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Marlene Dortch
Secretary
Federal Communications Commission
45 L Street, NE
Washington, DC 20554

Re: Expanding Flexible Use of the 12.2-12.7 GHz Band, WT Docket No. 20-443, GN Docket No 17-183

Dear Ms. Dortch:

DISH Network Corporation ("DISH") provides this response to the claims made by Space Exploration Technologies Corp. ("SpaceX") in a recent ex parte submitted in the above-captioned proceedings. While DISH and others have repeatedly demonstrated that higher-power terrestrial operations in the 12.2-12.7 GHz band ("12 GHz Band") can co-exist with, and avoid interfering into, non-geostationary orbit ("NGSO") satellite systems, SpaceX continues to rely on two studies prepared nearly six years ago by Tom Peters, former Chief Engineer for the Wireless Telecommunication Bureau and submitted by the MVDDS Coalition (of which DISH is a member), which questioned sharing between the two services.[1] In doing so, SpaceX ignores or obfuscates three critical developments since the studies were first submitted in 2016, erroneously asserting that there have been "no changed facts or circumstances since then."[2] As described below, SpaceX's assertion is wrong, and the 2016 Peters Studies have been superseded by the more granular, comprehensive, and probabilistic analysis prepared by RKF Engineering Solutions, LLC ("RKF") and submitted on May 7, 2021.[3]

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[1] *See* Comments of MVDDS 5G Coalition, RM-11768, Attachment 1 (June 8, 2016) (attaching MVDDS 12.2-12.7 GHz Co-Primary Service Coexistence) ("First Peters Study"); Petition to Deny of the MVDDS 5G Coalition, File No. SAT-LOI-20160428-00041, Attachment 1 (Aug. 15, 2016) (attaching MVDDS 12.2-12.7 GHz NGSO Coexistence Study) ("Second Peters Study") (collectively "Peters Studies").

[2] Letter from David Goldman, Space Exploration Technologies Corp., to Marlene Dortch, FCC, WT Docket No. 20-443, GN Docket No. 17-183, at 1 (Mar. 18, 2022) ("SpaceX Ex Parte").

[3] RKF Engineering Solutions LLC, Assessment of Feasibility of Coexistence between NGSO FSS Earth Stations and 5G Operations in the 12 GHz Band (May 2021) (submitted as Appendix

First, SpaceX ignores that since 2016, the actual mode of NGSO operations, including the operations of SpaceX itself, have changed and now such operations avoid low elevation angles. Rather than confront this change, SpaceX ignores the obstructions that make low angles undesirable for NGSO operations and unsatisfactory for NGSO users. Instead, SpaceX argues that if such obstructions did not exist, SpaceX would be able to provide satisfactory service from low angles, and, in that world, that service would be impeded by higher-power terrestrial operations. But the obstructions ***do*** exist and ***do*** impede low-angle NGSO services today. Despite SpaceX's protestation, the accumulation of satellite service in the United States in a northern orbital shell ***does*** mean higher elevation angles, as shown unwittingly by SpaceX itself.

Second, SpaceX entirely ignores technical advances, such as horizon nulling, which will mitigate *any* potential for harmful interference into NGSO services, and will make terrestrial services even more benign in the 12 GHz sharing environment. Moreover, while SpaceX notes that not all of the assumptions used by the studies are "worst-case," it does not, and cannot, dispute what Mr. Peters himself explained at the time: that his 2016 analysis was "[u]sing worst-case assumptions."[4] Nor is it possible to dispute that the studies took a snapshot of that worst-case analysis and did not assess the probability of interference over time and locations, something that the RKF Report does do.

Third, SpaceX ignores the D.C. Circuit's 2021 decision in *AT&T Services, Inc. v. FCC* and a string of Commission decisions that have upheld the soundness of "Monte Carlo," probabilistic analyses for assessing interference potential. Worst-case approaches have their place in interference analysis: they are a useful starting point, not a dispositive ending point. In light of this precedent, it has now become clear that the possibility of an impact on NGSO operations should be assessed based on a probabilistic analysis.[5]

SpaceX also takes issue with the geographic distribution assumptions made by RKF in its 2021 analysis. But its focus on these assumptions creates a powerful inference that RKF's conclusions are correct if the assumptions are proven true. In that respect, SpaceX ignores that the geographic distribution of 5G assumed by RKF can be *made* true by imposing appropriate conditions on terrestrial licensees. As for the geographic distribution of NGSO users, RKF has given the potential for interference the benefit of the doubt. In other words, RKF has placed some NGSO users in "a textured population model that recognizes pockets of high population

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A to Comments of RS Access, LLC, WT Docket No. 20-443, GN Docket No. 17-183 (May 7, 2021)) ("RKF Report").

[4] First Peters Study at 33.

[5] *See, e.g.*, *AT&T Services, Inc. v. FCC*, 21 F.4th 841, 853 (2021); Unlicensed Use of the 6 GHz Band; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz, *Report and Order and Further Notice of Proposed Rulemaking*, 35 FCC Rcd. 3852 (2020); Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, *Order on Reconsideration and Second Report and Order*, 31 FCC Rcd. 5011, 5085 ¶ 254 (2016).

densities throughout the United States."[6] RKF has done so despite SpaceX's repeated and emphatic assertions that it does not target urban populations:

- "I want to be clear . . . it's not like Starlink is some huge threat to telcos. I want to be super clear it is not";[7]
- "Starlink will be great for any sparsely populated areas with expensive or little to no connectivity!";[8] and
- "Starlink is really meant for those who are least served. [The] Bay [Area] usually has great Internet."[9]

Still, despite assuming urban NGSO users, RKF has concluded that a mere 0.888% of NGSO users would face the potential for interference from terrestrial services, let alone suffer such interference.[10] Horizon nulling, among other things, would further reduce that tiny percentage.

SpaceX's system can operate in a very similar way to the GSO-like systems that the 2016 Peters Studies explicitly stated they did not study. As the First Peters Study noted:

> An NGSO FSS satellite constellation can theoretically maintain a highly elliptical orbit and time its active operations to align with the perigee of its orbit in a manner intended to simulate the operation of a geostationary satellite orbit (GSO) system . . . . From an interference standpoint, operation of this type of an NGSO constellation would more closely resemble a geostationary broadcast-satellite services (DBS) system than it would a standard NGSO FSS constellation, which would presumably result in a more manageable interference environment than a standard NGSO FSS system.[11]

SpaceX would like to have boundless flexibility to serve customers from any of its satellites, no matter how low they are over the customer's horizon. But SpaceX does not have that flexibility today, as it is licensed to operate at elevation angles no lower than 25 degrees.[12]

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[6] RKF Report at i. Specifically, RKF assumed a "a dense deployment of satellite terminals in metropolitan centers where RDOF funds were assigned, such as Chicago, San Francisco, and Baltimore." *Id.* at 9.

[7] Via Satellite Magazine, Elon Musk, Founder & Chief Engineer, SpaceX - SATELLITE 2020 Opening Day Keynote, YouTube, at 16:15 (Mar. 9, 2020), https://www.youtube.com/watch?v=HPV8Xp3pEpI.

[8] Elon Musk (@ElonMusk), Twitter (Feb. 5, 2020, 6:02 PM ET), https://twitter.com/elonmusk/status/1225192950956744704.

[9] Elon Musk (@ElonMusk), Twitter (Feb. 24, 2021, 8:28 PM ET), https://twitter.com/elonmusk/status/1364749052626231296.

[10] RKF Report at 2.

[11] First Peters Study at 32 n.82

[12] *See* Space Exploration Holdings, LLC Request for Modification of the Authorization for the SpaceX NGSO Satellite System, *Order and Authorization and Order on Reconsideration*, 36

And SpaceX may only transmit using an Nco of 1, permitting only one NGSO satellite to transmit to an area at a time in the same band,[13] further limiting SpaceX's use of satellites at lower elevation angles. SpaceX will be compelled to conduct the vast majority of its operations at even higher angles, not due to regulatory restrictions or for fear of suffering interference from terrestrial sources, but for purely practical reasons—quality of service.

SpaceX does not address the fact that comparatively low elevation angles translate into service of unacceptable quality.[14] Nor does SpaceX address the diagram that DISH referenced from Starlink's own user instruction manual showing the importance that SpaceX places on avoiding obstructions and ensuring an elevation angle of at least 60 degrees and routinely up to 80 degrees.[15] Rather, SpaceX claims obstructions matter precisely because SpaceX operates at lower elevation angles.[16] That argument is not credible: SpaceX has a license to operate a satellite system, not level trees or demolish buildings. So long as obstructions exist, SpaceX will be hampered, or even precluded, from operating at low angles. And, when it is not advocating before the Commission, SpaceX admits that its earth stations cannot receive communications from satellites at lower elevation angles because: "obstructions generally cause outages."[17]

SpaceX is also silent on the fact that even if the elevation angle distribution curve it relies on were accurate—which it is not—its argument reflects an obsolescent world.[18] As the number of SpaceX's in-orbit satellites increases, and as the quality problems of low elevation angle

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FCC Rcd. 7995, 7996 ¶ 1 n.3 (2021) ("*SpaceX Third Modification Order*"). While SpaceX has requested authority for lower-angle operations in its much-amended Gen2 application, no such authority has been granted by the Commission. And, even in that proposal, SpaceX claims that use of lower elevation angles, if it were to be approved, would be rare: "SpaceX proposes to operate its user terminals at a minimum elevation angle of twenty-five degrees in the large majority of cases but to go as low as five degrees for communications with its two high altitude orbital shells (which account for less than two percent of satellites in the Gen2 system)." Consolidated Opposition to Petitions and Response to Comments of Space Exploration Holdings, LLC, File Nos. SAT-LOA-20200526-00055 and SAT-AMD-20210818-00105, at 38 (Feb. 24, 2022).

[13] *See SpaceX Third Modification Order*, 36 FCC Rcd. at 8047 ¶ 97(e).

[14] *See* Letter from Pantelis Michalopoulos, Counsel to DISH Network Corporation, to Marlene Dortch, FCC, WT Docket No. 20-443, GN Docket No 17-183, at 8-9 (Jan. 13, 2022) (DISH Jan. 13 Letter").

[15] *See id.* at 9, 9 n.46.

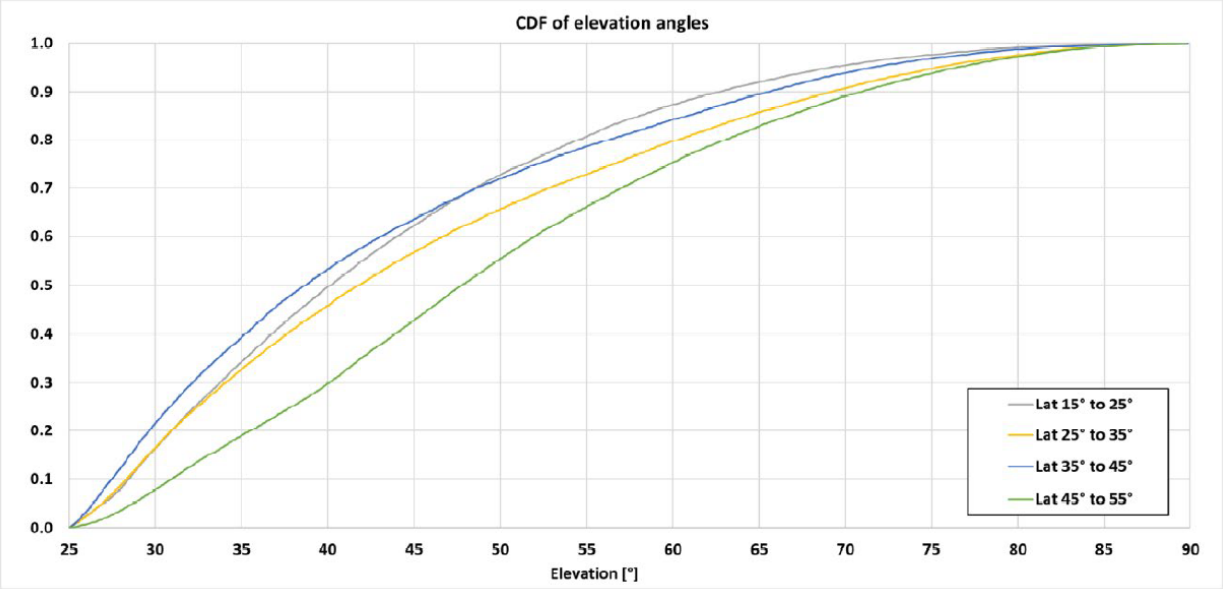
[16] SpaceX Ex Parte at 5 n.30.

[17] Jon Brodkin, SpaceX Starlink Engineers Take Questions in Reddit AMA, Ars Technica (Nov. 24, 2020), https://arstechnica.com/information-technology/2020/11/spacex-starlink-questions-answered-wider-beta-soon-no-plan-for-data-caps.

[18] *See* DISH Jan. 13 Letter at 8-11.

operations persist, it is inevitable that those curves will skew decisively towards higher angles. Nor is it clear what SpaceX's "CDF [cumulative distribution function] of elevation angles" figure means.[19] Are the elevation angles included in the chart only those used to provide downlink service in the 12 GHz band to a customer, or does the chart include elevation angles that are possible but not used? And to what geography does the chart pertain—the United States or a broader region? In any event, to permit a meaningful dialogue and understand the actual risks, if any, present, SpaceX must provide information about the realities of its current and planned service.

SpaceX also fails to address DISH's point that even the curves SpaceX cites are a world away from the NGSO world posited in 2016 by Mr. Peters.[20] Thus, the CDF figure that purports to represent SpaceX's version of reality still shows that the frequency of the minimum 25º angle is near zero for all latitudes.[21] Even the frequency of 30º or lower elevation angles is slightly more than 20% for the lower latitudes and less than 10% for the higher latitudes. Nor does SpaceX's chart, reproduced below, plot a line for the aggregate distribution of elevation for satellites from all latitudes. If the operations depicted are weighted towards the higher latitudes, the aggregate curve would be close to the "Lat 45° to 55°" line, meaning a greater proportion of high elevation angles; we just do not know.[22]



[19] SpaceX Ex Parte at 5.

[20] *See* DISH Jan. 13 Letter at 8-10.

[21] SpaceX Ex Parte at 5.

[22] *Id.*

In short, SpaceX's figure does not "tell[] a very different story" than DISH's account.[23] While SpaceX's story is opaque, it appears to be substantially the same. In any event, SpaceX must supply information on the aggregate frequency of elevation angles actually used to provide service from all altitudes.

Clustering means high elevation angles. SpaceX incorrectly minimizes the importance of the clustering of its satellites serving North America at 53°N.[24] It suggests that the point is a "red herring."[25] Far from it. While SpaceX is correct that inclination does not mean elevation, the use of 53° inclination inherently makes for higher elevation angles.[26] The reason is that the satellites in that orbital shell make a round trip up to 53º North and back down. This "round trip" means that the satellites stay at a high elevation angle for much of the U.S. population for a longer time compared to lower latitudes. Thus, for a large portion of the U.S. population, the satellite will be at a high elevation angle for longer, because it will cover, say, the four-degree distance (from 49º N to 53º N) twice compared to any lower latitudinal range, say 28º N to 32º N, which it will cover once. The following is an illustration based on a public website that is meant to simulate the orbits of the Starlink satellites.[27] It is a snapshot of the constellation at a given point in time—12:30 PM EST on Sunday, April 17, 2022. Superimposed on the screenshot are green and red boxes. The green lines define a latitudinal range approximately between 49º and 53º N. The red lines define a latitudinal range approximately between 28º and 32º N. The number of satellites (the blue dots) is significantly higher in the range bounded by the green lines than in the one bounded by the red lines.

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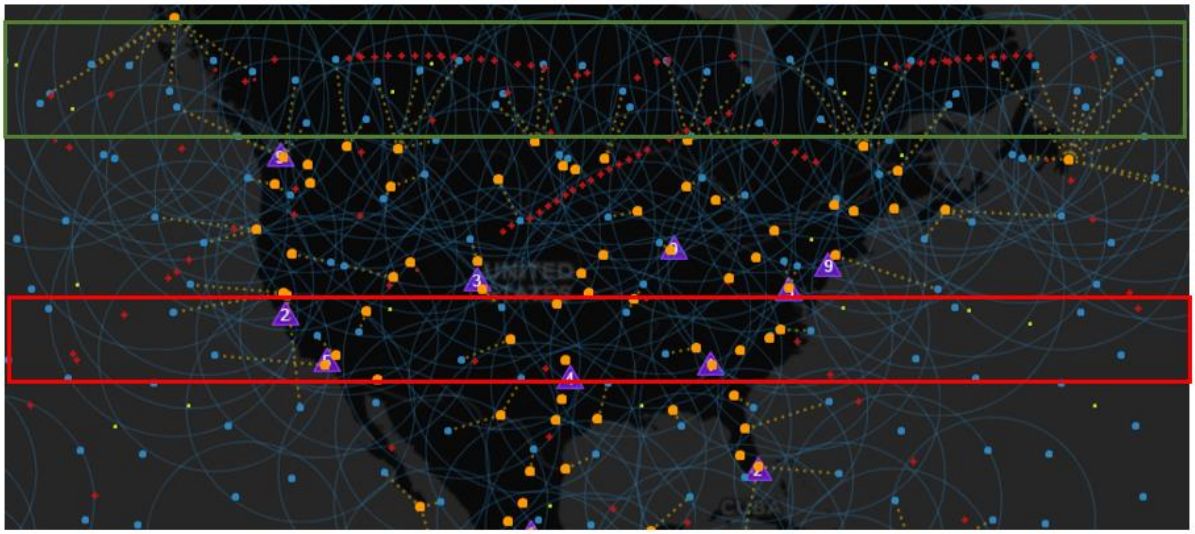
[23] *Id.*

[24] Starlink actually has two shells that have inclinations near 53° - one with 1584 satellites at 550 km with exactly 53° inclination, and a second with 1584 satellites at 540 km with 53.2° inclination. These two shells represent roughly 72% of the 4408 satellites in the complete constellation.

[25] *Id.* at 5.

[26] DISH Jan. 13 Letter at 9-10

[27] Mike Puchol, Starlink Tracker, starlink.sx (image created on Apr. 17, 2022 12:30 PM EST).



Horizon nulling dramatically lowers the interference risk. SpaceX is silent about horizon nulling and its hugely beneficial effect in mitigating any interference potential. With proper design of the antenna, good coverage can be provided over the base station sector area while achieving 20 dB or more suppression outside the sector area toward the horizon by using beamforming and horizon nulling. In this manner, advanced antenna systems can reduce interference at NGSO terminals by 20 dB or more outside the base station sector coverage area compared to conventional antennas that were available in 2016. Notably, neither the 2016 Peters Studies nor the 2021 RKF Report used horizon nulling. This means the interference levels found by the 2021 RKF Report can be correspondingly reduced by that 20 dB of suppression. As Mr. Peters noted in 2021:

> In the nearly five years since those reports were submitted, technology has advanced significantly, with beamforming and beamsteering of 5G base stations progressing from theoretical concepts to a commercially practical reality. Current 5G equipment supports these technologies today such that the phased array panel antennas used by wireless base stations can transmit narrowly focused beams, with very little unfocused radiation. These beams are capable of tracking mobile devices such that the transmitted energy is directed only where it is wanted and not where it could cause excessive EPFD levels or create interference.[28]

SpaceX's attempt to attack the worst-case nature of the 2016 Peters Studies fails. In 2016, Mr. Peters candidly acknowledged the studies he conducted followed a worst-case approach, even though that acknowledgement ran against the conclusion the studies reached. In Mr. Peters' words, "we generally sought to rely upon worst-case assumptions to address

[28] Declaration of Tom Peters ¶ 6 (attached as Exhibit 1, Comments of DISH Network Corporation, WT Docket No. 20-443, GN Docket No. 17-183 (May 7, 2021)).

uncertainty."[29] In the face of what at the time was an admission, SpaceX's attempt to deride DISH for pointing out the studies' worst-case nature falls flat. For example, SpaceX purports to dispute that the Peters Studies used "worst-case propagation loss."[30] But SpaceX does not explain why. The fact is that Mr. Peters assumed free-space propagation for the terrestrial signals. In reality, of course, these signals would be attenuated, by the atmosphere and obstacles alike, on their way to NGSO dishes, significantly lessening any interference potential. As another example, SpaceX disputes the Peters Studies' key worst-case assumption—a near-zero elevation angle. Yet the Peters Studies explicitly stated their assumption that the terrestrial signal would hit the NGSO dish at the boresight.[31] The only elevation angle that makes such interference possible under any known geometry is near zero. While Mr. Peters also noted that even "30 dB" of antenna discrimination would not provide adequate mitigation,[32] what SpaceX does not say is this: the RKF Report's use of 25º minimum elevation angles resulted in NGSO antenna discrimination far better than 30 dB—about 34-36 dB.[33]

If terrestrial services in the 12 GHz band are unshackled from the outdated restrictions to which they remain subject, they can be used in 5G offerings, helping advance and cement the 5G revolution and United States 5G leadership. SpaceX has repeatedly failed to provide information or analysis to counter the technical studies submitted by DISH and others that show the 12 GHz band can be unleashed for 5G use. The Commission now has all the information needed to make a choice between all of the services to which the band is already allocated *and* the benefits of 5G, or some of the above services and no 5G. The choice is clear: the Commission should proceed with allowing 5G terrestrial operations in the 12 GHz Band.

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[29] First Peters Study at 2.

[30] SpaceX Ex Parte at 3.

[31] *See* Second Peters Study at 10-11, 17.

[32] First Peters Study at 33.

[33] According to SpaceX's application for its first-generation system, the maximum antenna gain of its terminal is about 34 dBi in the 12 GHz band. *See* Space Exploration Holdings, LLC, File No. SAT-MOD-20200417-00037, Schedule S (filed Apr. 17, 2020). Furthermore, SpaceX has suggested the following antenna pattern as the most appropriate to use for its terminal: "For Class B WBES, the maximum antenna gain of each of the co-polarized components in any direction ϕ degrees from the antenna main beam axis shall not exceed the following limits . . . G = -2 dBi for $48° \leq \phi \leq 180°$." Reply Comments of Space Exploration Holdings, LLC, WT Docket No. 20-443, at 10 (July 7, 2021). That pattern translates into total rejection of 36 dB for all elevation angles above 48°, and for a minimum rejection of 34 dB at a 25° elevation angle.

Respectfully submitted,

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