STRAIGHTPATH
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June 23, 2016

VIA ELECTRONIC FILING

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Written *Ex Parte* Presentation

GN Docket No. 14-177, ***Use of Spectrum Bands Above 24 GHz for Mobile Radio Services***

Dear Ms. Dortch:

In its recent response to our June 14th letter, The Boeing Company ("Boeing") continues to cloud the record in this proceeding regarding the 37/39 GHz bands by misrepresenting the state of the art of phased array technologies for Fifth Generation wireless ("5G") and fixed satellite service ("FSS") technologies.[1/] Boeing's requests untimely ask the Commission to reverse its "soft segmentation" approach to the V-band and significantly expand FSS rights at the expense of terrestrial services, and they will cripple the mobile industry's efforts to provide gigabit mobility to the American people.

The Satellite Industry Has Made No Use of the 37/39 GHz Band

The fact that Boeing referred to "[e]xperimental V-band satellite systems" in "other regions of the world" and "government satellite systems" in the U.S. as the strongest evidence that the satellite industry is "using" the V-band—including the 37/39 GHz bands—exemplifies the lack of use of these bands by the satellite industry more than a decade after these bands were allocated in the United States.[2/] It is also revealing that Boeing waited until the last minute in

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[1/] *See* Letter from Bruce A. Olcott, Counsel to The Boeing Company to Marlene H. Dortch, Secretary, FCC, GN Docket No. 14-177, *et al.* (filed June 17, 2016) ("Boeing Ex Parte Letter") (discussing Letter from Davidi Jonas, CEO and President, Straight Path Communications, Inc. to Marlene H. Dortch, Secretary, FCC, GN Docket No. 14-177 (filed June 14, 2016) ("Straight Path Ex Parte Letter")).

[2/] *See* Boeing Ex Parte Letter at 2.

this proceeding—a year-and-a-half after the Commission issued its Notice of Inquiry[3/]—to claim that Boeing is now "developing" a satellite network that "requires access to the entire V-band."[4/] Without any technical details, investment plans, or a specific timeframe, Boeing makes nothing but an empty claim.

Furthermore, Boeing misrepresented CTIA's good-faith compromise as a concession that 5G in millimeter wave bands will not work in less populated areas.[5/] In fact, in that very same letter, CTIA proposed that:[6/]

- Upper Microwave Flexible Use ("UMFU") licensees have primary rights to the spectrum in the bands.
- FSS parties that desire primary rights/protections be required to participate in a market-based approach (either via auction or lease).
- Existing FSS land-based earth stations be afforded "operation rights" in the bands with a secondary status.
- Future FSS earth stations not be deployed in the top-150 Metropolitan Statistical Areas ("MSAs"), as defined by the Cellular Market Areas ("CMAs") used by the Commission, without participation in a market-based solution (either participation in the UMFU auction or through a lease with an UMFU licensee).
- Outside the top-150 MSAs, future FSS earth stations be deployed only on a secondary, non-interference basis.

CTIA's proposal is plainly contradictory to Boeing's requests. While it is true that urban deployment provides the highest return on investment for mobile operators, suburban and rural deployments using cell radii of multiple kilometers are also important deployment scenarios for 5G. Verizon CEO Lowell McAdam has stated that he expects the operator "could run fiber from its cell towers in order to deliver fixed 5G services, including in rural areas."[7/] Our analysis also shows that 5G mobile services in millimeter wave bands are economically viable for areas with a population density of more than 10 people/km^2, which covers more than 98.6% of the U.S. population.[8/] Other types of services, such as fixed broadband and backhaul, are likely to be economically viable in even less populated areas.

3/ *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, et al.*, Notice of Inquiry, 29 FCC Rcd. 13020 (2014) (released on October 17, 2014).

4/ *See* Letter from Bruce A. Olcott, Counsel to The Boeing Company to Marlene H. Dortch, Secretary, FCC, GN Docket No. 14-177, *et al.*, at Attachment (filed May 9, 2016).

5/ *See* Boeing Ex Parte Letter at 2.

6/ *See* Letter from Scott K. Bergmann, Vice President, Regulatory Affairs, CTIA to Marlene H. Dortch, Secretary, FCC, GN Docket No. 14-177, *et al.*, at 3-4 (filed May 20, 2016).

7/ *See* Mike Dano, "Verizon's McAdam on 5G: Fixed deployment 'gives you all the return on capital that you need' – Carrier's 5G tests in Basking Ridge show 1.8 Gbps, reach of up to 1,000 meters," FierceWireless (May 24, 2016), *available at* http://www.fiercewireless.com/story/verizons-mcadam-5g-fixed-deployment-gives-you-all-return-capital-you-need/2016-05-24.

8/ *See* Comments of Straight Path Communications, Inc., GN Docket No. 14-177, *et al.*, at 12 (filed Jan. 27, 2016) ("Straight Path Comments").

Boeing's Technical Analysis is Flawed

Boeing argues that there is little need for a 5G base station to point its antenna pattern upwards to serve customers in tall buildings. Yet this deployment scenario is more common than Boeing imagines. According to a recent survey by the U.S. Energy and Information Administration,[9/] there are 5.6 million commercial buildings in the United States, with 190,000 buildings having four or more floors. These buildings accommodate more than 25 million workers.

Table 1. Number of commercial buildings, floors, and workers in the United States, 2012[10/]

	Number of buildings (thousand)	Total floorspace (million square feet)	Total workers (thousand)	Mean square feet per building (thousand)	Mean square feet per worker	Mean operating hours per week
All buildings	5,557	87,093	88,182	15.7	988	62
Number of floors						
One	3,836	39,809	35,019	10.4	1,137	60
Two	1,158	20,206	19,744	17.5	1,023	60
Three	374	8,140	7,826	21.8	1,040	69
Four to nine	177	13,535	16,248	76.6	833	84
Ten or more	13	5,404	9,343	429.2	578	108

Many of these tall buildings are located in dense urban areas where micro base stations are deployed with heights around 10–30 meters. In other words, tens of millions of mobile broadband subscribers are already being served today by base stations *below* them with antennas that cover large angles above the horizon. Boeing's proposal that 5G base stations suppress FSS interference above horizon by 20 dB will prevent these deployment scenarios.

Boeing also confuses the maximum antenna configuration in a 3GPP Technical Report[11/] with the typical antenna configuration for 5G base stations. A 5G base station is not *required* to implement 256 antenna elements. Many 5G base stations will have smaller antenna configurations and thus wider side lobes that are susceptible to satellite interference. Further, Boeing misunderstands how these antenna elements are used. In 5G systems, antenna elements are often not employed for the sole purpose of forming a single beam that rejects interference from all other spatial directions except the main lobe. For example, 5G base stations need to transmit and receive a variety of control signals using different wide beams for essential system functions such as synchronization, system acquisition, random access, packet data control, acknowledgement, etc., all covering or scanning through the entire coverage area of the cell.

9/ *See* U.S. Energy Information Administration, 2012 Commercial Building Energy Consumption Survey , *available at* http://www.eia.gov/consumption/commercial/ ("2012 CBECS").

10/ *See* 2012 CBECS at Table B.1, *available at* http://www.eia.gov/consumption/commercial/data/2012/bc/pdf/b1-b2.pdf.

11/ *See* 3GPP TR 38.900 V1.0.0, "Channel model for frequency spectrum above 6 GHz," at 21-22 (Section 7.3,"Antenna modelling"), *available* at http://www.3gpp.org/ftp//Specs/archive/38_series/38.900/38900-100.zip ("3GPP Technical Report").

These beams vary from a few degrees to a few tens of degrees depending on base station antenna configuration, the intended coverage area, and the user mobility, among others. It is impossible to suppress the side lobes of all these signals to below 20 dB above horizon as Boeing proposes.

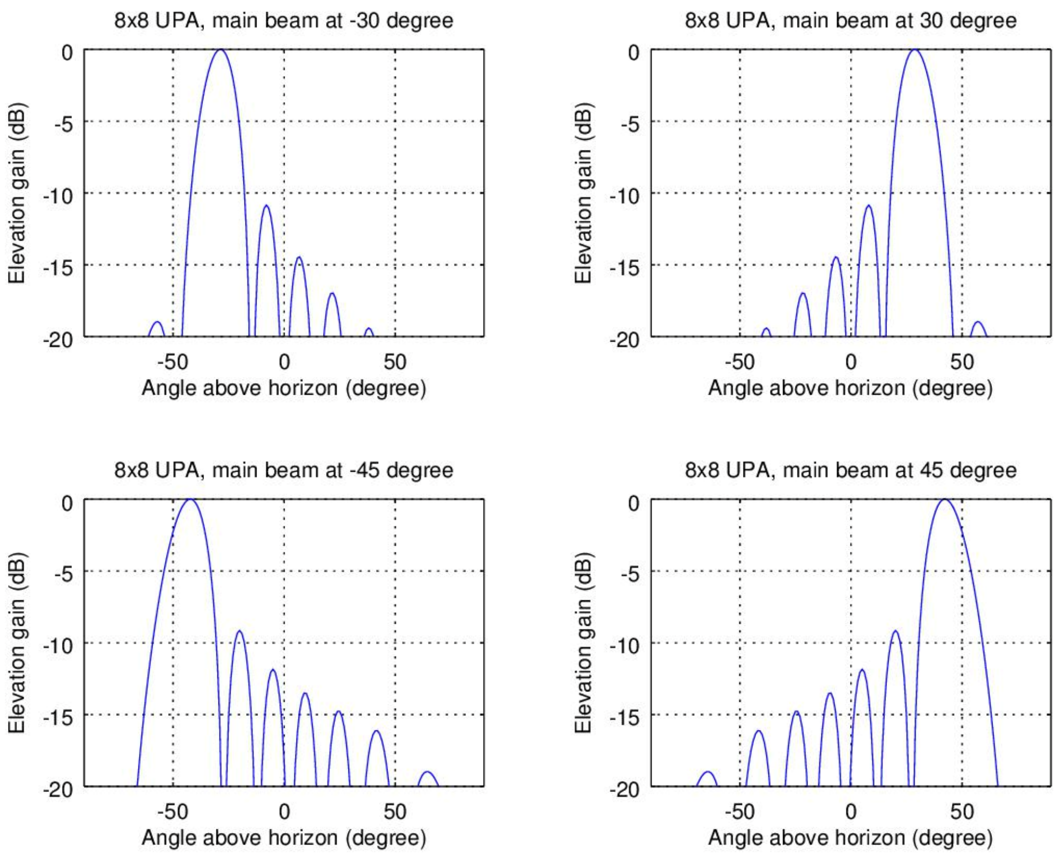

Figure 1. Elevation gain patterns for 8x8 Uniform Planar Array

A simple illustration of the side lobes of a 5G base station with a 64-element antenna array arranged in 8×8 Uniform Planar Array ("UPA") fashion is shown in Figure 1. Significant side lobes occur when the beams are steered away from the broadside of the antenna array. Even if the base station intends to steer the beam downwards, *e.g.*, as shown in the case with main beam pointing at 30 degree or 45 degree below horizon, the side lobes above horizon are often much higher than -20 dB.

This situation gets worse in the case of hybrid beamforming and multi-user multiple input, multiple output ("MIMO") transceivers, in which the whole antenna array is further divided into subarrays. For example, assume an 8×8 array is divided into four 4×4 sub-arrays. Analog beamforming is performed within each 4×4 sub-array to gain the benefit of beamforming while a digital MIMO processing is applied across the four sub-arrays to increase spectral utilization by transmitting or receiving multiple spatial streams at the same time. As shown in Figure 2 below, the elevation gain patterns of the 4×4 sub-arrays have much wider beamwidth and higher side lobes than those of the 8×8 antenna array. Again, Boeing's proposal to require the base station to reject satellite interference above horizon by 20 dB will simply not work.

Boeing requests that the Commission increase the permitted satellite power flux density ("PFD") by 12 dB based on the requirement for 5G base stations to reject multiple moving satellite interferers above the horizon. However, 5G base stations may only be able to suppress the interference by a few dBs, with no guarantee that nulls can be formed to track multiple moving satellites. Accordingly, the satellite system Boeing claims to be developing will already create non-negligible interference to 5G base stations at the current level PFD of -117 dBW/m^2/MHz. As our analysis shows, increasing the satellite PFD further by 12 dB will create a major reduction of coverage for 5G fixed and mobile services and severely damaging the economics and prospect of 5G deployments in this band.[12/]

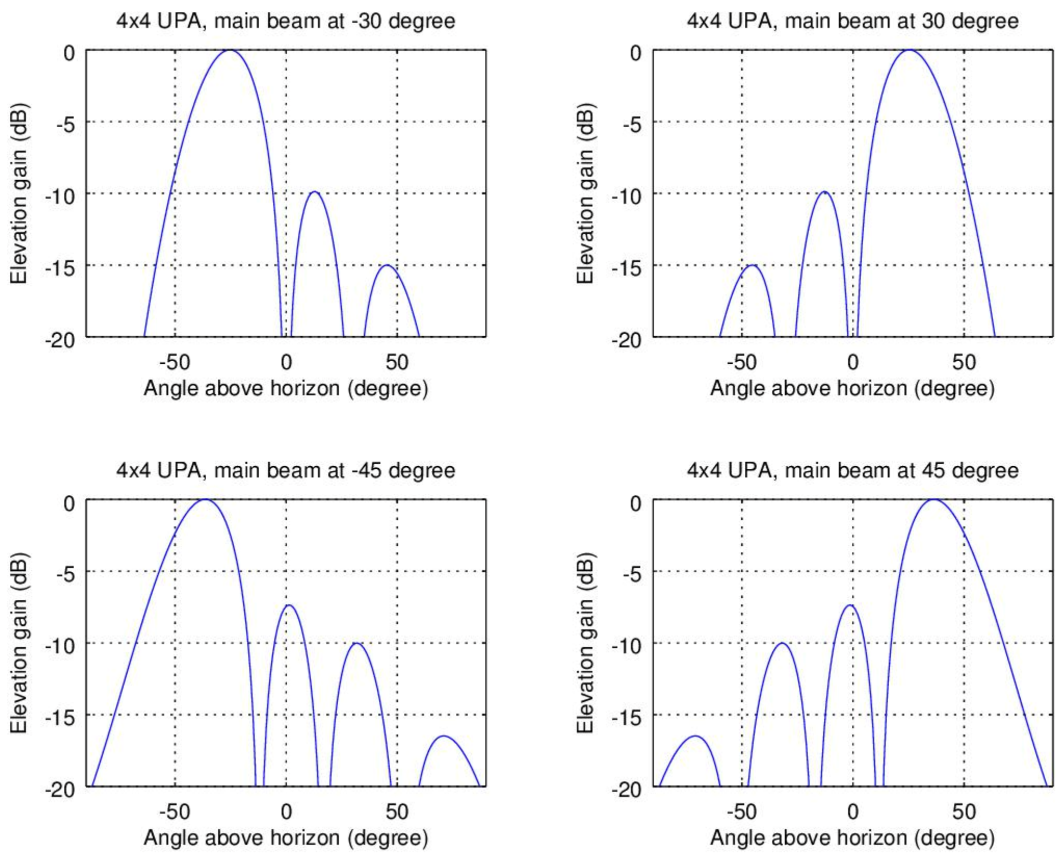

Figure 2. Elevation gain patterns for 4x4 Uniform Planar Array

For FSS ground stations, Boeing appears to have exaggerated what the state of the art phased array technology can achieve at reasonable cost. The typical phase shifters that we can economically achieve in the Gallium Arsenide (GaAs) or Silicon Germanium (SiGe) process have limited resolution and accuracy. For example, one of the latest phase shifters at 8–12 GHz from a major RF device vendor, TGP2109-SM, costs more than $50 apiece.[13/] This part has a root mean square ("RMS") phase error of 4^o and RMS amplitude error of 0.5 dB, with an

[12/] *See* Straight Path Comments at 33-37, Appendix B.

[13/] *See* Product Details, "TriQuint (Qorvo) TGP2109-SM," Mouser Electronics, http://www.mouser.com/ProductDetail/TriQuint-Qorvo/TGP2109-SM/ (last visited June 23, 2016).

additional quantization noise of 2.8°.[14/] A simple rule of thumb is that the side lobes generated by these error and noise factors alone is

$$\frac{1}{N}\left(\varphi_r^2 + \varphi_q^2 + \delta^2\right)$$

where φ_r is the RMS phase error, φ_q is the quantization noise, and δ is the RMS amplitude error. In order for this term to be reduced below 50 dB, a 1000-element antenna array would be needed. An expensive and difficult feat to achieve. With 5G trial networks already starting this year and commercial deployment expected within four years, it is unlikely that the performance of phased array radio frequency integrated circuit ("RFIC") can be much better than this, if not worse due to higher level of integration and the continuous drive towards lower cost design and manufacturing processes.

In its analysis, Boeing applied the antenna specification in ITU S.1428[15/]—intended for non-geostationary FSS ground stations—to 5G Base Stations. This is incorrect and not acceptable in the mobile industry. 5G base stations have very different constraints from FSS ground stations and will use very different antennas to support a large variety of services and deployment scenarios. Straight Path continues to support the Commission's proposal to adopt flexible rules, including rules governing antenna patterns, to allow UMFUS services to efficiently use the millimeter-wave spectrum.

Boeing also misunderstands our concern about its analysis of the aggregated 5G interference to FSS ground stations. That analysis is based on the following two premises:

1. most 5G interferers are non-line-of-sight ("NLOS") with the FSS ground station most of the time; and
2. there is only a single dominant 5G interferer at a given time while the contribution of other interfering 5G base stations and mobile stations can be ignored.

As we explained in our previous filing,[16/] neither of these two assumptions is true. NLOS channel conditions often occur in dense urban areas due to the high density of man-made structures. While the urban areas account for more than 80% of population in the U.S., however, they only represent 3% of the land mass of the U.S.[17/] In the vast 97% of the U.S. land area where the other 20% of the U.S. population reside (and in the suburban areas within the urban areas), the premise of NLOS channel condition is often not true. In these areas where line-of-sight ("LOS") and near-line-of-sight channel conditions frequently occur, the path loss exponent is often close to that of free space, *i.e.*, the path loss exponent is close to 2, instead of 3 or 4. The aggregated interference from 5G stations is further exacerbated by the fact that the number of interferers grows proportionally to the area (*i.e.*, the area within a 10-km radius has 100 times

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[14/] *See* Datasheet, TGP2109-SM 8-12 6-Bit Digital Phase Shifter, TriQuint | Qorvo (rev. Sept. 30, 2015), *available at* http://www.triquint.com/products/d/DOC-E-00001045.

[15/] *See* Recommendation ITU-R S.1428-1, "Reference FSS earth-station radiation patterns for use in interference assessment involving non-GSO satellites in frequency bands between 10.7 GHz and 30 GHz," *available at* https://www.itu.int/dms_pubrec/itu-r/rec/s/R-REC-S.1428-1-200102-I!!PDF-E.pdf.

[16/] *See* Straight Path Ex Parte Letter.

[17/] *See* Wendell Cox, "New US Urban Area Data Released," NewGeography.com (Mar. 26, 2012), *available at* http://www.newgeography.com/content/002747-new-us-urban-area-data-released.

more interferers than the area within 1-km radius). As a result, the interference from mobile stations and base stations further away cannot be ignored.

Based on the faulty analysis, Boeing asks the Commission to "[l]ift the prohibition on satellite end user receivers in the 37/39 GHz band" and to "[i]mpose no limits on receive-only gateway facilities in the 37/39 GHz band."[18/] But if large number of satellite end user receivers are deployed in residential areas, and if no exclusion zones are provided for the FSS gateway facilities, a large portion of these receivers will be overwhelmed by 5G fixed and mobile services deployed in the same area, creating a use environments that would be antithetical to the public interest. Straight Path therefore urges the Commission not to adopt rules based on Boeing's overly simplistic and optimistic analysis with seriously flawed assumptions.

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While Boeing claims "the Commission does not need to make a choice between promoting 5G terrestrial systems or broadband satellite systems in the 37/39 GHz band,"[19/] its flawed analyses (and its overreaching proposals) prove otherwise. At stake in this proceeding is nothing less than U.S. leadership in the use of 5G technologies in the millimeter wave bands.

Straight Path looks forward to working with all interested stakeholders to produce a timely resolution of this proceeding. Should there be any questions, the Commission is asked to contact the undersigned directly. Pursuant to Section 1.1206(b)(2) of the Commission's rules, a copy of this letter has been submitted in the record of the above-referenced proceeding.

Respectfully submitted,

/s/ Davidi Jonas

Davidi Jonas
CEO and President
Straight Path Communications, Inc.

18/ *See* Boeing Ex Parte Letter at 9.

19/ *Id.* at 3.