JONES DAY

51 LOUISIANA AVENUE, N.W. • WASHINGTON, D.C. 20001.2113

TELEPHONE: +1.202.879.3939 • FACSIMILE: +1.202.626.1700

DIRECT NUMBER: (202) 879-3630
BOLCOTT@JONESDAY.COM

July 5, 2016

VIA ELECTRONIC FILING

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: Written *Ex Parte* Notice, GN Docket No. 14-177, IB Docket Nos. 15-256 and 97-95; RM-11664; and WT Docket No. 10-112

Dear Ms. Dortch:

The Boeing Company ("Boeing"), through its counsel, hereby expresses its significant concern with, and opposition to, the proposed adoption of a 5G base station maximum transmit power of 75 dBm per 100 MHz in the Spectrum Frontiers proceeding.[1] This power limit is substantially higher than the 62 dBm per 100 MHz that was proposed in the Notice of Proposed Rulemaking ("NPRM")[2] after a year-long Notice of Inquiry ("NOI") proceeding,[3] and has only recently been suggested without requisite technical or policy foundation.[4]

The record in this proceeding lacks sufficient justification for dramatically increasing the 5G base station transmit power from 62 dBm to 75 dBm, and Boeing questions whether any such justification could exist. The only reason for the proposed increase that is offered in a "Fact Sheet" announcing the new limit is that it is "based upon anticipated deployment needs."[5] No

[1] *See* Fact Sheet: *Spectrum Frontiers Proposal to Identify, Open Up Vast Amounts of New High-Band Spectrum for Next Generation (5G) Wireless Broadband*, Federal Communications Commission, at 2 (June 23, 2016) ("*Fact Sheet*").

[2] *See* Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, GN Docket No. 14-177, Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service Rules for the 42-43.5 GHz Band, RM-11664, et al., *Notice of Proposed Rulemaking*, FCC 15-138, ¶ 274 (2015) ("*Spectrum Frontiers NPRM*").

[3] Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, WT Docket No. 14-177, Notice of Inquiry, 29 FCC Rcd 13020 (2014) ("*Spectrum Frontiers NOI*").

[4] *See* Letter from Joint Filers (AT&T, Ericsson, Intel, Nokia, Qualcomm, Samsung, and Verizon) to Marlene H. Dortch, Secretary, Federal Communications Commission (April 21, 2016).

[5] *Fact Sheet* at 2.

party, however, has provided a technical analysis showing that 5G systems would benefit appreciably from such a power increase. In fact, in the Spectrum Frontiers NPRM, the Commission evaluated a wide range of possible power levels for new terrestrial wireless services in the 28, 37 and 39 GHz bands and correctly concluded after careful consideration to propose a power limit of 62 dBm per 100 MHz for these bands.

As Boeing explains herein, such a power increase would provide little to no improvement to 5G performance, coverage, or deployment costs, and would undermine the policy objective of maximizing the potential 5G data system options for end users. Such a substantial power increase would also limit significantly the capabilities and strength of a satellite system operating in the 37.5-40.0 ("37/39") GHz band. Boeing therefore urges the Commission to refrain from adopting a 75 dBm base station transmit limit, or at least explore the technical considerations of this issue further in its planned Further NPRM.

The 62 dBm Limit Should Not Be Dramatically Increased Without Foundation. In the Spectrum Frontiers NOI, the Commission noted power limits applicable to terrestrial operations in the 28 GHz and 39 GHz bands, and invited comment on appropriate power limits for new small cell, mobile 5G operation in millimeter wave ("mmW") spectrum.[6] The Commission carefully considered comments on maximum power limits in response to the NOI and in the Spectrum Frontiers NPRM explained in detail the basis for its proposal of 62 dBm:

> Commenters suggest a maximum transmission power limit of 58-65 dBm EIRP for base stations. Intel states that "58 dBm (631 watts) EIRP for base station transmitters … could achieve the performance and range for the applications targeted for these bands." Samsung states that, in its field trials, "Based on a 58 dBm EIRP limit, satisfactory communications links were attained even in non-line-of-sight scenarios more than 200 meters away." Straight Path states that "the FCC [should] adopt an EIRP limit of 65 dBm (3160 watts) for base stations operating in the 39 GHz and LMDS bands. This is consistent with the maximum power limit for other spectrum in which mobile services operate – e.g., the Cellular, Broadband PCS, WCS, AWS, and 700 MHz bands."[7]

The Commission also discussed the application of a 100 MHz reference bandwidth and the practice of permitting operators to double their power (*i.e.*, an additional 3 dB) in rural counties.[8] In addition, the Commission discussed that potential for higher-power operation but

[6] *Spectrum Frontiers NOI*, ¶41.

[7] *Spectrum Frontiers NPRM*, ¶¶ 273-274 (footnotes omitted).

[8] *Id.*, ¶ 275.

only in the context of high-gain, fixed point-to-point backhaul links and not for base station-to-end user service links.[9]

In the face of this extensive record supporting a base station power limit of 62 dBm, several interested parties only now suggest a last-minute 13 dB increase to that limit and provide no real technical or policy foundation for the proposed change. Given the extensive comment and careful consideration given by the Commission in developing its original base station power limit proposal, such a dramatic increase in power cannot be justified.

NGSO FSS Capacity Degrades Rapidly with the 5G Base Station Power Increase. In questioning whether an adequate record has been developed to justify a significant increase in the 5G base station power limit, Boeing understands that the goal of the Commission is to maximize flexibility for future 5G licensees. Such flexibility, however, should not come at the direct expense of opportunities to share mmW spectrum with other beneficial communications services, such as Boeing's proposed non-geostationary satellite orbit ("NGSO") system, which would operate in the fixed-satellite service ("FSS") in the V-band[10] to provide low-latency, very high data-rate broadband service throughout the United States and internationally.[11] In order to provide improved high data-rate services to consumers, the NGSO FSS system proposed by Boeing would require access to the entire V-band, including the 37/39 GHz portion of the spectrum.

As Boeing has demonstrated in multiple technical submissions to the Commission, Boeing's proposed NGSO FSS system could share the 37/39 GHz band with terrestrial 5G licensees.[12] Permitting transmissions from 5G base stations to operate at 75 dBm would mean terrestrial 5G licensees would have the ability to effectively exclude the proposed NGSO FSS system. As previously stated, Boeing is confident that the vast majority of its NGSO FSS earth station receivers would be able to withstand transmissions from 5G base stations operating at a maximum power limit of 62 dBm. The percentage of FSS earth station receivers that would be able to withstand adequately interference from 5G base stations, however, would drop

[9] *Id.*, ¶ 276.

[10] The V-band frequencies to be used by the NGSO FSS system proposed by Boeing include the 37.5-42.5 GHz (downlink) and the 47.2-50.2 and 50.4-52.4 GHz (uplink) spectrum bands.

[11] *See* The Boeing Company Application for Authority to Launch and Operate a Non-Geostationary Low Earth Orbit Satellite System in the Fixed Satellite Service (S2966), SAT-LOA-20160622-00058 (filed June 22, 2016).

[12] *See* Letter from Bruce Olcott, Counsel to The Boeing Company, to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 14-177, et al. (May 9, 2016), at Attachment 1; Letter from Bruce Olcott, Counsel to The Boeing Company, to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 14-177 (June 6, 2016) ("*Boeing June Letter*"), at Attachment 1.

dramatically if those base stations were permitted to operate at power levels as high as 75 dBm. Figure 1 illustrates the general interference model between 5G terrestrial and satellite systems based on IMT-2000 and 3GPP definitions.[13] Figure 2 shows the percentage of Boeing's receive-only earth stations seeing a given C/I ratio at the receiver due to 5G base station transmissions at various power levels ranging from 62 dBm to 75 dBm per 100 MHz.

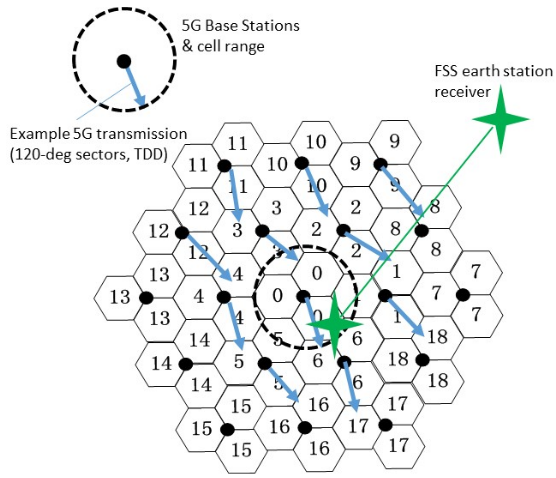

Figure 1 – IMT-2020/3GPP Cell Model

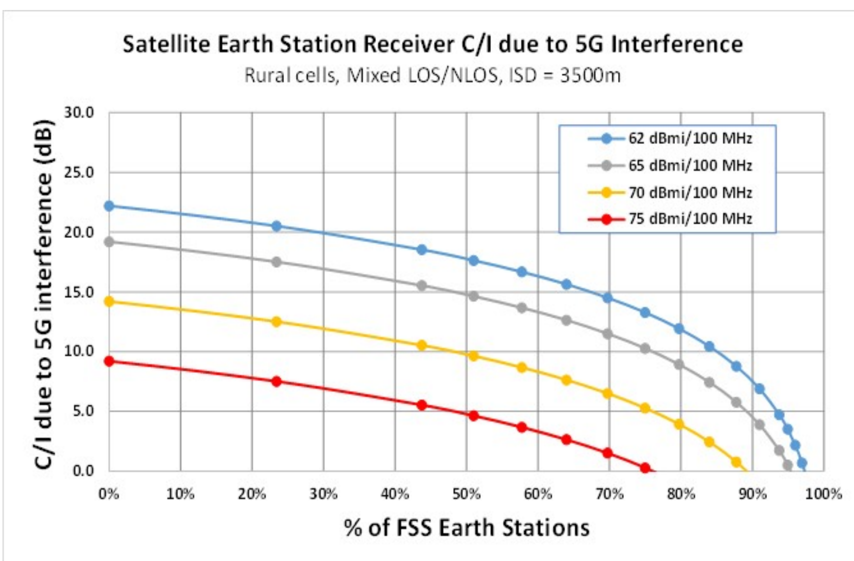

Figure 2 – 5G interference C/I into FSS Earth Station as a Function of Base Station EIRP

[13] *See* ITU-R M IMT-2020 [IMT.MODEL] "Modeling and simulation of transmissions from IMT networks for use in sharing and compatibility studies" – draft recommendation rev.4 (June 25, 2016).

Boeing's previous analysis showing that spectrum sharing is feasible assumed urban cell conditions with non-line-of-sight ("NLOS") losses and relied on 5G base station power levels of 62 dBm, resulting in 20 dB C/I ratios toward the protection of Boeing's satellite earth station receivers. In Boeing's updated spectrum sharing scenarios, rural deployments are considered with mixtures of line-of-sight ("LOS") and NLOS losses with three example spacing distances between the 5G base stations (inter-site distances or "ISDs"). Operation of 5G base stations in rural areas at a power level of 62 dBm reduces the C/I ratio to 15 dB. Seventy percent of the satellite earth station terminals would see this C/I level, resulting in significant but manageable performance degradation. When the 5G base station power level is increased to 75 dBm, however, the resulting C/I ratios fall well below 5 dB for 50 percent of the users. The results of this greatly increased interference are shown in Figure 3 in terms of satellite system capacity (data throughput) reductions in affected region.

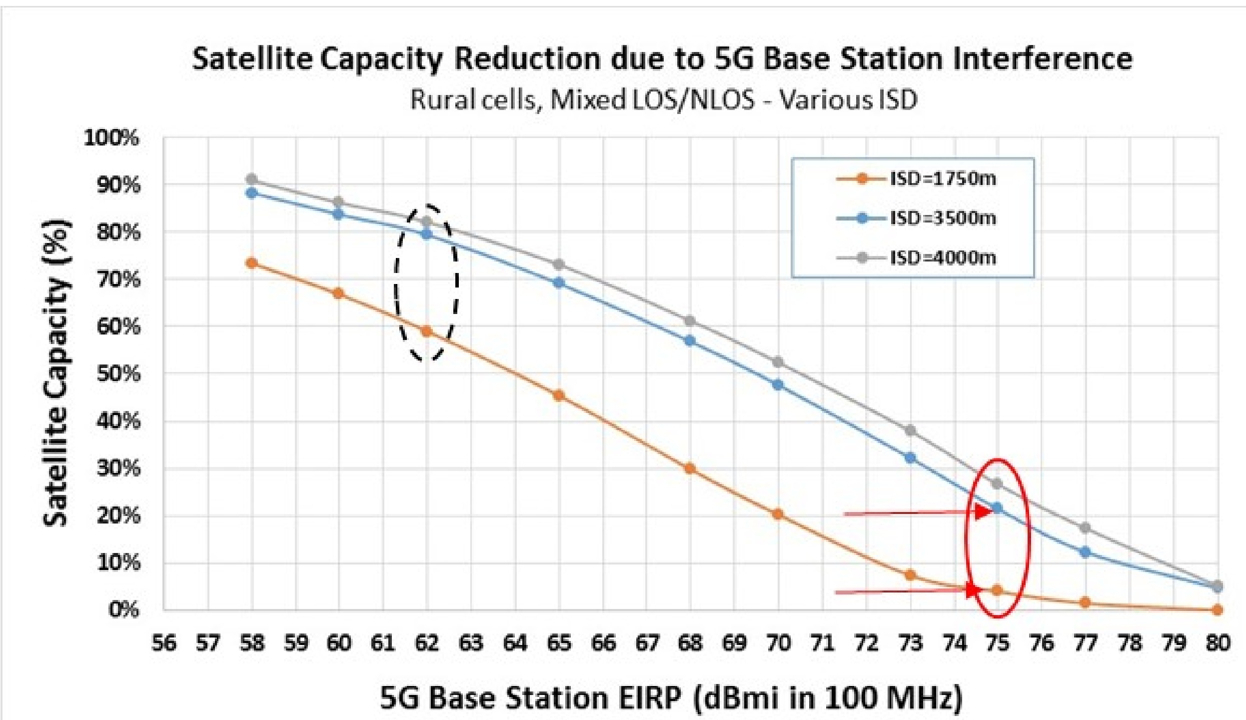

Figure 3 – NGSO FSS Capacity Degrades Rapidly with 5G Base Station Power Increase

Allowing a 5G base station power increase of 13 dB, to 75 dBmi per 100 MHz,[14] reduces the system throughput capacity of Boeing's proposed NGSO FSS system by a factor of five or more (to just 20 percent), depending on the deployment spacing of the 5G base stations. This stands in stark contrast to the very minor degradations introduced by worst-case satellite system operations into the 5G receivers.[15]

Boeing's concern about the significant detrimental impact of the proposed 75 dBm power level is heightened by the fact that the record in this proceeding lacks justification for the adoption of this higher power limit, particularly with respect to the 37/39 GHz band, which has significantly different propagation characteristics than lower spectrum bands currently under consideration for 5G services. As explained below, the Commission's original proposal to adopt a maximum power limit of 62 dBm provides ample flexibility to 5G licensees, while helping to facilitate spectrum sharing in the 37/39 GHz band between terrestrial 5G licensees and broadband satellite communications services.

The Commission's Original Proposal of 62 dBm Supports 5G Deployment Goals. The Commission's original proposal achieved the objective of maximizing the ability of both terrestrial 5G and NGSO FSS systems to share the 37/39 GHz band in furtherance of high data-rate broadband service. One of the recent arguments that have been made for increasing the 5G base station power limit to 75 dBm is the potential for "wide area coverage in suburban and highway areas in an economical way."[16] In making this argument, the Telecommunications Industry Association ("TIA") asserts that "[h]igher power allows adequate headroom to improve and innovate with state-of-the-art technology."[17] TIA and other proponents of this position have provided no technical analysis to the Commission demonstrating that this observation applies to the 37/39 GHz band. In fact, TIA acknowledges in its concluding sentence that "[p]ower has a cost, and if used indiscriminately could also create self-interference."[18]

The bulk of the technical analysis on proposed 5G operations in the 37/39 GHz band was filed with the Commission by Straight Path Communications, Inc. ("Straight Path"). In these

[14] The NPRM employs the term "dBm" when referring to the proposed power level and this letter also uses this term when making reference to the NPRM and the Fact Sheet. In other portions of this paper, the term "dBmi" is used, which reflects that this is an antenna directional power, *i.e.*, decibels milliwatts in relation to isotropic. Boeing's use of the term dBmi does not alter any of the calculations or conclusions of this letter.

[15] *See Boeing June Letter*, Attachment at 7 (showing less than 0.6 dB degradations to 5G operations).

[16] *See* Letter from Dileep Srihari, Director, Legislative and Government Affairs, Telecommunications Industry Association, to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 14-177, at 3 (June 17, 2016) ("*TIA Letter*").

[17] *Id.*, at 3-4.

[18] *Id.* at 4.

technical filings, Straight Path consistently proposed a 5G base station transmit level of 65 dBmi per 500 MHz.[19] Although Straight Path's proposal appears similar to the power level proposed in the Commission's NPRM, Straight Path's proposal of 65 dBmi per 500 MHz resulted in an equivalent EIRP of only 58 dBmi in 100 MHz, which is 4 dB less than the level proposed by the Commission in the NPRM.

The technical analysis and link budgets reported by Straight Path considered three conditions: (1) urban cells, (2) a light suburban deployment (based on NYU measurement data at the University of Texas-Austin campus), and (3) a rural cell deployment. Straight Path's data is summarized in Table 1 including the calculated path loss conditions. As indicated in Table 1, the analyses submitted by Straight Path in both 2015 and 2016, using a power level of 58 dBmi in 100 MHz, were able to overcome a total of 160 dB in path losses, and were considered by Straight Path to be fully adequate to support 5G data rate goals in both urban and rural deployments. Specifically, Straight Path estimated that a forward link data rate of approximate 200 Mbps and a return link data rate of approximately 13 Mbps could be achieved in each of these cases with a base station EIRP density of only 58 dBmi per 100 MHz.

Deployment	ISD (m)	Path Losses	Other Losses	Total Propagation Losses (dB)
Urban Deployment	150m 500m	NLOS (130 dB) NLOS (148 dB)	0.5+30 = 30.5 dB 1.7+10 = 11.7 dB	160.7 159.7
Light Suburban	900m 3100m	Near-LOS (126 dB) Near LOS (139 dB)	3.1+30 = 33.1 dB 10.7+10 = 20.7 dB	159.7 159.7
Rural	1700m 4800m	LOS (124 dB) LOS (133 dB)	16.6+10 = 26.6 dB 6 +30 = 36 dB	160.0 159.8

Table 1 – Cell Deployment and Propagation Loss Examples[20]

Apparently abandoning its prior analysis, Straight Path employs in its recent June 20 *ex parte* letter numerous different technical assumptions in an apparent effort to argue that a higher power of 75 dBm is necessary to achieve comparable performance to what Straight Path previously showed was achievable using far lower base station power levels.[21] Specifically, in

[19] Letter from Russell H. Fox and Angela Y. Kung on behalf of Straight Path Communications, Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 14-177 (Jan. 15, 2015) ("*Straight Path 2015 Letter*"), at Appendix A; Letter from Davidi Jonas, CEO and President, Straight Path Communications, Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 14-177, *et al.* (Jan. 27, 2016) ("*Straight Path Jan. 27 Letter*"), at Appendix A.

[20] *Straight Path Jan. 27 Letter*, Appendix A.

[21] Letter from Davidi Jonas, CEO and President, Straight Path Communications, Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 14-177, *et al.* (June 20, 2016) ("*Straight Path June 20 Letter*").

arguing that more power is needed, Straight Path employs a smaller bandwidth, greatly decreased mobile handset capabilities, a less efficient waveform (with higher overhead), and a more complex (and expensive) base station array in order to justify the need for more EIRP to compensate for worse path loss. When these new variables are extracted from Straight Path's revised analysis, it is evident that Straight Path's prior arguments regarding the capabilities of 5G systems operating at lower power levels continue to be correct.

For example, Straight Path's new analysis assumes an increased path loss total of -167 dB to set performance goals for 5G services within urban cells.[22] When utilizing the same "coupling loss curves" as shown in Straight Path's June 20 letter, the link budgets previously used by Straight Path are able to compensate for -160 dB losses, which would continue to support 90 percent of users in its Urban Micro-cell large-scale calibration model, and 80 percent of users for the Urban Macro cell case, at the 200 Mbps/13 Mbps data rates reported earlier by Straight Path in January.[23] Further, the Commission's originally proposed levels of 62 dBmi in 100 MHz would support -164 dB of losses, covering 95 percent of users in the Urban micro-cell, and 85 percent of the users in the Urban macro-cell at the 200 Mbps/13 Mbps rates. The remaining 5 to 15 percent of users would still receive service albeit potentially at lower data rates, or could be served at the full 200 Mbps/13 Mbps data rates through other measures, such as massive MIMO and MU-MIMO, options which are discussed further below.

To illustrate this point, Figures 4a and 4b show the 5G data rates supported by various base station power levels. The urban results are based on the 3GPP propagation loss model, which is based on the same measured data used in the coupling loss curves quoted by Straight Path[24] and released in the latest 3GPP channel propagation modeling report.[25]

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[22] *See id.,* at Appendix II.

[23] One of the stated reasons for the EIRP increase was that the bandwidth available for 5G links was decreased from 500 MHz to 200 MHz while maintaining the same 5G data rate targets. *See id.*, Appendix II. This raises the required bandwidth efficiency and EIRP artificially when tied to a perceived requirement for servicing for the worst-case edge of cell users in higher efficiency modes.

[24] *See id.*, Appendix II. In addition, Straight Path changed its assumptions regarding mobile handset performance, decreasing it by 5 dB (including changes in gain, noise figure, and losses) in Straight Path's recent budgets when compared to its January 2016 analysis. The values used in this letter are based on the original 16 element handset performance (16 dBi gain and 5 dB noise figure).

[25] *See* 3rd Generation Partnership Project Technical Specification, "*Channel model for frequency spectrum above 6 GHz (Release 14)*," 3GPP TR 38.900 V1.0.0 (2016-06), Table 7.4.1-1: Path loss models.

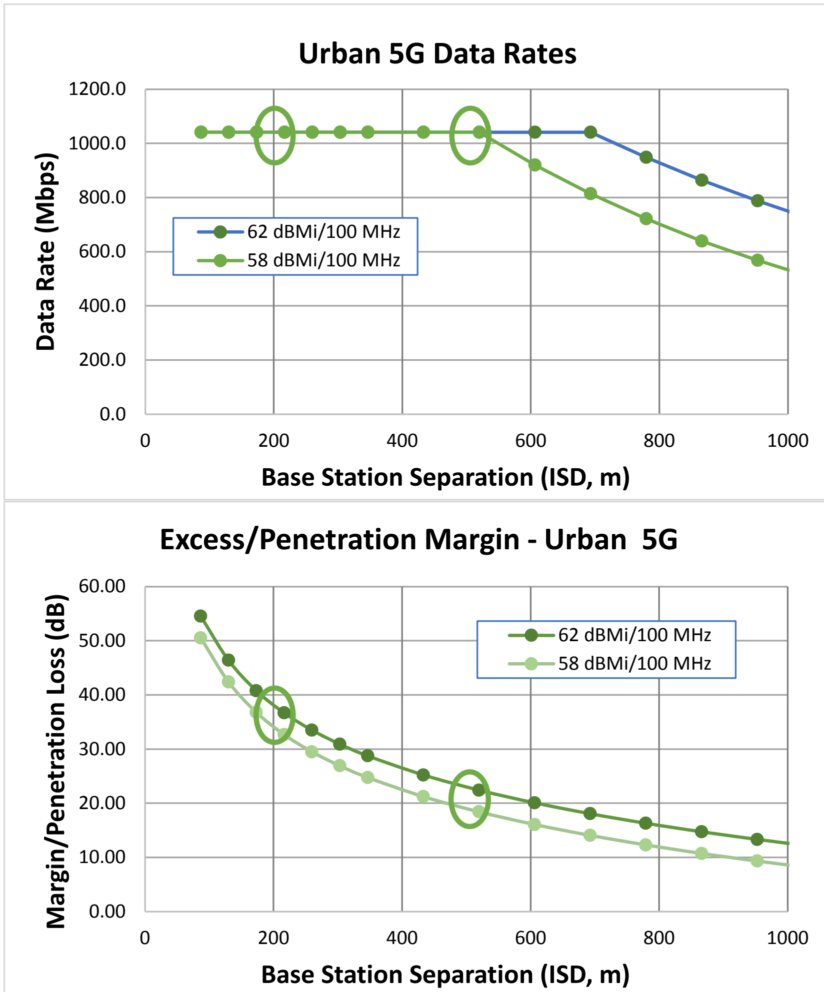

Figure 4a - 5G Urban Data Rates and Penetration Margins
(in 500 MHz channel, using 3GPP Urban Micro-cell NLOS Model)

Figure 4a clearly shows very high 5G data rates are achieved even at maximum distances of 200 meters for Urban Micro-cells and 500 meters for Urban Macro-cells in NLOS conditions. In addition, a margin of up to 20 to 50 dB is available for these users for indoor penetration. The data rates achieved in Figure 4a on the 58 dBmi line are similar to those previously quoted by Straight Path, and the rates shown on the 62 dBmi line are achieved using the Commission's proposed 62 dBmi per 100 MHz level and are in excess of the rates envisioned in Straight Path's filings prior to June 2016.

Figure 4b shows the same capabilities for a Rural deployment scenario, in this case using the NYU propagation model (and with rain loss) originally reported by Straight Path. Again, both the ISD cell distances and data rates achieved fully support 5G services at the lower EIRP levels; in fact, Rural cells may be separated by more than 3 kilometers and sustain these rates with 20 dB margin left for blockage and penetration.

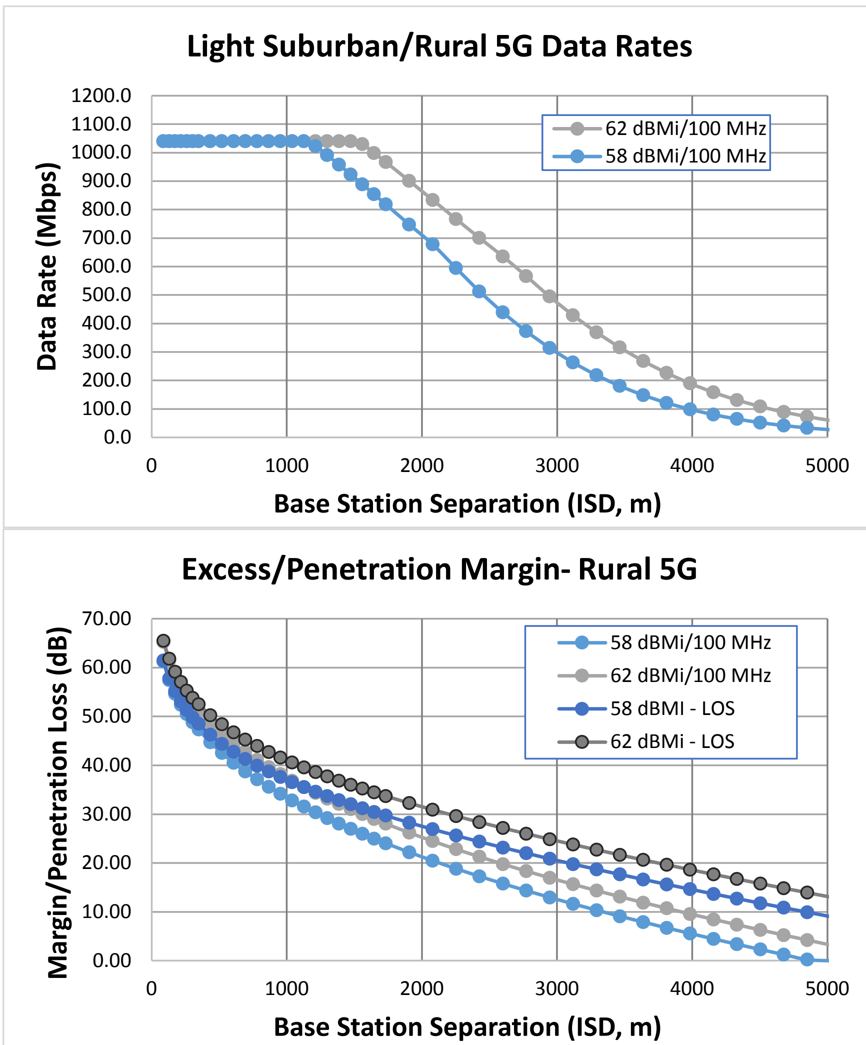

Figure 4b - 5G Rural Data Rates and Penetration Margins
(In 500 MHz channel, using NYU measured light suburban./rural NLOS Model)

Therefore, Straight Path's recent justifications for authorizing base station power limits as high as 75 dBm result not from new analysis, but rather, from changes in technical assumptions.

Straight Path fails to justify many of its new assumptions. The Commission, and the public interest, would be better served by relying on Straight Path's prior analysis, which clearly showed adequate 5G performance capabilities using base station transmit levels in the range of 62 dBm or lower.

Increased EIRP Levels Can Drive 5G Deployment Costs. Boeing understands that during a recent meeting between Commission staff and TIA representatives, FCC staff raised questions about whether an increase in the maximum base station transmit level might result in reduced deployment costs for 5G licensees. As Straight Path's analysis shows, the opposite is likely true. Specifically, to achieve the results quoted in Straight Path's June 20 letter, Straight Path assumed the use of a phased array antenna that was much larger and more complex than the arrays it employed in its prior analyses, increasing from 256 to 1024 elements.[26] Such an increase in array size, particularly when associated with a large Urban micro or macro cell deployment (with cell ranges of 200 to 500 meters), would represent a significant cost increase for 5G deployment.

Granted, a 5G licensee might attempt to employ higher power levels without increasing the size or complexity of its phased array antennas, but such measures would increase costs in other ways. For example, should a higher power level be deployed with a lower-element count or simpler base station (also suggested by Straight Path in other of its comments[27]), these simpler stations may have difficulty achieving a higher EIRP due to reduced antenna gains. Indeed, a 4x4 base station, with only 16 elements and limited antenna gain, would require 1000 watts total, or more than 60 watts per element, to achieve the same EIRP density level as the 256 element array, resulting in very high power consumption costs. As a result, it is far from clear that authorizing 5G licensees to employ an increased EIRP would reduce 5G deployment costs or improve performance for 5G systems.

5G Licensees Can Employ Other Measures to Optimize Performance. Rather than increase the power of 5G base stations, 5G licensees can achieve substantial improvements in path loss and service rates through the use of adaptive coding and modulation. For example, to compensate for users operating in the highest fading (*i.e.*, the 10 percent or less of cases not covered by penetration margins), current communications systems utilize adaptive modulation and coding to employ a higher or lower order modulated signals to service fading users. LTE and other advanced waveforms offer a dynamic range of 25 dB to maintain the highest possible data rates during the fading and penetration losses discussed above. Through the use of this approach, more than 90 percent of users will achieve the minimum rates shown in Figures 4a and 4b and, when a fading or penetration loss exceeds the values shown in Figure 3b or 4b, users can

[26] *Straight Path June 20 Letter*, Appendix II (Reference 10).

[27] *Straight Path Jan. 27 Letter* at 3 (explain that "a 5G base station is not required to implement 256 antenna elements. Many 5G base stations will have smaller antenna…").

be automatically switched to a more bandwidth efficient mode. This can be combined with MIMO techniques to maintain overall system capacity in heavy fading conditions.

Indoor Users and Devices Will Continue to Leverage Access to Other Networks. A further argument expressed by TIA and others for increasing the base station transmit limit to 75 dBm is that higher power "will help overcome expected increases in loss when propagating in dense urban environments and through foliage, ground clutter, and various building materials."[28] As TIA acknowledges, "building penetration loss above 6 GHz becomes very significant for newer builds with a higher share of infrared reflective glass."[29] These concerns are also reflected in both 3GPP and ITU-R technical reports, which conclude that penetration losses are increasingly severe at higher mmW frequencies.[30]

This argument ignores the fact that such building penetration losses cannot be overcome reliably by brute force increases in base station transmit power. Reflective building materials are still likely to reflect mmW signals at higher power levels, producing even more powerful reflective transmissions in undesired directions, resulting in significant inter- and intra-system interference. Therefore, increasing 5G operating levels for outdoor access points would not serve the public interest because they will be largely unsuccessful in providing any indoor service that could be comparable to services already available using other spectrum bands.

Existing services such as Wi-Fi are already available to successfully facilitate the transition of user devices between outdoor access points and indoor operating modes. As Ericsson notes,

> It is important to understand that high frequencies, especially those above 10 GHz, can only serve as a complement to lower frequency bands, and will mainly provide additional system capacity and very wide transmission bandwidths for extreme data rates in dense deployments. Spectrum allocations at lower bands will remain the

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[28] *TIA Letter* at 3.

[29] *Id.*

[30] *See* 3rd Generation Partnership Project Technical Specification, "Channel model for frequency spectrum above 6 GHz (Release 14)", 3GPP TR 38.900 V1.0.0 (2016-06), Section 7.4.3, O-to-I penetration loss (including a 22 to 25 dB difference in "low" versus "high" loss models); *see also* "5G Channel Model for bands up to 100 GHz," Annex A, (March 2016) (including measurements by Ericsson in section A.9 including variances of more than 30 dB of clear versus low-E/IRR glass, 15 dB in wood studs, and 47 dB to more than 60 dB for brick and cement materials).

> backbone for mobile-communication networks in the 5G era, providing ubiquitous wide-area connectivity.[31]

Further, the capabilities of existing services at lower spectrum bands continue to be improved. As one example, the use of massive MIMO and MU-MIMO recently achieved an equivalent spectral efficiency of 79.4 bps/Hz using 128-elements beamforming and MIMO – reportedly, the highest ever recorded to date using 128-elements beamforming and MIMO, while operating in the 3.5 GHz band.[32] With such significant capabilities available using beamforming and MIMO techniques, it is unclear why EIRP increases would be necessary for mmW 5G systems since they already utilize hundreds of times the bandwidth available versus existing 4G systems and can utilize adaptive coding, beamforming and MIMO technologies referred to herein to provide 5G services without EIRP increases.

Conclusion

The Commission has sought in this proceeding to be the leading force in the global push for new communications services using mmW frequencies and Boeing would like to help the Commission achieve this goal of maximizing consumer choices and universal availability of 5G high data communication services, even in the most rural and remote portions of the country. The Commission should resist efforts to effectively prevent NGSO FSS system solutions, as recently proposed by Boeing, from using the 37/39 GHz band and maintain its original proposal of a base station power limit of 62 dBmi in 100 MHz to ensure maximum spectrum sharing between terrestrial 5G and broadband satellite services and to provide additional certainty that mmW broadband communications services will be equally available to all consumers on a competitive basis.

The regulatory measures that Boeing has sought to facilitate spectrum sharing in the 37/39 GHz band are modest and generally consistent with the network design and operational characteristics that 5G network operators are likely to employ to avoid interference into their own networks. Included with these requested measures is a reasonable limit on 5G base station power of 62 dBmi per 100 MHz in order to enable satellite receive terminals to withstand interference from 5G base station transmissions. The record of this proceeding includes no indication that such a power limit would impede the robust deployment of 5G communications systems. In fact, the opposite is true – 5G proponents have based many of their technical papers that they have filed with the Commission on the use of base station power levels in the range of

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[31] *See* http://www.ericsson.com/res/docs/whitepapers/wp-5g.pdf April 2016.

[32] *See* http://www.fiercewireless.com/tech/story/bristol-lund-claim-record-5g-spectral-efficiency/2016-03-27 (reporting that a massive MIMO demonstration achieved "an unprecedented bandwidth efficiency" of 79.4 bit/s/Hz, conducted at 3.5 GHz, and achieved 12-16 MIMO processing using 128 elements).

62 dBmi in 100 MHz or lower.[33] Boeing therefore urges the Commission to adopt its originally proposed base station transmit power limit of 62 dBm and, to the extent appropriate or desirable, more fully explore the technical considerations of any higher limit in its planned Further NPRM.

Thank you for your attention to this matter. Please contact the undersigned if you have any questions.

Sincerely,

Bruce A. Olcott
Counsel to The Boeing Company

[33] *See, e.g.,* Letter from Joint Filers (AT&T, Nokia, T-Mobile, Samsung, and Verizon) to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 14-177 *et al.*, at 9 (May 6, 2016) (discussing FSS/UMFU co-existence simulation and indicating use of 62 dBmi in 100 MHz for all results).