First

Report and Order would provide the United States with a concise and indisputable statement of U.S. policy that can be effectively used to build consensus at the CPM. Issuance of a First Report and Order would also give other administrations additional notice that the United States intends to deploy aggressively global NGSO FSS systems in the Ku-band within the stringent milestone requirements of ITU-R Radio Regulations S9.1 and S11.44.[1]

Admittedly, any Report and Order issued prior to the CPM would be unable to resolve each and every question that has been raised in the *NPRM* and the various comments filed in this proceeding. An initial FCC order could resolve a great many questions, however, and could crystallize the remaining issues that must be addressed by the Commission and WRC-00. In the end, an initial FCC order would provide significant assistance in establishing consensus at the fall CPM and could bring to focus the remaining issues that must be resolved in the months leading up to WRC-00 in Istanbul.

II. THE COMMISSION SHOULD ADOPT A DUAL EPFD MASK APPROACH IN ORDER TO MAXIMIZE THE NUMBER AND DIVERSITY OF NGSO FSS SYSTEMS THAT CAN OPERATE IN THE KU-BAND ON A SHARED BASIS WITH GSO NETWORKS.

In its initial comments in this proceeding, Boeing raised concern that any EPFD mask adopted in this proceeding should not unnecessarily constrain NGSO FSS systems that only produce long term interference into GSO networks without producing short

[1] Radio Regulations S9.1 and S11.44 require administrations to bring satellite networks into use within five years following the date of receipt by the ITU-R of the Advance Notification information specified in S9.1. The regulations also permit a two-year extension under certain limited circumstances. Since the ITU-R received initial information for most NGSO FSS systems in late 1997, the deadline for bringing these systems into use is late 2002 – approximately three and a half years away.

term interference. Boeing's concern originated from the Chairman's Report for the January 1999 meeting of JTG 4-9-11, which speculated that the long term EPFD limit for NGSO FSS systems might be used as a freely adjustable variable in order to maximize the allowable EPFD limit for short term interference events.[2] Boeing argued that the Commission should encourage the international community to determine the most appropriate short term and long term EPFD limits independent of each other, rather than subordinate the value for either limit in order to maximize the other.

Since Boeing filed its initial comments with the Commission, Boeing has presented papers before US WP 4A and US JWP 10-11S recommending that the conflict between short term and long term interference dominated NGSO FSS systems be resolved by adopting two EPFD masks.[3] The use of two EPFD masks would maximize the number and diversity of NGSO FSS system designs that can be accommodated in the Ku-band. For example, Boeing's proposed NGSO FSS system produces a worst case increase in GSO FSS network unavailability of less than 0.6% – a small fraction of the 10% increase in unavailability provisionally adopted by WRC-97. Despite this miniscule

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[2] *See* Chairman's Report of the Third Meeting of JTG 4-9-11, ITU-R Doc. 4-9-11/367-E, at Attachment 1, Section 11.3.2 (Feb. 5, 1999). The report indicated that JTG 4-9-11 may recommend that a value for short term interference should be established by selecting the most lenient EPFD limit available that does not result in excessive sync-loss to GSO FSS space-to-Earth links. The report then suggests that the 10% unavailability limit could be complied with by making "consequential adjustments to other limits" – presumably referring to the long term EPFD level. *Id.*

[3] *See, e.g.,* Doc. USWP-4A/73, Doc. USWP 4A/49, Doc JWP 10-11s/USA15. Pursuant to Boeing's dual mask approach, one of the masks – a short term interference dominated mask – would be similar to the one currently being considered by the ITU-R and would allow for systems such as SkyBridge, which have higher peak interference for small percentages of time. The second mask – a long term interference dominated mask – would be developed using a single EPFD level not to be exceeded 100% of the time. This would accommodate NGSO FSS systems similar to Boeing.

impact on unavailability, however, the Boeing system cannot satisfy the EPFD mask that was proposed by the United States at the January meeting of JTG 4-9-11. Thus, adoption of a dual EPFD mask approach would enable the construction of a greater number of diverse NGSO FSS system designs, to the ultimate benefit of consumers, while protecting GSO systems.

Boeing's dual mask approach complies fully with the 10% increase in unavailability ceiling provisionally adopted by WRC-97. This is because each of the masks would be developed initially as aggregate masks, both independently compliant with the 10% unavailability limit. Each aggregate EPFD mask would then be disaggregated by "N" (the maximum total number of NGSO systems) to provide a single-entry mask.[4] Since each mask would be based on an aggregate mask, the underlying 10% unavailability ceiling would be satisfied regardless of the number of NGSO FSS systems that chose to comply with the long term interference dominated mask, or the number that chose to comply with the short term interference dominated mask.

Boeing's two mask approach could be implemented without any significant increase in regulatory burden for the ITU and FCC. This is because Boeing's dual mask approach can be administered in the same way that a regulation regime based on a single mask is administered – as illustrated in Boeing's proposed draft CPM text, included as Attachment 1 to these reply comments.

[4] In the case of the short term interference dominated mask, this would involve dividing the EPFD power by N in Zone A, and dividing the time percentage by N in Zone B. In the case of the long term interference dominated mask, this would simply involve dividing the aggregate EPFD value by N to determine a single-entry EPFD value for 100% of the time.

Boeing's dual mask proposal has received strong support in the U.S. GSO community. Boeing has reached agreement with GSO FSS interests in the U.S. on appropriate values for a single entry long term interference dominated EPFD mask, which are listed below in Table 1 for each of the antenna sizes under consideration.[5]

Table 1 – Long term EPFD Mask

Antenna Diameter	% Time Not Exceeded	EPFD Aggregate	EPFD Single-entry N = 3	EPFD Single-entry N = 5
Meters	%	DBW/m2-4kHz	DBW/m2-4kHz	dBW/m2-4kHz
0.6	100	-172.1	-176.9	-179.1
1.2	100	-178.1	-182.9	-185.1
1.8	100	-181.6	-186.4	-188.6
3.0	100	-186.7	-191.5	-193.7
7.0	100	-194.1	-198.9	-201.1
10.0	100	-197.2	-202.0	-204.2

Boeing's dual mask approach is also strongly supported by other NGSO FSS applicants – particularly those that are long term interference dominated. In fact, only one party, SkyBridge, has opposed a dual mask approach. SkyBridge's objections are two-fold.[6] First, SkyBridge argued before USWP-4A and US JWP 10-11S that two masks are unnecessary because SkyBridge has proposed a single EPFD mask that could accommodate each of the NGSO FSS applications pending before the FCC.[7] SkyBridge's EPFD mask is just a proposal, however, and numerous parties in the U.S.

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[5] *See* WP 4A/US-73, "US Proposed Aggregate $EPFD_{DWN}$ Mask for Ku and Ka-band."

[6] *See E-mail Message from Leslie Taylor, Leslie Taylor Associations, Inc., to USWP4A Participants*, March 31, 1999, 5:36 p.m. (explaining SkyBridge's two objections to Boeing's proposed dual EPFD mask approach).

[7] *See id.*

GSO community oppose it. Thus, Boeing cannot place reliance on the remote possibility that SkyBridge may succeed in getting its mask adopted by both the ITU and the FCC without alteration.

Even if SkyBridge does succeed in winning adoption of its single mask, that does not lessen the significant public interest benefits that can be realized by adopting a dual mask approach. Utilizing two masks will provide NGSO FSS systems with significantly more flexibility in designing constellations, while continuing to protect GSO networks. The additional flexibility will enable NGSO FSS system operators to provide a wider range of consumer services to the public.

SkyBridge's second objection to Boeing's dual mask approach is that it may receive an unfavorable reception by the international community if it is perceived as accommodating all NGSO FSS applicants other than SkyBridge.[8] In making this argument, SkyBridge seems to be encouraging misperception in the international community, rather than attempting to build consensus.

A fundamental component of Boeing's dual mask approach is that it includes the adoption of <u>two</u> masks – one for long term interference dominated systems and another for short term interference dominated systems. Boeing acknowledges that the final values that will be included in the short term interference dominated mask still must achieve international consensus. This consensus has been delayed by an ongoing examination into sync loss events that may be caused by short term interference dominated systems into GSO networks. The problem of setting appropriate values to

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[8] *See id.*

address sync loss must be resolved, however, regardless of whether a single mask or a dual mask approach is eventually adopted.

Furthermore, SkyBridge has no justification to harbor concern that the international regulatory approval process for the long term interference dominated mask might "get ahead" of the approval process for the short term interference dominated mask. Both the ITU and FCC would likely oppose such an inequitable result, which could harm the public interest by reducing the number and diversity of NGSO FSS systems that are able to serve consumers in the Ku-band.

In light of the significant public interest benefits that can be achieved by adopting a dual mask approach, along with the strong support for this approach that has been displayed by the U.S. satellite industry, the FCC should adopt a dual mask regulatory structure for NGSO FSS systems licensed by the United States to operate in the Ku-band. Boeing also encourages the United States to support a dual mask approach before the ITU-R and WRC-00 regulatory development process.

III. REGARDLESS OF THE NUMBER OF EPFD MASKS ADOPTED BY THE FCC AND ITU, THE UNITED STATES SHOULD DISCARD THE EPFD LIMITS INCLUDED IN U.S. DOCUMENT JTG 4-9-11/342.

Despite the strong objections of NGSO FSS proponents in the United States, the U.S. delegation submitted very stringent EPFD limits at the January meeting of JTG 4-9-11. The limits were included in Document JTG 4-9-11/342 (hereinafter referred to as "the Document 342 EPFD limits"). PanAmSat subsequently argued in its initial comments in this proceeding that the FCC should adopt the Document 342 EPFD limits to regulate NGSO FSS systems authorized to serve the United States.

When the Document 342 EPFD limits were introduced before JTG 4-9-11, Boeing and other NGSO FSS proponents were not given an advance opportunity to review the proposal. Boeing has recently analyzed Document 342 in some detail and urges the Commission and the U.S. government to abandon the Document 342 EPFD limits because they appear to be based on inaccurate data and computational software with numerical instabilities.

An example of the inaccurate data used in Document 342 can be found in the list of cities used in the EPFD calculations. A number of the cities were listed as having altitudes of over 2000 meters, which Boeing found unusual. Boeing checked the altitudes of several of the cities and found them to be in error.[9]

Table 2 – Altitudes of Cities in Document 342

City	Listed Altitude Meters	Actual Altitude Meters
Urumqi, China	1962	914
Yumen, China	2070	1598
Provo, Utah, U.S.	2246	1387
Kabul, Afghanistan	2513	1796
Ta'if, Saudi Arabia	1905	1630

The use of inaccurate altitude information is highly relevant in assessing the validity of the proposed Document 342 EPFD limits. The altitude information was used in an ITU-R rain model to calculate the rain attenuation that would be experienced by a GSO earth station in the specified cities. GSO earth stations at higher altitudes could be

[9] Table 2 shows a number of the cities used in the document 342 study, the altitudes used in the study, and the actual altitudes of the cities. *See* Webster's New Geographical Dictionary, G. & C. Merriam Company, 1972; The Columbia Lippincott Gazetteer of the World, Columbia Univ Press, 1962. Boeing did not do an exhaustive review of all the locations but only a spot check of some locations.

expected to experience less rain condition between the earth station and the GSO satellite, resulting in lower rain attenuation. Since the proposed EPFD limits for NGSO FSS systems is based on a 10% increase in GSO network unavailability, the amount of rain attenuation experienced by a GSO earth station is a critical parameter. Any error in rain attenuation that resulted from the use of inaccurate altitude data would therefore compromise the validity of the EPFD limits proposed in Document 342.

Another example of flawed input data can be found in the use of rain statistics in Document 342 that were based on the ITU-R rain zone map contained in ITU-R Recommendation P.837. The ITU-R rain zone map provides a general indication of the rain statistics over a broad area and is intended for use only when more accurate rain data for a specific location is unavailable. Boeing spot-checked the rain rate statistics used in Document 342 against the actual rain rate data for the specific locations.[10] As Table 3 indicates, the actual local rain rate is often substantially greater than the rain rate used in the Document 342 study, further reducing the overall availability of the GSO links.

Table 3 – Rain Rate Statistics

City	Study Rain Zone	Study Rain Rate at P = 0.01% mm/hr	Local Rain Rate at P = 0.01% mm/hr
Urumqi, China	A	8	22.5
Yumen, China	A	8	25.5
Provo, Utah, U.S.	B	12	27
Kabul, Afghanistan	C	15	30
Ta'if, Saudi Arabia	C	15	Unavailable

[10] *See* Northern Hemisphere Atlas of 1 Minute Rain Fall Rates, AFGL-TR-83-02, Oct. 1983.

As in the first example, the use of information that misrepresents (often by a substantial amount) the rain attenuation experienced by specific GSO earth stations will have a significant impact on the accuracy of the resulting analysis and, once again, compromises the reliability of the limits proposed in Document 342.

Another major problem with the Document 342 EPFD limits is that they were developed using computational software that experiences numerical instabilities. Boeing has been working with the software, which was made available to some parties by its developer, PanAmSat, and has discovered instability problems relating to the computation of total GSO system availability when exposed to rain and NGSO FSS interference. An example of the numerical instability can be found in the entry for Urumqi, China in Document 342, Annex 2, Table A2-1. The entry shows that the increase in unavailability is about 68-71% over an approximate 6 dB range in EPFD mask inputs, and then suddenly drops below the 10% requirement in the next 1 dB EPFD mask step. This unusual result is an anomaly. In reality, rather than producing an accurate result, the software essentially "blows-up" and computes a total system availability of 183%, almost double the 100% availability that can be experienced in real life.

Even before the software becomes unstable, however, it appears to produce inaccurate results, such as the 68% increase in unavailability reported in the previous mask step for Urumqi, China. In the interest of all parties, Boeing is continuing to work with the software in an attempt to correct the numerical instability problems. While this troubleshooting process in ongoing, however, Boeing urges the FCC and United States government to disregard the Document 342 results.

Furthermore, even after the software and data used in producing Document 342 is corrected, Boeing would continue to object to the EPFD limits arising from the calculations therein because they are based on assumptions that Boeing considers inappropriate. For example, the only source of link degradation considered in Document 342 is rain attenuation. Other degradation factors influence the availability of a GSO link, such as scintillation and depolarization due to ice and snow. These factors should be considered in any calculation of the EPFD limits that a NGSO FSS system must meet in order to remain below the 10% unavailability ceiling that has been agreed to in JTG 4-9-11 to protect GSO networks.

IV. INITIAL COMMENTS HAVE EXPRESSED SUPPORT FOR THE EPFDup LIMITS DEVELOPED BY JTG 4-9-11.

In the initial comments filed in this proceeding, each of the parties that addressed the matter concurred in the adoption of a new definition of APFD, generally referred to as EPFDup. The new definition was developed by JTG 4-9-11 in January, with substantial participation by the United States delegation. Therefore, Boeing urges the Commission to utilize the new terminology in licensing rules for NGSO FSS systems authorized to serve the United States.

Most of the commentors also agreed that the FCC and ITU should adopt an EPFDup limit of –170 dBW/m2-4kHz. In fact, the U.S. position before the April 26, 1999 meeting of WP-4A indicates support for both the definitional change and the adoption of an EPFDup value of –170 dBW/m2-4kHz.[11] In fact, only one party, Telesat

[11] Doc. US WP-4A/2, "Draft New Recommendation (Effective Power Flux Density)up, EPFDup."

Canada, has expressed reservation with the value, indicating that it would like to engage in further study. Boeing believes that any further examination will simply reinforce the conclusions already reached by most parties that the EPFDup value of –170 dBW/m2-4kHz is appropriate to protect GSO networks. Therefore, Boeing urges the Commission to adopt this limit for NGSO FSS systems in the United States.

V. ALL PARTIES APPEAR TO AGREE THAT THE DBS INDUSTRY CAN BE PROTECTED USING THE INTERFERENCE LIMITS UNDER DEVELOPMENT BY THE ITU-R.

In its initial comments in this proceeding, Boeing concurred with the position of U.S. direct broadcast satellite ("DBS") interests that the provisional EPFD limits adopted by WRC-97 to protect DBS need to be modified. Boeing observed that JTG 4-9-11 is close to achieving consensus on an appropriate set of EPFD mask limits that would adequately protect DBS operations. Thus, rather than adopt the WRC-97 provisional limits for use in the United States, Boeing believes that the Commission should await the outcome of deliberations by JWP 10-11S and JTG 4-9-11 and adopt the regulatory limits endorsed by those bodies.

The comments filed in this proceeding by U.S. DBS operators mostly coincide with Boeing's position. Thus, Boeing believes that the Commission can move forward with this proceeding in confidence that the technical requirements of the DBS industry will not be affected adversely by the launch of NGSO FSS networks in the Ku-band.

Boeing would provide one caveat to the deliberations that have been conducted thus far by JWP 10-11S on appropriate limits to protect broadcast satellite service ("BSS") systems. Boeing believes that the international regulatory body should utilize a dual EPFD mask in order to optimize flexibility for NGSO FSS systems, while protecting

fully BSS networks. Boeing's justifications for adopting two EPFD masks and the details of Boeing's proposal are addressed *supra* in Section III of these comments.

VI. THE COMMISSION SHOULD PLACE REASONABLE RESTRICTIONS ON NGSO FSS OPERATIONS TO PROTECT TERRESTRIAL FIXED SERVICES IN THE KU-BAND.

Boeing believes that the comments filed in this proceeding support the Commission's tentative conclusion that NGSO FSS systems can share the Ku-band with incumbent terrestrial fixed services ("FS") without encumbering FS growth and development. Spectrum sharing can occur utilizing reasonable restrictions on NGSO FSS operations. These restrictions were outlined by Boeing in its initial comments and include:

- The same pfd limits used by GSO FSS networks to protect FS networks are adequate for use by NGSO FSS networks.
- Standard coordination procedures should be used to permit sharing between NGSO FSS Gateway facilities and terrestrial transmitters.
- The Commission should place reasonable limits on its proposed use of Gateway exclusion zones.
- Ku-band NGSO FSS Gateway uplink operations can share the 12.75-13.25 GHz band with incumbent terrestrial services.

As the Commission observed in the *NPRM*, any proposal to implement restrictive regulations for Gateway earth station complexes necessitates a balancing between the needs of FS and NGSO FSS licensees.[12] Adoption of restrictions that are excessively burdensome will increase the costs for NGSO FSS licensees, without providing

[12] *See Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-band Frequency Range and Subsidiary Terrestrial Use of the 12.2-12.7 GHz Band by Direct Broadcast Satellite Licensees and Their Affiliates*, Notice of Proposed Rulemaking, FCC 98-310, ¶ 23 (Nov. 24, 1998) ("*NPRM*").

corresponding benefits to FS licensees. As discussed below, Boeing believes that an appropriate balancing of interests can be accomplished utilizing the outputs of the ITU-R working group process and by adopting existing coordination procedures to address concerns expressed by FS interests.

A. The Same PFD Limits Used by GSO FSS Networks to Protect Fixed Services are Adequate for use by NGSO FSS Networks.

The Commission acknowledged in the *NPRM* that WRC-97 provisionally adopted its pfd limits because the limits had generally proven to be reliable for sharing between GSO FSS and FS networks. Boeing believes that the dynamics of the NGSO satellite will not significantly alter the protection provided by these provisional limits to FS systems. All systems, GSO and NGSO, must comply with these pfd limits at any elevation angle.

SBC Communications, Inc. argues that "... reliance on the WRC-97 pfd limits is based on the assumption that fixed service stations generally have an elevation angle of only a few degrees," which SBC argued does not hold true in some cases, such as in mountainous areas.[13] For example, Pacific Bell reports having four sites that have an antenna tilt of over 20 degrees, and six other sites with a tilt over 10 degrees.[14] SBC also argued that incumbent FS licensees should not bear any burden for NGSO FSS interference problems.[15]

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[13] Comments of SBC Communications, Inc., ET Docket No. 98-206, at 3 (March 2, 1999) ("*SBC Comments*").

[14] *See id.*

[15] *See id.* at 4.

Boeing believes that the higher elevation tilt angle FS links will not be harmed by interference from the Boeing system. FS microwave links over flat terrain generally have 50 to 75 kilometer transmission paths. Given a 20° elevation angle, a delta terrain height of 3000 meters would produce a transmission path of only 3.4 kilometers. This reduction in path length provides more than 23 dB of margin over flat terrain links, which is far greater than the 10 dB increase in the provisional limits between 0° and 20°. Additionally, at 20° elevation angle the Boeing NGSO FSS system produces a pfd level of less than –150 dBW/m^2-4kHz, which is more than 8 dB below the provisional limit at 20° and is also below the provisional limit at 0° elevation.[16] This level produces a Boeing system I_0 of –186 dBW/m^2-Hz. Assuming a 1.5 watt fixed link transmitter, with a 60 centimeter antenna and a 3.4 kilometer link, the carrier power at the receive antenna would be ~ –88 dBW/m^2, providing nearly 100 dB of C/I_0 protection. Therefore, interference from the Boeing system should not be a problem for FS microwave links, regardless of their elevation angles.

The Fixed Communications Wireless Coalition ("FWCC") endorses the use of WRC-97 GSO FSS emissions limits for NGSO FSS systems,[17] but has concerns that the dynamics of the NGSO satellites will create severe interference for FS stations unless appropriate precautions are implemented.[18] FWCC also believes that the impact of

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[16] See *The Boeing Company Application for Authority to Launch and Operate a Non-Geostationary Medium Earth Orbit Satellite System in the Fixed Satellite* Service, IBFS File No. SAT-LOA-19990108-00006, at 101, 102 (Jan. 8, 1999).

[17] *See* Comments of the Fixed Wireless Communication Coalition, ET Docket No. 98-206, at *ii* and 16 (March 2, 1999) ("*FWCC Comments*").

[18] *See id.* at 11-16.

interference on FS operations is not well understood by the NGSO operators (e.g., Automatic Transmitter Power Control ("ATPC") interaction with interference and recovery from synchronization loss). Other groups expressed similar comments.[19]

Boeing believes the long term nature of its system interference will not negatively interact with FS ATPC link equipment. Boeing's interference statistics have no short term spikes that may "mislead" ATPC equipment. Instead, interference from the Boeing system will be quite similar to rain fades. Therefore, ATPC equipment should respond to Boeing system interference essentially in the same way that it does currently responds to conditions of precipitation.

Since the close of WRC-97, ITU-R Study Group 9 ("SG 9") and JTG 4-9-11 have studied extensively the issue of interference from NGSO systems to FS systems. At the January 1999 meeting of JTG 4-9-11, the international body reached a consensus that "the current article S21 per satellite pfd limits ... are adequate for the protection of the FS in the 10.7 – 12.75 GHz band from aggregate interference from three assumed non-homogeneous, non-GSO FSS systems."[20] Representatives of the FS service industry in the United States actively participated in these deliberations. Accordingly, Boeing believes that the Commission should concur with JTG 4-9-11 in acknowledging the adequacy of existing pfd limits to protect FS networks from both GSO and NGSO transmissions. Boeing also opposes SBC's proposal that NGSO operators bear all

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[19] *See* Comments of the Fixed Point-to-Point Communication Section, Wireless Communication Division of the Telecommunications Industry Association, ET Docket No. 98-206, at 2 (March 2, 1999); Comments of the Association of American Railroads, ET Docket No. 98-206, at 2 (March 2, 1999).

[20] *See* Doc. JTG 4-9-11/TEMP/72(Rev. 1), "PFD Limits in the 11/12 GHz Bands."

financial burdens for interference mitigation after these systems are operational and are within their licensed parameters. Coordination procedures during the licensing process will provide adequate protection for both the FS and NGSO operator.

B. Standard Coordination Procedures Should be Used to Protect NGSO FSS Gateway Facilities for Terrestrial Transmitters.

In the *NPRM*, the Commission proposes to use the same coordination procedures used by GSO earth stations to protect NGSO Gateway facilities from terrestrial interference in the 10.7-11.7 GHz band.[21] Boeing agrees that existing coordination procedures are adequate to protect NGSO Gateway complexes. In contrast, the FWCC argues that the Commission should attempt to micromanage sharing between NGSO and the FS in the 11 GHz band, calling for adoption of a long list of often arbitrary restrictions on NGSO Gateways. For example, FWCC wants NGSO FSS licensees to collocate their Gateway facilities and limit their total number to forty.[22]

Boeing opposes any move to "codify" arbitrary limitations (e.g., 40 NGSO FSS Gateways, 18 dB shielding, 4 b/s/Hz spectrum efficiency, etc.) in the Commission's regulations. Existing coordination rules are adequate to determine the appropriate shielding and spectrum sharing parameters that will be necessary to enable co-frequency operations at each specific location. Furthermore, considerations of cost will ultimately restrict the upper limit of NGSO Gateways to only those facilities that are necessary for efficient operations. For example, Boeing currently plans to have two Gateway

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[21] *See NPRM*, ¶ 22.

[22] *See FWCC Comments* at i & 4-7.

complexes within the continental United States ("CONUS"). Thus, it is not anticipated that there will be any significant problem in coordination.

C. The Commission Should Place Reasonable Limits on its Proposed Use of Gateway Exclusion Zones.

The Commission acknowledged in the *NPRM*, that any proposal to implement exclusion zones for Gateway earth station complexes necessitates a balancing between the needs of the fixed service and NGSO FSS licensees.[23] Use of exclusion zones that are excessively burdensome will increase the costs for NGSO FSS licensees, without providing corresponding benefits to FS systems.

For example, SBC proposes a 200 kilometer radius for exclusion zones, plus restrictions in rural areas.[24] FWCC wants 50 kilometer exclusion zones on either side of existing intercity routes[25] and Petroleum Communication, Inc. wants the entire Gulf of Mexico added to the exclusion zone.[26]

These commentors appear to overlook the fact that any exclusion zones adopted by the Commission would be used in combination with traditional coordination, rather than as a replacement. Thus, existing microwave routes along intercity routes, for example, would still be protected fully through the coordination process, regardless of scope of the exclusion zones that are adopted.

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[23] *See NPRM*, ¶ 23.

[24] *See SBC Comments* at 5.

[25] *See FWCC Comments* at 8.

[26] *See* Comments of Petroleum Communication, Inc., ET Docket No. 98-206, at 4 (March 2, 1999) ("*Petroleum Comments*").

Furthermore, as Boeing noted in its initial comments, use of excessive exclusion zones will unnecessarily increase costs for Ku-band NGSO FSS licensees. Boeing's Gateway facilities will require reliable access to the public switched telephone network ("PSTN") and fiber network connections. Since such resources are not readily available in remote areas, Boeing would be required to construct additional terrestrial telecommunications infrastructure, possibly at significant cost. A reduction in the proposed exclusion zone restrictions would minimize the burden on Ku-band NGSO FSS licensees.

Thus, Boeing maintains its position that the Commission should prescribe exclusion zones only around the 25 largest population centers and should limit the exclusion zone to 50 kilometers. Additionally, the Commission should refrain from adopting exclusion zones for non-urban areas. While Boeing acknowledges that numerous fixed links exist in non-urban areas, Boeing believes that these users can operate co-frequency with Ku-band NGSO FSS Gateway facilities using standard spectrum coordination procedures.

Finally, Boeing believes that any exclusion zones adopted in this proceeding should sunset five years following their adoption. As the Commission notes in the *NPRM*, the purpose of the exclusion zones would be to permit the migration of FS systems from the 2 GHz band allocation for the mobile satellite service ("MSS"). The launch of 2 GHz MSS systems is likely to begin next year, with a number of MSS systems in operation several years later. Thus, it seems likely that FS migration from the 2 GHz MSS band will be completed well before the five-year deadline.

In contrast, the FWCC opposes a sunset on exclusion zones, arguing that 2 GHz relocation will not be the sole source of growth and development in FS operations at

11 GHz.[27] Once again, however, FWCC's position seems to disregard the role that coordination procedures can play in the spectrum sharing process. Through the use of accepted coordination procedures, additional FS systems can be accommodated using shielding and other interference avoidance techniques to protect co-frequency operations.

D. Ku-band NGSO FSS Gateway Uplink Operations Can Share the 12.75-13.25 GHz Band With Incumbent Terrestrial Services.

The Society of Broadcast Engineers ("SBE") argues that while NGSO Gateway stations might be able to share the 12.75-13.25 GHz spectrum with fixed, point-to-point Television Broadcast Auxiliary Service ("TV BAS") stations, no such sharing would be possible with mobile TV Pickup stations.[28] SBE also argues that exclusion zones are needed for the NGSO FSS uplink Gateways in the 12.75-13.25 GHz band and that NGSO FSS Gateways be prohibited from operating in the 13.1500-13.2115 GHz band within 100 kilometers of the 50 most populated cities.[29]

Boeing acknowledges that there is heavy terrestrial use of the 12.75-13.25 GHz band, but concurs with the Commission's tentative conclusion that extending existing coordination procedures to this band will be adequate for siting NGSO FSS Gateway complexes.[30] Therefore, Boeing opposes the use of exclusion zones, or any prohibition of NGSO Gateway operation in the band. Boeing observes, however, that by adopting

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[27] *See FWCC Comments* at *i*, 8.

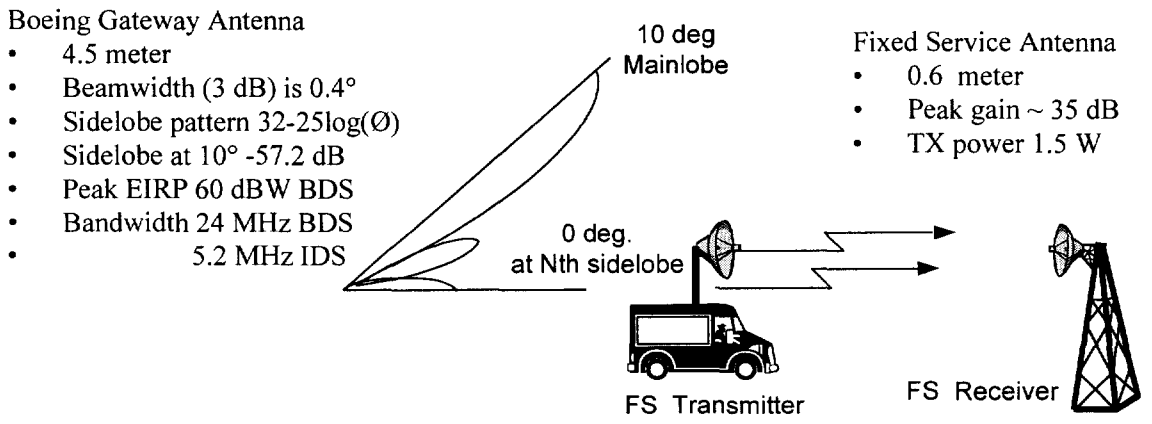
[28] *See SBE Comments* at 1.

[29] *See id.* at 3.

[30] *See NPRM*, ¶ 34. Extending existing coordination procedures to this band would require changes to Parts 74, 76 and, perhaps, 101 of the Commission's rules.

exclusion zones for NGSO FSS Gateway facilities operating in the 10.7-11.7 GHz downlink band, the Commission is creating a *de facto* exclusion zone that applies to each of the paired NGSO FSS Gateway frequency bands.

With respect to mobile operations in the band,[31] Boeing believes that its two planned Gateway facilities will affect only a small area and should not have a significant impact on mobile TV Pickup stations. Boeing also notes that certain design constraints that it has incorporated into its plans for Gateway facilities will actually benefit terrestrial users. For example, Boeing Gateway complexes will require unobstructed fields-of-view from elevation angles of ≥10° to track system satellites. This means that Gateway facilities will be sited well away from FS relay towers used by mobile users. Boeing has also proposed to use 4.5 meter antennas in its Gateway facilities. These large antennas produce a very narrow mainbeam (0.4°) and sidelobe power levels that are well below the carrier level of a typical FS mobile link. For example, assuming an in-line worst case geometry shown below, the C/I_0 is 100 dB. Other more realistic geometries would provide far greater protection.



[31] *See id.*

Addressing the interference concern with respect to mainbeam tracking of the satellites, Boeing will be able to provide long term data to "neighborhood" users of the band since the movements of its satellites will be quite regular and repeating.

Boeing also observes that there is a long history of cooperation in avoiding interference among electronic news gathering ("ENG") operators and other users of the band. Boeing will contact the several television stations in the vicinity of its Gateway complexes and arrange communications paths to provide assistance for ENG vehicles through periodic information on the hourly/daily variations in interference contours for the areas surrounding the multiple tracking earth stations at each Gateway.

VII. NO PARTY IN THIS PROCEEDING HAS DISPUTED THE SUBSTANTIAL INTER-DEPENDENCE THAT WILL BE NECESSARY BETWEEN CO-FREQUENCY NGSO FSS SYSTEMS AND ITS JUSTIFICATION FOR USE OF STRICT FINANCIAL QUALIFICATION RULES.

In its initial comments, Boeing expressed support for the Commission's tentative conclusion that strict financial qualification standards should be adopted for Ku-band NGSO FSS applicants. Strict financial qualification rules are necessary because of the significant number of NGSO FSS applications pending in this proceeding and because of the substantial technical inter-dependence that will be necessary between co-frequency NGSO FSS licensees.

Only one commentor – Virtual Geosatellite – disputes the need for strict financial qualification standards. Virtual Geosatellite argues that using corporate balance sheets to demonstrate an applicant's ability to construct a satellite system is "pointless" because (1) "even large corporations" seek external investment to build major satellite systems and (2) "history has shown" that a company's assets are not an accurate predictor of whether the company will proceed with construction.

The Commission has previously addressed Virtual Geosatellite's first argument. The Commission has correctly observed that

> [c]urrent assets – which includes cash, inventory, and accounts receivable – provide a general measure of a company's ability to finance the project itself or to raise funds from lenders and equity investors on the basis of its on-going operations. Highly capitalized companies possess more collateral and, thus, are in a better position to borrow money than thinly capitalized companies.[32]

Thus, the fact that a well capitalized company may chose to seek external financing to help in the construction of a global satellite system is not relevant. Highly capitalized companies are in a much stronger position to obtain such financing and are therefore in a far better position to expend the substantial sums necessary to construct a global satellite system.

With respect to Virtual Geosatellite's second argument, Boeing disputes the contention that a company's assets are not an accurate predictor of whether it will proceed with construction. Virtual Geosatellite provides no examples supporting its position. In fact, the geostationary arc is filled with telecommunications satellites that were constructed, launched and are operated by well financed participants in the satellite communications industry.

Admittedly, some financially qualified companies have chosen to abandon satellite projects following receipt of a FCC license. This fact is entirely irrelevant, however, to the issue of whether highly capitalized companies are more likely to build FCC licensed systems. The decision to move forward with construction of a newly

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[32] *Mobile Satellite Service in the 1610-1626.5/2483.5-2500 MHz Frequency Bands*, 9 FCC Rcd 5936, 5950 (1994) ("*Big LEO Order*").

licensed satellite system entails two entirely separate questions: (1) is the licensee financially capable of constructing the system and (2) does it continue to be financially prudent to construct the system.

Regardless, of whether a company is financially capable of constructing a major satellite system, the company should not initiate construction if, at the time the license is issued, it no longer remains financially prudent to proceed with construction. The decision to move forward should be based entirely on updated market information and the current priorities and expertise of the licensee. Therefore, the fact that some financially qualified companies have concluded that it was no longer prudent to construct licensed systems cannot be used to support a claim that a company's assets are not an accurate predictor of whether a company will proceed with construction.

Furthermore, the most important issue in the debate over financial qualification rules is not whether each and every licensed satellite system gets built, but instead, whether scarce spectrum resources are forced to remain fallow. On this issue, financially qualified companies have a strong record of serving the public interest. For example, when TRW determined that it would not construct its Odyssey system, the licensee notified the Commission in writing and promptly relinquished control of its license. This is not an isolated example. It stands in sharp contrast to the actions of some financially unqualified companies, however, which have utilized every regulatory, judicial and political means available to stave off license revocation.

As a final point, Boeing wants to address concerns expressed outside this proceeding that enforcement of strict financial qualification rules would (1) inhibit the market's ability to decide which satellite projects should succeed and (2) exclude small

entrepreneurs from obtaining licenses for innovative satellite systems. Boeing believes that both of these contentions are false.

Entrepreneurs with innovative satellite system designs have always been able to satisfy the Commission's financial qualification rules by approaching the financial markets with their ideas and developing sufficient backing to qualify for a FCC license. One such example is CD Radio, which convinced enough investors about the merits of its plans to enable the company to win a satellite license at auction.[33] In contrast, other start up companies seem more interested in promoting their possession of a FCC license on Wall Street, rather than promoting good ideas. Boeing believes that success in the equity markets is not dictated by a company's control over FCC-issued parchment. Instead, financial markets are far concerned with the merits of a company's business plans and the technical expertise to execute them.

Thus, strict enforcement of financial qualification rules does not bar entrepreneurs from obtaining FCC licenses and it does not inhibit that market's ability to finance innovative satellite systems. The Commission's financial qualification rules simply require that the process of raising capital begin before a license is issued, rather than after.

In conclusion, the Commission should move forward with its tentative plans to adopt strict financial qualification rules in the Ku-band NGSO FSS proceeding. Enforcement of such rules will expedite the provision of new and innovative satellite

[33] While CD Radio was not required to satisfy the Commission's traditional financial qualification rules, Boeing believes that assigning a license by auction is perhaps the strictest form of financial qualification threshold available.

services to consumers – assisting all segments of the global satellite communications industry both in the short term and in the long term.

VIII. ALL KU-BAND NGSO FSS SYSTEMS LICENSED IN THE CURRENT PROCESSING ROUND MUST ASSUME AN EQUAL PORTION OF THE SPECTRUM SHARING BURDEN.

In the NPRM, the Commission made an important observation about NGSO co-frequency spectrum sharing – an observation that no party in this proceeding has disputed. Specifically, the Commission expects "all NGSO FSS applicants to bear some portion of the technical and operational constraints necessary to accommodate multiple NGSO FSS systems."[34] As Boeing indicated in its initial comments, this equitable principle should guide all aspects of the Commission's Ku-band NGSO FSS licensing process. Without an equitable distribution of burden sharing, licensees that are encumbered with a disproportionate share of the spectrum sharing burden will be forced to bear a significant additional costs in constructing and operating their satellite systems. The additional cost could compromise the viability of such systems.

In order to avoid this inequitable result, all first round licensees should be required to incorporate a portion of the burden of spectrum sharing into their system designs. The Commission should ensure that this requirement is carried out in practice by adopting certain rules for U.S.-licensed Ku-band NGSO FSS systems.

First, the Commission should clarify its existing rule that permits U.S. licensees to initiate satellite construction at their own risk prior to grant of a license.[35] The

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[34] *NPRM*, ¶ 70.

[35] *See* 47 C.F.R. 25.113(f).

Commission should require that NGSO FSS systems initiating construction at their own risk acknowledge in writing to the Commission that the risk of early construct includes the risk that the applicant may be required to make modifications to its system design in order to incorporate an equitable portion of the burden of co-frequency spectrum sharing.[36] Such a requirement is necessary because of indications by NGSO FSS applicants of plans to initiate construction of satellites "in the near future" – possibly before spectrum sharing negotiations are completed.[37]

Second, the Commission should adopt a requirement that all Ku-band NGSO FSS systems must be capable of employing an interference mitigation technique permitting co-frequency operations with inhomogeneous NGSO FSS systems.[38] As Boeing highlighted in its initial comments, none of the first round applicants have proposed homogeneous satellite systems and it is highly unlikely that the applicants could redesign their systems to make them homogeneous.[39] Furthermore, it would be arguably undesirable to redesign the various systems to make them homogeneous. Such a radical redesign process could force NGSO FSS applicants to sacrifice unique design aspects of

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[36] Section 25.113(f) of the Commission's rules currently requires satellite system applicants to notify the Commission in writing prior to initiating satellite construction at their own risk. Thus, the additional requirement requested by Boeing would not constitute an administrative burden either for applicants or the Commission staff.

[37] *See, e.g.*, Comments of SkyBridge L.L.C., ET Docket No. 98-206, at 118 n.240 (March 2, 1999) ("*SkyBridge Comments*").

[38] Inhomogeneous NGSO systems are generally defined as two or more systems that have different satellite constellations and/or radio frequency parameters.

[39] Homogeneous NGSO systems are generally defined as two or more systems that have satellite constellations with similar orbit and radio frequency parameters.

their constellations that were incorporated to optimize the provision of specialized services to consumers on a cost-effective basis.[40]

At least one other NGSO FSS applicant has urged the Commission to require the use of interference mitigation techniques.[41] Such an obligation is necessary because of the inherent tendency of co-frequency inhomogeneous NGSO FSS systems to produce harmful levels of inter-system interference. The satellites of co-frequency inhomogeneous constellations regularly align with the main-beam of satellites of other inhomogeneous systems, resulting in mutual interference events. In order to prevent this interference, acceptable mitigation techniques must be employed, such as satellite or earth station diversity.[42]

In arguing in favor of equitable burden sharing, Boeing acknowledges that some applicants in this proceeding have proposed highly elliptical orbit ("HEO") satellite systems that are apparently incapable of employing commonly accepted interference mitigation techniques.[43] In order to accommodate this shortcoming, HEO proponents have requested that their systems be given priority over non-HEO systems, relegating more common types

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[40] For example, SkyBridge's use of a low earth orbit constellation, while reducing signal transmission delays, necessitates far more satellites than a comparable NGSO constellation at a higher altitude. While such a trade-off may be appropriate for SkyBridge, it would be inappropriate for other NGSO licensees seeking to reduce consumer costs through the use of smaller NGSO constellations.

[41] *See SkyBridge Comments* at 79-80.

[42] *See id.* at 80 (arguing that all NGSO FSS licensees must be capable of employing satellite diversity).

[43] *See, e.g.,* Comments of Denali Telecom, L.L.C., ET Docket No. 98-206, at 6 (March 2, 1999) ("*Denali Comments*").

of NGSO constellation designs to *de facto* secondary status.[44] Additionally, one HEO applicant argued that all Ku-band NGSO FSS systems should be *required* to employ HEO designs.[45]

Boeing opposes the grant of any special priority to HEO systems and believes that HEO designs should not be used as a model of NGSO FSS systems. Such special treatment is unwarranted because it would permit proponents of a less flexible constellation design to externalize the costs of spectrum sharing, while using a scarce global resource to "cream skim" in the provision of consumer services. As explained below, Boeing believes that HEO constellation designs offer significant disadvantages as compared to more common NGSO constellations and the Commission should license HEO systems only if proponents of such systems can overcome the numerous shortcomings that are inherent with such systems. This includes employing an interference mitigation technique that will permit HEO licensees to account for an equitable portion of the burden of co-frequency operations in the Ku-band.

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[44] *See, e.g.,* Comment of Virtual Geostationary, ET Docket No. 98-206, at 8 (March 2, 1999) ("*Virtual Geostationary Comments*"); Comments of the Office of Prime Minister, Government of the Kingdom of Tonga, ET Docket No. 98-206, at 3 (March 2, 1999) ("*Tonga Comments*").

[45] *See Virtual Geostationary Comments* at ii. Virtual Geostationary argues that its virtual geostationary "orbit constellation should be the baseline requirements for NGSO systems." *Id.* at 4-8. At the same time, Virgo claims that it "holds intellectual property rights (consisting of U.S. and foreign patents and patent filings) relating to the use of constellations of elliptical orbit satellites in the field of communications and data transfer." *Id.* at 5. In other words, Virgo is apparently hoping that the Commission adopts a design requirement that cannot be built without Virgo's authorization. Such a requirement would stifle competition and is clearly adverse to the public interest.

IX. THE COMMISSION SHOULD LICENSE HEO SATELLITE SYSTEMS IN THE KU-BAND ONLY IF HEO APPLICANTS CAN RESOLVE THE NUMEROUS PROBLEMS INHERENT WITH SUCH SYSTEMS.

Two applicants[46] and one non-applicant[47] in this proceeding are promoting the use of HEO constellation designs for NGSO FSS satellite systems in the Ku-band. The parties highlight the ability of HEO systems to operate co-frequency with existing GSO systems (a characteristic that HEO systems share with Boeing's MEO system), while largely ignoring the numerous disadvantages that exist with HEO systems. Boeing believes that the Commission should undertake a critical review of HEO constellation designs before licensing any such systems in the Ku-band.

The primary shortcoming with a HEO constellation design is that it uses a scarce global resource to provide far less than global coverage. As indicated in Boeing's initial comments, Boeing strongly supports the Commission's goal of adopting a global coverage requirement for NGSO FSS systems in the Ku-band. A global coverage requirement furthers the Commission's goal of promoting universal service, while exporting U.S. telecommunications capabilities to all regions of the world.

A HEO constellation cannot provide global coverage, unless two HEO constellations are overlaid on each other – one focusing on the northern hemisphere, while an inverted HEO focuses on the southern hemisphere. Denali acknowledges this in

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[46] Virtual Geostationary and Denali Telecom.

[47] *See Tonga Comments* at 2-3.

its application[48] and argues that since its HEO system will not provide global coverage the Commission should not impose such a requirement.[49] Tonga also acknowledges the regional limitations of HEO constellations.[50] Tonga's endorsement of HEO orbits thus seems to be in conflict with Tonga's position that NGSO and HEO systems "are really international systems" in nature and due to their high costs, "the objective of providing a global service essentially becomes an operational imperative."

Virgo claims it will satisfy the Commission's proposed global coverage requirement using a second inverted HEO orbital plane.[51] Virgo further argues that all other applicants should also be required to utilize this two layered approach. Virgo's position is opposed not only by NGSO applicants, but also be other HEO applicants that argue that because of the problems associated with operating an inverted HEO constellation "it would be inefficient to impose" such a requirement.[52]

A major problem with utilizing an inverted HEO design is that the elliptical nature of the orbit requires that satellite control be from ground-stations located at mid-latitude or higher. This can be a significant problem in the Southern Hemisphere due to

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[48] *See* Application of Denali Telecom, LLC, File No. 160-SAT-P/LA-97/13, IBFS File No. SAT-LOA-19970926-00127, at 15-23, 36 (Sept. 26, 1997) ("*Denali Application*"). Denali indicates that it will limit its service area to between 25° N and 85° N. *See id.* at 38.

[49] *See Denali Comments* at 5.

[50] *See Tonga Comments* at 4.

[51] Virgo proposes an inverted HEO system in that the argument of perigee for its Australis plane is 90°, as opposed to 270° as is found in a typical HEO constellation. *See* Application of Virtual Geosatellite, LLC, IBFS File No. SAT-LOA-19990108-00007, at 14 (Jan. 8, 1999) ("*Virtual Geostationary Application*").

[52] *See Denali Comments* at 5.

the lack of available dry land between 35°S and 70°S. Denali not only acknowledges this inherent limitation, it offers it up as justification for the Commission to drop its global coverage requirement.[53] Inverted HEO operators would be forced to deal with the problem by locating Gateway earth stations in either in New Zealand or South America. Should a HEO operator locate its earth stations further north, the amount of coverage provided to the higher southern latitudes will be reduced, compromising global coverage. Even with southern earth station locations, inverted HEO operators would be forced to reduce the activity of a single satellite to 60% of the day.[54]

A second shortcoming of inverted HEO constellations involves atmospheric drag and the potential for aging HEO satellites to break up and fall to Earth. The perigee of a traditional HEO system is sufficiently low to be affected by atmospheric drag, occurring (in a typical Molniya orbit) as low as 555 kilometers, well below the cyclical atmospheric maximum of more than 900 kilometers.[55] As a result of this atmospheric drag, pieces of aging HEO satellites are literally burned off the spacecraft on each perigee pass due to friction with the upper atmosphere, while the apogee altitude begins to decrease. If a satellite disposal technique is not used preemptively, the process of disintegration continues until orbital decay causes the remaining portions of the satellite to re-enter the atmosphere. This reentry problem is of particular concern with respect to an inverted HEO orbit because of the likelihood that the reentry will occur over the heavily populated

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[53] *See id.* at 4-5

[54] *See, e.g.*, *Virtual Geosatellite Application* at 14.

[55] The atmosphere is subject to an eleven-year solar cycle in which the atmosphere will regularly expand out past an altitude of 900 kilometers.

Northern Hemisphere. This risk translates into an increased liability for the owner/operator of the satellite.

Another well known problem with HEO orbits (both northern pointing and inverted) is that they necessitate a satellite path that repeatedly crosses through the Van Allen radiation belts, which surround the earth from an altitude of 1,000 km to 17,500 km and again from 25,500 km to about 40,000 km. The lower Van Allen belt subjects satellites to high neutron and proton flux, while the upper belt subjects the satellite to electron flux. As a result, many of the spacecraft sub-systems (*e.g.*, electrical power, thermal control, command & data handling and communications payload) must be shielded against ionization, displacement and spallation damage. The end result is an increase in the weight and cost of the spacecraft in order to maintain the reliability of the various sub-systems. Denali acknowledges this problem in its application, indicating that it would use increased shielding or radiation tolerant components in some of its sub-systems.[56] In contrast, Virgo makes no mention of this problem in its application, even though its Virgo satellites would be subjected to six transits of the Van Allen belts each day, resulting in a 50% increase in radiation exposure as compared to other HEO designs.[57]

The fifth disadvantage with using a HEO orbit involves the very nature of the orbital dynamics of an elliptical orbit. As a result of the orbital dynamics, the service area from a constant gain, antenna beam will increase or decrease in area, as a function of

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[56] *See Denali Application* at 36

[57] For example, the Russian Molniya orbital design transits the Van Allen belts just four times a day.

where and when the satellite is in the active service arc of the orbit. Because of these variations, active pointing and control mechanisms must be used for any communications system. Additionally, the changes in satellite altitude require the addition of active power control for a constant gain antenna in the satellite and earth station. HEO applicants should be required to adequately explain how they will address these additional technical burdens in their systems.

A sixth disadvantage of HEO orbits is that in order to keep the rate of change of the argument of perigee equal to zero requires that the inclination of the orbit – the critical inclination – be 63.435°. Establishing critical inclination necessitates employing a larger and more expensive launch vehicle to expend the additional energy necessary in order to place the satellite into its final orbit.

In light of the numerous disadvantages inherent with HEO constellation designs, the Commission should undertake a critical review of HEO constellation designs before licensing any such systems in the Ku-band. Furthermore, HEO systems should be required to modify their systems so that they are capable of employing commonly accepted interference mitigation techniques. In any event, under no circumstances should NGSO FSS applicants be required, or even encouraged, to utilize these technically challenging constellation designs.

X. NO PARTY IN THIS PROCEEDING HAS DISPUTED BOEING'S POSITION THAT FIRST ROUND LICENSEES SHOULD NOT BE REQUIRED TO REDESIGN THEIR SYSTEMS TO ACCOMMODATE SECOND ROUND APPLICANTS.

As Boeing indicated in its initial comments, first round FCC licensees should not be required to redesign their satellite systems in order to accommodate NGSO FSS systems resulting from subsequent FCC application processing rounds. No party

disputed this position in its comments. One party, the Kingdom of Tonga, indicated that the Commission should ensure that its satellite system authorization procedures do not exclude non-U.S. licensed satellite systems from providing service into the United States.[58]

The Commission has gone to great lengths, however, to ensure that non-U.S. licensed satellite systems are given full and equal consideration in the FCC's authorization process. The Commission spent several years developing its DISCO I and DISCO II rules, which permit non-U.S. entry in the U.S. market on the same terms and conditions as U.S. licensees. Non-U.S. systems seeking to serve the United States are permitted to file letters of intent and/or earth station applications to be authorized to serve the United States. Such filings can be made in response to a FCC-issued application cut-off notice, using the same deadline requirements applicable to U.S.-based applicants.

A number of non-U.S. satellite operators have already taken advantage of the U.S. open entry policy.[59] Thus, no reason exists to create exceptions for non-U.S. licensees. Throughout the DISCO II proceeding, the Commission repeatedly made clear that, in order to safeguard competition, non-U.S. systems must be required to comply with the same technical, financial and legal requirements applicable to U.S. systems.[60] Without

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[58] *See Tonga Comments* at 2.

[59] For example, Letters of Intent were filed in the Commission's 2 GHz MSS proceeding by ICO Services Limited, TMI and Inmarsat. A number of other systems have applied for entry using earth station applications.

[60] *See Regulatory Policies Governing Domestic Fixed Satellites and Separate International Satellite Systems*, FCC 96-210, ¶¶ 53, 61 (May 14, 1996) ("*DISCO II NPRM*").

such compliance, U.S.-licensed systems would be at a competitive disadvantage to non-U.S. systems.

Furthermore, no exception should be made for the Kingdom of Tonga, which is skilled participant in the global satellite regulatory process. Tonga was one of the first entities to file an Advance Notice with the ITU for a NGSO FSS system in the Ku-band, submitting its notice at the close of WRC-97. At the time that Tonga filed its Advance Notice, the FCC had already indicated publicly that it was planning to announce an application cut-off deadline for NGSO FSS operators seeking to serve the United States.[61] Thus, Tonga had more than a year to prepare its FCC application. In light of these facts, Tonga should not be granted an unprecedented exception to the Commission's longstanding application filing requirements.

XI. THE COMMISSION SHOULD UTILIZE ONE OR MORE OF THE SOFTWARE SIMULATION TOOLS UNDER DEVELOPMENT TO VERIFY THE PERFORMANCE OF NGSO FSS SYSTEMS.

All the commenters in this proceeding appear to concur with the Commission's conclusion that a software simulation tool should be used to verify that Ku-band NGSO FSS licensees satisfy the interference limits adopted in this proceeding. Boeing believes that appropriate software is likely to become available either through the JTG 4-9-11 development process, or from a private software development company. In either case, however, the Commission should refrain from adopting any particular simulation tools for official use until it has undergone adequate testing.

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[61] *See* Public Notice, "*Satellite Policy Branch Information: Application Accepted for Filing*," Report No. SPB-98, at 2 (Aug. 28, 1997).

PanAmSat argues that the FCC should develop its own publicly available software tool.[62] While Boeing has no objection to such a proposal, Boeing believes that NGSO FSS licensees should have the option to use appropriate software developed by the ITU-R or private industry if the Commission's software is not available in time for prompt construction of NGSO FSS systems. Use of software developed by industry or the ITU-R will almost certainly be adequate to protect U.S.-licensed GSO systems since the U.S. government, along with U.S. satellite operators, are playing a sizable role in the development of various software verification tools. If a situation were to arise in which internationally developed software did not adequately reflect U.S. needs, the U.S. could always develop a modified version of the internationally-available software (essentially a software patch) to address U.S. interference issues.

PanAmSat also argues that NGSO FSS applicants should be required to disclose "all theoretical design considerations addressing interference mitigation performance," including earth station tracking and diversity algorithms.[63] PanAmSat argues that such disclosure is necessary to enable accurate computerized simulations. In reality, none of the software verification tools under development utilize earth station tracking and diversity algorithms. This is because such information is entirely unnecessary to accurately simulate the interference characteristics of a NGSO FSS system. Furthermore, NGSO FSS operators can be expected to adjust frequently their satellite hand-off

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[62] *See* Comments of PanAmSat Corporation, ET Docket No. 98-206, at 15 (March 2, 1999) ("*PanAmSat Comments*").

[63] *See id.*

algorithms in order to optimize satellite system capacity, while continually complying with applicable interference protection limits.

While all the commentors in this proceeding appear to support the use of a software verification tool, however, DirecTV proposed the additional obligation that NGSO FSS system capabilities should be demonstrated under experimental licenses using actual in-the-field testing.[64] Needless to say, if adopted, this would be an unprecedented requirement. No satellite service has ever been required by the Commission to launch and operate test satellites. Furthermore, such testing is entirely unnecessary due to the abundance of technical information that has been produced by the ITU-R on NGSO/GSO spectrum sharing.

XII. THE COMMISSION SHOULD MAINTAIN ITS CURRENTLY PROPOSED SEGREGATION BETWEEN NGSO FSS GATEWAY AND SERVICE LINK BANDS.

One NGSO FSS applicant has suggested that licensees should be permitted to operate both Gateway and service downlinks in the 11.2-11.7 GHz band.[65] Boeing objects to the introduction of service links into a Gateway only frequency band because of the interference impact that ubiquitous user terminals could have on Gateway transmissions. Interference to Gateway links is of particular concern because an interruption in a Gateway link results in an outage of all the associated service links.

As evidenced in the various NGSO FSS applications, significant differences exist between Gateway and service links with respect to such factors as antenna sizes, pfd and

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[64] *See* Comments of DirecTV, ET Docket No. 98-206, at 21-23 (March 2, 1999).

[65] *See Virtual Geosatellite Comments* at 13

availability requirements. Boeing has conducted initial studies that indicate that a significant potential for interference to Gateway links exists if service link terminals with smaller antenna diameters and higher pfds are allowed to operate in the same band. Therefore, Boeing urges the Commission to retain its proposed segregation of NGSO FSS Gateway and service link bands.

XIII. THE COMMISSION SHOULD MAINTAIN ITS INTERNATIONAL SYSTEMS ONLY REQUIREMENT FOR GSO FSS SYSTEMS IN THE 10.7-11.7 GHz BAND, UNLESS GSO EARTH STATIONS TRULY QUALIFY AS GATEWAY FACILITIES.

Boeing concurs with PanAmSat's position that "the Commission should treat GSO systems and NGSO systems equitably with respect to domestic use of the 10.7-11.7 GHz and 12.75-13.25 GHz bands."[66] Specifically, the Commission should permit GSO FSS networks to provide domestic services in the 10.7-11.7 GHz and 12.75-13.25 GHz bands, but only so long as GSO operations are limited to Gateway transmissions. As discussed above, the Commission correctly proposed to limit NGSO FSS operations in the 10.7-11.7 GHz and 12.75-13.25 GHz bands to Gateway operations. This same restriction should be imposed on GSO FSS networks. Such treatment would be both equitable and would help control the number of earth stations deployed in the band, thus aiding in coordination.

[66] *PanAmSat Comments* at 19; *see also* Comments of GE American Communications, Inc., ET Docket No. 98-206, at 24-25 (March 2, 1999) (arguing that the Commission's rules for NGSO FSS systems should not be more permissive than the rules for GSO FSS systems).

XIV. Ku-BAND NGSO FSS SYSTEMS CAN ADEQUATELY PROTECT THE RADIO ASTRONOMY SERVICE WITHOUT IMPOSING EXCESSIVE REGULATIONS.

In its initial comments, Boeing expressed a willingness to consult with radio astronomy interests in order to minimize out-of-band emissions from its space-to-Earth feederlinks into radio astronomy operations in the 10.68-10.7 GHz band. As Boeing indicated, the flexibility inherent in its constellation design will aid in reducing out-of-band emissions. Other mitigation techniques can include siting Gateways to avoid radio astronomy receivers, using low sidelobe satellite antennas, downlink adaptive power control and providing a wider guard band.

Despite the availability of relatively non-disruptive mitigation techniques such as these, the Committee of Radio Frequencies ("CORF") of the National Research Council ("NRC") submitted comments demanding new rules that would reduce in-band space-to-Earth pfd limits by 10 dB (even for locations where there are no radio astronomy sites) and also requiring NGSO satellite transmitters to employ filters that can "provide at least 50dB of suppression in an adjacent band."[67]

Not only is the CORF proposal unwarranted and excessive, but it also constitutes an unprecedented intrusion into the design flexibility of satellite operators in adjacent bands. CORF incorrectly indicates that ITU-R Recommendation RA.769-1 dictates requirements for NGSO transmitters, rather than just recommendations that operators licensed by other countries may disregard regardless of the rules adopted by the FCC.[68]

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[67] Comments of the National Academy of Sciences' Committee on Radio Frequencies, ET Docket No. 98-206, at 3-4 (March 2, 1999) ("*NRC Comments*").

[68] *See id.* at 1, 3.

In addition, the Commission should take note that ITU Radio Regulation S5.482 permits thirty countries in Regions 1 and 3 to use the band 10.6-10.68 GHz for fixed and mobile services without restriction. Furthermore, almost forty nations (in all ITU Regions) may employ the band 10.68-10.7 GHz for fixed and mobile services using equipment in operation prior to 1985. The terrestrial use of these frequencies can cause considerable interference to radio astronomy observations. Finally, Boeing reminds the NRC and the Commission of footnote US74:

> In the bands 25.55-25.67, 73.0-74.6, 406.1-410.0, 608-614, 1400-1427, 1660.5-1670.0, 22690-2700 and 4990-5000 MHz and in the bands 10.68-10.7, 15.35-15.4, 23.6-224.0, 31.3-31.5, 86-92, 105-116 and 217-231 GHz, the radio astronomy service shall be protected from extraband radiation <u>only to the extent that such radiation exceeds the level which would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates.</u>[69]

Boeing also points out that footnote US277 states that the radio astronomy service shall not receive protection from FS operating in the one hundred most populous U.S. urbanized areas. This restriction is somewhat ironic, since the Commission is proposing to bar NGSO FSS Gateway Facilities from the same 100 urban areas.

This does not mean that NGSO FSS systems cannot adequately protect the radio astronomy service. Boeing has proposed out-of-band emission avoidance techniques that can provide radio astronomers with sufficient protection without inappropriately constraining NGSO FSS operations in the band. Boeing is willing to implement such measures as siting Gateway facilities away from radio astronomy receivers and modifying other elements of its flexible MEO system in an endeavor to meet the

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[69] *See* 47 C.F.R. § 2.106, n.US74 (*emphasis added*).

requirements of that portion of the radio astronomy community that is actually conducting observations in this band.[70] Thus, Boeing believes that the Commission should reject any effort to impose intrusive and excessive regulations on NGSO FSS systems, such as specific design requirements and the use of specific filters.

XV. BOEING'S NGSO FSS SYSTEM WILL ADEQUATELY PROTECT THE SECONDARY SERVICE PROVIDED BY QUALCOMM IN THE KU-BAND.

In its comments, Qualcomm acknowledges its status as a secondary service in the Ku-band, yet seeks protection equivalent to a primary service. While Boeing believes that it would be inappropriate to elevate Qualcomm's service to primary status, Boeing considers the issue irrelevant because NGSO FSS systems such as Boeing's will not cause unreasonable interference into Qualcomm's Omnitracs system.

A simulation was conducted to determine the EPFD produced by the Boeing Ku-band NGSO system into Omnitracs antennas, as described by Qualcomm in an Attachment to its comments.[71] Figure 1 below is a plot of the percentage of time that the EPFD level of the Boeing system is exceeded into Omnitracs antennas as a function of the EPFD level. The peak EPFD produced by Boeing's NGSO FSS system into the

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[70] Boeing notes that US277 lists only six radio astronomy sites that have been coordinated for protection in this band but the NRC Comments list thirteen sites.

[71] Qualcomm included in its Comments an analysis of the No/Igo for its mobile terminal forward service links. *See* Comments of Qualcomm Incorporated, ET Docket No. 98-206, Attachment 1, at 2 (March 2, 1999). The calculated result is No/Igo equals 8.9 dB. *Id.* at 3. ITU-R RR S.1323 at "Recommends 1.1" states that a GSO network in the FSS bands should be designed to accept an interference from all other GSO FSS networks operating in the same frequency band of 25% of the total system noise power under clear-sky conditions. This results in a No/Igo of 6 dB. This slightly alters the calculation of No/Ino in Qualcomm's Attachment from No/Ino equals 11.7 dB to No/Ino equals 11.2 dB. Making this change, Qualcomm's "acceptable" EPFD becomes –153.3 dBW/m2-4kHz.

Omnitracs system is –152.6 dBW/m2-4kHz. This is only 0.7 dB greater than Qualcomm's request, and would occur for only 3% of the time.[72] Boeing does not consider this an unreasonable burden on a secondary service.

Furthermore, the EPFD was calculated using the worst case geometry for Boeing's satellites and the Omnitracs mobile earth terminals. For mobile earth terminals in other locations, the EPFD is expected to be much lower and will be below Qualcomm's corrected request of –153.3 dBW/m2-4kHz.

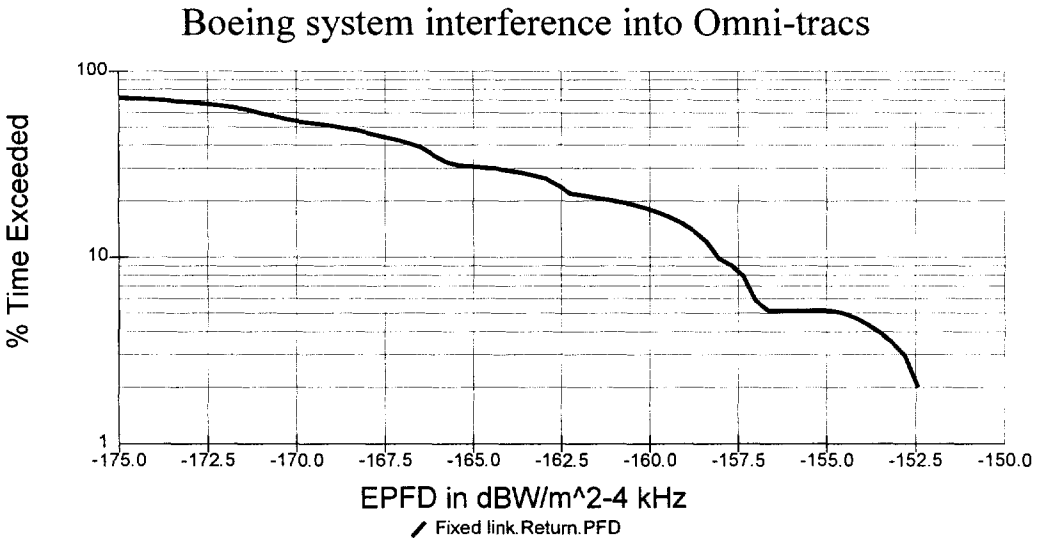

Figure 1: Boeing System Interference into Omnitracs

Boeing acknowledges that this analysis considers only one NGSO system and not the aggregate of all NGSO systems. It is unclear how the interference from multiple NGSO FSS systems would aggregate into an antenna with a beam design comparable to those used by Qualcomm. It is known, however, that the worst case earth station location for one NGSO system is not the same for all other NGSO systems. As a result, it is

[72] The peak interference from the Boeing Ku-band NGSO system results in a ΔTsys/Tsys equals 7.1% to an Omnitracs mobile terminal.

highly unlikely that the worst case EPFD levels from different NGSO FSS systems would aggregate directly at any given point on the earth. Studies on the aggregation of interference from multiple NGSO systems have shown that the EPFD into a given GSO earth terminal is typically dominated by one NGSO system. It is therefore expected that the aggregate EPFD into an Omnitracs mobile terminal will probably not be much greater than that produced by a single NGSO system, and certainly not the addition of the peak EPFD of each system.

XVI. NORTHPOINT'S TECHNICAL ARGUMENTS IN FAVOR OF ITS PROPOSAL ARE CONTRADICTED BY ITS OWN FCC FILINGS.

In its Comments in this proceeding, Northpoint continues to suggest that the primary goal of its proposal to use the 12.2-12.7 GHz band is to assist DBS providers and subscribers by providing seamless, unobtrusive, interference-free delivery of local television programming. The U.S. DBS industry has conclusively exposed many of the problems with Northpoint's concept, testing and analysis. Boeing sees little need to repeat those conclusions.

Boeing does wish to highlight two additional problems with Northpoint's proposal that were not acknowledged in Northpoint's initial comments. First, in both its initial comments and its highly touted field tests, Northpoint indicates that exclusion zones of between 200 meters and 19.46 square kilometers will result where NGSO FSS receivers will be subject to unacceptable interference.[73] As Boeing indicated in its initial

[73] *See* Comments of Northpoint Technology, Ltd., ET Docket No. 98-206, at 28 & Technical Annex at 32 (March 2, 1999) ("*Northpoint Comments*"). In its Comments, Northpoint euphemistically calls its exclusion areas "mitigation zones."

comments, such exclusion zones are unacceptable because they will seriously compromise the commercial viability of Boeing's service.

Importantly, however, Northpoint calculated its exclusion zone estimates using a transmitter EIRP of –17.5 dBW.[74] In contrast, Northpoint's "Broadwave Tampa" license applications lists a maximum transmit EIRP of 45 dBm (i.e., 15 dBW).[75] This EIRP is 32.5 dB, or almost 1,800 times greater than the EIRP used for Northpoint's testing. The higher level of transmitted power would increase the linear dimensions of the exclusion zones by more than 40 times over Northpoint's estimates.[76] In other words, if authorized, each and every Northpoint transmitter could impose an exclusion zone of between 230 and 246 square kilometers and Northpoint would still be operating within the limits of its requested license.

Boeing does not believe it is necessary to explain in detail the significance of such a huge exclusion zone on its proposed NGSO FSS services. In short, it would wipe out the widespread provision of such services in any area where Northpoint provides service.

A second flaw in Northpoint's proposal relates to how Northpoint will cope with rain fades without increasing interference to DBS and NGSO FSS receivers. In its Petition for Rulemaking, Northpoint indicated that in order to accommodate a C/N reduction of a DBS signal due to heavy rainfall, it would adjust its transmitter output

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[74] *Northpoint Comments*, Exhibit 1, Table 3 (listing HPA power of –25 dBW, antenna gain of 10 dB, and 2.5 dB of line losses).

[75] Application of Broadwave Tampa, LLC for License to Provide a New Terrestrial Transport Service in the 12.2-12.7 GHz Band, Exhibit 2 (Engineering/Technical Parameters Exhibit) (Jan. 8, 1999).

[76] Depending on the shape of Northpoint's transmitting antenna radiation pattern, the increase in exclusion zone area could be a factor of almost 1,800!

power.[77] Specifically, "if there is 3dB of fade affecting the DBS link in a given area, Northpoint can decrease the power of its transmission by 3dB to avoid harmful interference."[78]

The rain fade mitigation approach proposed by Northpoint will not be effective, however, because it does not take into account the small-cell nature of high rainfall events. The absorption and scattering of signals above 10 GHz is strongly dependent upon the rain rate and size of rain drops. The rain rates that are significantly detrimental in the 12.2-12.7 GHz band generally occur within small cells within a storm. NASA Reference Publication 1082(04) provides this illustrative information.[79]

A typical horizontal distribution of rain rate (observed at a 1.4° elevation angle) is shown in Figure 2 for a thundershower in New England.[80] As indicated, rain rate variations of 100:1 are observed over ranges of 10 kilometers for a shower containing four intense cells.

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[77] *See* Northpoint Technology, Ltd., Petition for Rulemaking, RM-9245, at 15, 16 (March 6, 1998).

[78] *Id.*

[79] *See* Propagation Effects Handbook for Satellite systems Design, Fourth Edition, NASA Reference Publication 1082(04), Feb. 1989.

[80] *See* Crane and Blood, 1979. Similar measurements have been made by Goldhirsh (1976), at Wallops Island, Virginia.

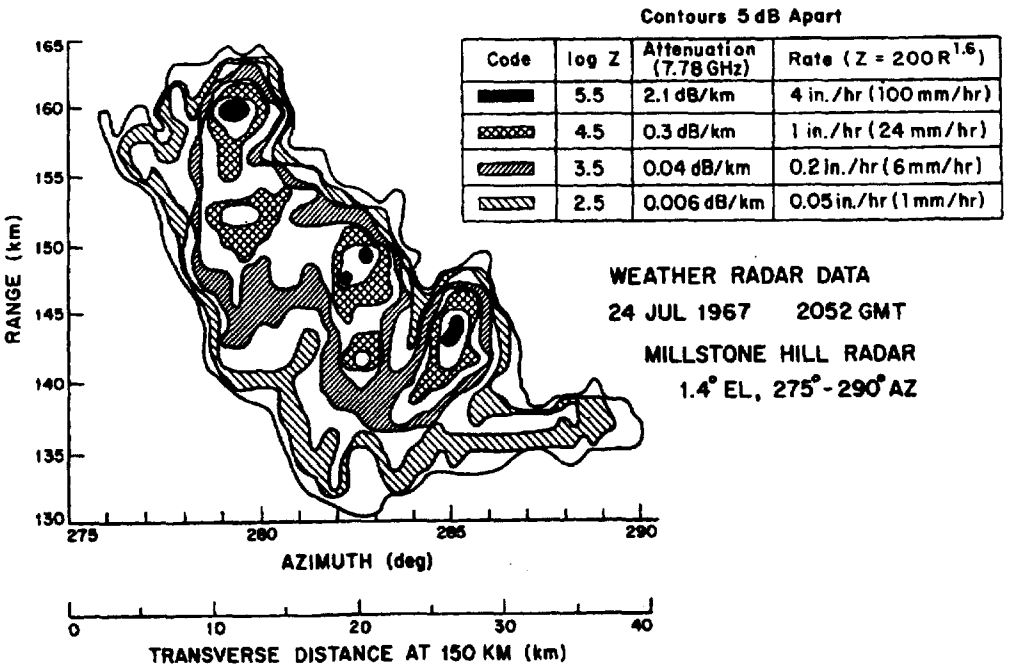

Figure 2 – Weather Radar Map for New England Showers

The relevance of this small rain-cell characteristic is that the Northpoint approach for mitigating the effect of rain fades is dependent upon an assumption that rain rates will be uniform over the intended service area. Simply put, nature has not obliged Northpoint in its plans. For example, when there is a modest rain rate over the Northpoint rain sensor and a high rate in a rain cell in another part of the coverage area, the Northpoint sensor will not cause the Northpoint signal to be reduced while the satellite signal will significantly fade. As a result, the Northpoint signal will cause much more interference to the satellite receiver than under clear sky conditions.

Northpoint may be aware of the inherent problems with its rain fade mitigation technique. Subsequent filings by Northpoint are silent on the subject, thus failing to provide any pro-active method to reduce the effect of its interference on a rain-faded satellite receiver. Unfortunately, providing no method of mitigating the impact on rain-

faded satellite receivers will, under most heavy rain circumstances, lead to further increases in the size of exclusion zones. In sum, if Northpoint tries to mitigate against rain fades in the way described, it will be ineffective – and if no mitigation is attempted, exclusion zones will increase. In other words, Northpoint does not have a realistic approach to mitigate the interference effect of its system on DBS or NGSO FSS receivers during a significant rain event.

In light of the significant interference problems that would result from Northpoint's proposed system, the Commission should affirm its tentative conclusion that it would be inappropriate to authorize Northpoint to operate its terrestrial video distribution service in the Ku-band.

XVII. CONCLUSION

In light of the substantial public interest benefits that can be provided by introducing NGSO FSS systems into the Ku-band, the Commission should promptly adopt rules and licensing policies for such systems. The Commission's rules should largely be based on the outputs of the ITU-R study process, with certain improvements as outlined in Boeing's comments. Furthermore, the Commission should issue a First Report and Order in this proceeding prior to the ITU-R CPM in November 1999. Early release of a First Report and Order will expedite the provision of consumer services by

NGSO FSS systems and will crystallize the United States position before the CPM, thus aiding in the development of international consensus in the months leading up to the start of WRC-00.

Respectfully submitted,

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