Pantelis Michalopoulos
202 429 6494
pmichalo@steptoe.com

1330 Connecticut Avenue, NW
Washington, DC 20036-1795
202 429 3000 main
www.steptoe.com

Steptoe

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BY ECFS

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

Re: Expanding Flexible Use of the 12-12.7 GHz Band, WT Docket No. 20-443, GN Docket No. 17-183

Dear Ms. Dortch:

As Chairwoman Rosenworcel aptly stated, "freeing up more spectrum, and especially mid-band spectrum, for 5G" is one of the "key principles to help guide our 5G future."[1] The Chairwoman made that statement in response to a veritable chorus of interest in opening the 12 GHz band among the U.S. Senate Commerce Committee, with as many as six Senators on the committee asking written or oral questions about the matter during Chairwoman Rosenworcel's nomination process.[2] DISH today writes for three reasons.

First, DISH proposes a method for resolving the questions in dispute in this proceeding by building on Chairwoman Rosenworcel's list of outstanding issues—interference thresholds, operating parameters, and propagation models.[3]

Second, DISH discusses the D.C. Circuit's recent affirmance of the Commission's 6 GHz sharing order: the court's decision conclusively disposes of the zero-interference-potential-or-get-out-of-my-band approach taken by some opponents of a shared 12 GHz band. In the court's words, an analysis using "worst-case scenarios . . . does not rebut the persuasive showing . . . that

[1] Questions for the Record (Majority), Jessica Rosenworcel, Senate Commerce, Science, and Transportation Committee at 5 (Nov. 24, 2021), https://www.commerce.senate.gov/services/files/A853CE11-3D3C-4747-ADFC-817E6959B6F6.

[2] Questions for the Record, Jessica Rosenworcel, Senate Commerce, Science, and Transportation Committee (Nov. 24, 2021) (questions from Senators Markey, Wicker, Moran, Sullivan, and Blackburn); Senate Commerce Committee Confirmations Hearing at 2:30-31 (Nov. 17, 2021), https://www.c-span.org/video/?516047-1/senate-commerce-committee-confirmations-hearing (question from Senator Lummis).

[3] Questions for the Record (Minority), Jessica Rosenworcel, Senate Commerce, Science, and Transportation Committee, at 12 (Nov. 24, 2021), https://www.commerce.senate.gov/services/files/E4FB6E39-28F0-4328-902A-04F5F511825C.

the likelihood of interference is insignificant[,]" a showing made by means of a statistical "Monte Carlo" analysis.[4]

Third, DISH responds to SpaceX's latest attempt to thwart what is clearly the outcome that serves the public interest—putting the 12 GHz band to multiple uses subject to appropriate restrictions. SpaceX tries to do so by trying to hold DISH to views about sharing that DISH's expert engineer had expressed more than five years ago in significantly different circumstances.[5] But those views are compatible with the conclusions reached in 2021 by the RKF Study.[6] That study proves the feasibility of sharing between higher-powered terrestrial services and non-geostationary Fixed-Satellite Service ("NGSO FSS"), based on, among other things, the fact that the near zero-degree worst-case elevation angle assumed by Mr. Peters in 2016 has been overtaken by events: the minimum angle SpaceX is authorized to use is 25 degrees[7] and even 25 degree angles have been found to result in a poor experience for NGSO FSS customers anyway. The technological leaps and bounds achieved since 2016, including horizon nulling, can significantly mitigate even the minimal potential for interference (affecting a mere 0.88% of NGSO receive dishes) predicted by the RKF Study.

With respect to the first point, the Peters Studies did not assume the use of "horizon nulling" or other significant interference mitigation techniques enabled by advanced antenna systems. With respect to the second point, the First Peters Study clearly stated that NGSO systems "simulat[ing] the operation of a geostationary satellite orbit (GSO) system . . . would presumably result in a more manageable interference environment than a standard NGSO FSS system."[8] This is akin to what service quality expectations have compelled NGSO systems to become. In fact, NGSO mega-constellations such as Starlink were proposed and are now being built; and these are similar to high elliptical orbit systems in that a satellite is always almost directly overhead. In fact, in apparent recognition of complaints about service quality that have been loud and clear, SpaceX directs customers to position their dishes "within 35 degrees of vertical," indicating that NGSO signals will mostly be transmitted at elevation angles that are significantly higher than the licensed minimum of 25 degrees.[9]

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[4] *AT&T Servs., Inc. v. FCC*, -- F.4th -- No. 20-1190, 2021 WL 6122734, at *6 (Dec. 28, 2021).

[5] Comments of MVDDS 5G Coalition, RM-11768, Attach. 1 (June 8, 2016) (attaching *MVDDS 12.2-12.7 GHz Co-Primary Service Coexistence* (June 8, 2016)) ("First Peters Study"); Reply Comments of the MVDDS 5G Coalition, RM-11768, Appendix A (June 23, 2016) (attaching *MVDDS 12.2-12.7 GHz Co-Primary Service Coexistence II* (June 23, 2016)) ("Second Peters Study") (collectively, "Peters Studies").

[6] *See* Comments of RS Access, LLC, WT Docket No. 20-443, GN Docket No. 17-183, App. A (May 7, 2021) (attaching RKF Engineering Solutions, LLC, *Assessment of Feasibility of Coexistence between NGSO FSS Earth Stations and 5G Operations in the 12.2 – 12.7 GHz Band* (May 2021)) ("RKF Study").

[7] *Space Exploration Holdings, LLC Request for Modification of the Authorization for the SpaceX NGSO Satellite System*, Order and Authorization and Order on Reconsideration, 36 FCC Rcd. 7995, 7996 ¶ 1 n.3 (2021) ("*SpaceX Third Modification Order*").

[8] First Peters Study at 32 n.82.

[9] SpaceX, Starlink Install Guide at 2, https://api.starlink.com/public-files/StarlinkInstallGuide_Circular.pdf (last visited January 13, 2022) ("Starlink Install Guide").

Time does not stand still and the public interest cannot wait. The technical advances of the last five years significantly facilitate sharing between higher-power terrestrial service, on the one hand, and both NGSO FSS and DBS, on the other.[10] And the Commission should not be safeguarding the theoretical ability of non-geostationary systems to use angles that would not result in a satisfactory experience for their customers.

I. Outstanding Questions in the Proceeding

The question at the heart of this proceeding is simple. The band is allocated to DBS, NGSO FSS (subject to obligations to avoid interference into DBS and the outcome of the 12 GHz rulemaking), and terrestrial Multichannel Video and Data Distribution Service ("MVDDS"). If MVDDS services 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. So the option for the Commission is: all of the above—all of the services to which the band is already allocated, *and* the benefits of 5G? Or, some of the above, and no 5G in the band? For the public interest, the first choice is the best. To the end of freeing up more spectrum for 5G, Chairwoman Rosenworcel has identified certain questions that need to be resolved in this proceeding to achieve that goal: the appropriate "interference criteria"; the related question of "the level of increase in probability of interference that should be acceptable"; the appropriate "assumptions regarding the operational parameters and technical specifications of satellite user terminals in the band"; and the appropriate propagation model (that is, what obstructions should be considered in determining how much a terrestrial transmission has been attenuated before it reaches a satellite receiver).[11] DISH is ready to focus the dialogue on these issues.

On the first two questions identified by Chairwoman Rosenworcel, the record shows that all of the interference thresholds proposed by either side to the debate translate into similar outcomes: under each and every one of these criteria, only a minimal percentage of NGSO FSS dishes would suffer even the potential for interference. Specifically, as DISH has explained, only a handful of commenters have even mentioned, let alone proposed an alternative to the -8.5 dB interference-to-noise ("I/N") ratio applied by RKF. SpaceX and Boeing have mentioned the 6% $\Delta T/T$ criterion, which translates into an I/N ratio of -12.3 dB, while Google has cited the -129 dBm/MHz interference criterion applicable in the 3,600-3,700 MHz band, which equates to about the same I/N ratio, -12 dB.[12] But the difference among the three is minimal—the RKF Study showed that in the absence of any coordination, 0.888% of NGSO FSS users may

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[10] For sharing between high-power terrestrial service and DBS, DISH has already rebutted all arguments repeated in this record by AT&T and SES. Letter from Pantelis Michalopoulos, Counsel for DISH, to Marlene Dortch, FCC, WT Docket No. 20-443, at 6-10 (Aug. 29, 2021) ("DISH Aug. 29, 2021 Letter").

[11] Questions for the Record (Minority), Jessica Rosenworcel, Senate Commerce, Science, and Transportation Committee, at 12 (Nov. 24, 2021), https://www.commerce.senate.gov/services/files/E4FB6E39-28F0-4328-902A-04F5F511825C.

[12] DISH Aug. 29, 2021 Letter at 15, 21-22 (citing *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, 5089 ¶ 266 (2016)).

suffer even the potential for interference under the -8.5 dB criterion, while the number would be about 1.1% under the other two formulations.[13]

On the question of operational parameters and technical specifications, the NGSO systems' elevation angle remains one of the most important characteristics. The closer to the horizon an NGSO transmission, the more vulnerable the dish will be to transmissions from 5G base stations and consumer terminals. Conversely, at higher elevation angles, the NGSO receive dish generally becomes progressively more immune to interference from the comparatively horizontal 5G transmissions.

On the question of propagation models, RKF used a realistic propagation model that takes terrain and clutter into account, modelling path loss using 3GPP Specification 38.901, and the Irregular Terrain Model (ITM) similar to the approach used by the Commission for the 6 GHz band.[14] Some NGSO proponents take exception to some aspects of this method. For example, OneWeb takes issue with RKF's use of the 38.901 and ITM models.[15] As for Google, it has proposed three different propagation models. One of them assumes "free space" propagation of the terrestrial signal—meaning that this signal is not attenuated by any obstructions on its way to the NGSO dish and suffers the minimum amount of signal attenuation predicted by physics, and thus translating into comparatively greater interference potential. Crucially, however, Google acknowledges that this is a "worst-case" scenario.[16] While free space is an appropriate worst-case assumption for a preliminary study, it yields to the superior accuracy of a propagation model that admits the obvious—obstructions attenuate terrestrial transmissions, significantly lessening the potential for interference into NGSO FSS dishes.

II. Recent D.C. Circuit Precedent

The D.C. Circuit's recent 3-0 decision[17] affirming the Commission's 6 GHz sharing order negates two crucial aspects of the 5G opponents' arguments in this proceeding: that sharing between terrestrial service and NGSO FSS should be rejected unless zero interference is found; and that a worst-case-scenario look is superior to a statistical, "Monte Carlo" analysis. Both propositions were wrong before, and are all the more wrong now.

Zero interference is not the standard for sharing. To call the zero-interference argument antiquated is to be too charitable: the Commission had rejected it already in the

[13] RKF Study at 50. SpaceX's latest model also discusses the criterion used by Mr. Peters in 2016. SpaceX is correct that this criterion (interfering power no more than equal to noise) translates into a I/N ratio of zero. Letter from David Goldman, SpaceX, to Marlene Dortch, FCC, WT Docket No. 20-443; GN Docket No. 17-183, at 3 (Nov. 29, 2021) ("SpaceX Nov. 29 Letter"). What SpaceX does not mention is that, under this criterion, an even smaller percentage of NGSO dishes would experience the potential for interference under the RKF Study—about 0.10%. *See* RKF Study at 50.

[14] RKF Study at 44-45.

[15] Reply Comments of OneWeb, WT Docket No. 20-443, GN Docket No. 17-183, at 22-24 (July 7, 2021).

[16] Reply Comments of Google, WT Docket No. 20-443, GN Docket No. 17-183, at 12-13 (July 7, 2021).

[17] *See AT&T Servs., Inc. v. FCC,* -- F.4th -- No. 20-1190, 2021 WL 6122734 (D.C. Cir, Dec. 28, 2021).

Commission's relative antiquity, long before computer simulations under a Monte Carlo analysis were possible.[18] Still, the D.C. Circuit adds its authoritative voice to that of the Commission on the occasion of the 6 GHz Order, where the Commission opened the 6 GHz band to unlicensed uses.[19] The D.C. Circuit confirms that SpaceX and other 5G opponents are simply wrong when they claim that two services cannot share the same spectrum if there is *any* potential for interference, however miniscule.[20] Petitioners had urged the Court to reject the Commission's 6 GHz Order on similar grounds to what the 5G opponents argue here—that "*some* harmful interference will occur at some point, thus rendering the [6 GHz] Order arbitrary and capricious."[21] The Court, however, explained that zero interference was not the Commission's goal—"[the Commission] never claimed that the Order would reduce the risk of harmful interference to zero[,]" and that a low risk of interference "aligns perfectly with existing Commission regulations[.]"[22] This conclusion is consistent with decades of Commission precedent that zero interference is not the test for whether sharing is allowed.[23]

Statistical analysis is the preferred approach. The Court also rejected the view of 5G opponents that Monte Carlo analysis is akin to "gambling."[24] The Court fully supported the Commission's reliance on Monte Carlo analysis in the 6 GHz band, explaining:

> While traditional models select a single value (e.g., an average) for each variable, Monte Carlo analysis uses a range of possible values for each variable, runs hundreds of simulations, and produces a range of possible outcomes. In situations where interactions between the possible outcomes become exceptionally complex, Monte Carlo analysis can provide a more complete view of potential outcomes and their associated likelihoods.[25]

Indeed, the Court supported the Commission's decision to discount a worst-case analysis submitted by AT&T in the 6 GHz proceeding: "because the AT&T study uses worst-case scenarios, it does not 'rebut the persuasive showing' . . . that the likelihood of harmful interference is insignificant."[26]

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[18] *See* DISH Aug. 29, 2021 Letter at 7.

[19] *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) ("6 GHz Band Order").

[20] *See* DISH Aug. 29 Letter at 6 n.26 (collecting quotes).

[21] *AT&T Servs. Inc.*, 2021 WL 6122734, at *3 (emphasis added).

[22] *Id.*

[23] *See* DISH Aug. 29, 2021 Letter at 7 ("The Commission rejected this zero-interference idea as a prerequisite to sharing as early as 70 years ago.").

[24] Reply Comments of TechFreedom, WT Docket No. 20-443, GN Docket No. 17-183, at 4 (July 7, 2021).

[25] *AT&T Servs., Inc.*, 2021 WL 6122734, at *4 (internal quotations omitted).

[26] *Id.* at *6.

III. The Distraction Attempted by SpaceX

SpaceX does not look forward. It looks back, and seeks to distort both the past and the present in the process. SpaceX continues its misleading characterizations of the Peters Studies, while adding nothing new to the record.[27] SpaceX has supplied no evidence of its own to support the view that sharing between 5G and NGSO FSS services is impossible. The central claim made by SpaceX is that the 2016 Peters Studies "conclusively confirm the fundamental incompatibility of NGSO systems and a mobile service operating together in the 12 GHz Band."[28] But the 2016 Peters Studies were based on extremely conservative assumptions (including low elevation angles that have turned out to be unrealistic), and a worst-case analysis. They were also constrained by what was then the state of the art in the design of terrestrial antennas. By contrast, the 2021 RKF Study reflects more granular assumptions, realistic elevation angles, and a probabilistic, rather than worst-case analysis, as well as technological advances in terrestrial antennas. What the Peters Studies did find is that *at certain distances*, NGSO and terrestrial mobile service may not be able to share the 12 GHz band. Coexistence would be possible outside of that distance. This is still the case today, except that technical advances since 2016 have materially reduced the separation distance. And NGSO terminals within that limit would still have access to thousands of megahertz of spectrum outside of the 12 GHz band.[29]

Indeed, as explained below, there are important limitations to the Peters Studies that are ignored by SpaceX:

- The Peters Studies did not consider the case of NGSO satellites in a mega-constellation, and so therefore assumed that ground terminals would need to follow satellites from horizon to horizon.[30] This is not the case with the Starlink system, which in fact must avoid low elevation angles due to service quality concerns. In this sense, the Peters Studies were even worse than a realistic worst-case analysis.

- The Peters Studies were based on *worst-case* assumptions of several factors occurring simultaneously: worst-case power levels, worst-case propagation loss, and worst-case

[27] *See generally* SpaceX Nov. 29 Letter.

[28] *Id.* at 2.

[29] The 15,050 MHz of spectrum licensed to SpaceX outside the 12 GHz band, *see* Letter from Jeffrey Blum, DISH, to Marlene Dortch, FCC, File No. SAT-MOD-20200417-00037, at 4 (March 8, 2021), includes thousands of megahertz in downlinks. In addition, SpaceX is currently requesting user link authority for Ka band spectrum for which it already has a license, and requesting gateway authority for yet another 20,000 megahertz of spectrum in the E-band. *See* SpaceX, Application, IBFS File No. SAT-LOA-20200526-00055 (May 26, 2020); Letter from Jeffrey Blum, DISH, to Marlene Dortch, FCC, File No. SAT-MOD-20200417-00037, at 7 (July 14, 2020) ("DISH July 14 Letter"). E-band spectrum, too, may lend itself for user links.

[30] *See* First Peters Study at 32 n.82. At the time of the Peters Studies, no NGSO FSS operations had yet been authorized in the United States. First Peters Study at 7.

(i.e., very low) antenna elevation angles. Only when *all* of these factors occurred together would coexistence be challenging.

- The Peters Studies did not conduct a statistical analysis. By contrast, the RKF study used a Monte Carlo analysis to provide a more realistic assessment of the probability of potential interference events.

- The Peters Studies did not assume use of horizon nulling, massive MIMO, adaptive beam steering and beam forming, or aggregation of three or more carriers.

A. *The Peters Studies Support Coexistence*

As the First Peters Study noted, "[t]he study does not make any normative recommendations as to whether or how to permit coexistence between MVDDS and NGSO FSS operations in 12.2-12.7 GHz band."[31] Instead, the 2016 Peters Studies used worst-case, deterministic analysis. They assumed several worst-case elements would occur simultaneously: worst-case power levels, worst-case (free space) propagation loss, and worst-case (i.e., very low) antenna elevation angles. Only then would coexistence potentially not be possible at distances of less than one kilometer between the 5G mobile device and the NGSO receiver.[32] But SpaceX conveniently omits one of the 2016 Peters Studies' conclusions: even assuming this confluence of worst-case scenarios, and simply reducing the power, the First Peters Study found that the separation distance would be 22 meters, rather than one kilometer.[33] This is of critical importance because of the inference that can readily be drawn, even from the 2016 Peters Studies, once the worst-case assumptions are relaxed. It means that coexistence between mobile terminals and NGSO FSS systems would be possible even if time had stopped in 2016, even if no technical advances had occurred since then, even if the low elevation angles assumed by Mr. Peters were realistic, and even if RKF had not conducted its study. And, what is more, the "best case" assumptions of 2016 did not include the higher elevation angles that non-geostationary systems need to use, nor did they reflect any of the mitigation techniques mentioned above.

To start with, DISH has already documented the Commission's well-established views against "overprotect[ion]" "based on worst case assumptions."[34] As discussed above, these views were unequivocally endorsed recently by the D.C. Circuit.[35] In fact, the Commission has been shifting in recent years from "snapshot" studies of interference at a frozen point in time (usually the assumed moment of worst interference) to Monte Carlo probabilistic studies.[36] For example, in using Monte Carlo studies to analyze interference in the 6 GHz band, the

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[31] First Peters Study at 4 n.16.

[32] *See* First Peters Study at 33.

[33] First Peters Study at 34. Specifically, the 22-meter conclusion assumed mobile power of only -40 dBm per 24 MHz, but left all of the other worst-case assumptions unchanged. *Id.*

[34] *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).

[35] *See* above at 4-5.

[36] *See 6 GHz Band Order*, 35 FCC Rcd. at 3891-92 ¶ 109, 3892 ¶ 112, 3893-94 ¶ 116, 3898-99 ¶ 127.

Commission "recognize[d] that an approach based on Monte Carlo simulations would give a more reliable prediction of the likelihood of interference"[37] because, "[t]o evaluate the spectrum sharing potential, including aggregate interference impact, a technical analysis should instead take a statistical approach such as in Monte Carlo simulations so as to probabilistically account for many intertwined phenomena."[38]

B. *The 2016 Peters Studies Emphasized That Their Analysis Does Not Apply to Higher Elevation Angles*

Importantly, the Peters Studies did not consider the case of today's mega-constellations such as Starlink or OneWeb:

> 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. But the only known GSO-like NGSO constellation surrendered its authorization in 2007. No other GSO-like NGSO constellations planned. *Therefore, this analysis does not address GSO-like NGSO FSS systems.*[39]

In this sense, the Peters Studies were even worse than a realistic worst-case analysis. Starlink is similar to the high elliptical orbit GSO-like systems not examined by Mr. Peters in that it eschews low elevation angles. While the system is authorized to transmit at angles as low as 25 degrees,[40] all available evidence suggests that such transmissions need to be highly infrequent– and in any event, a world away from the near-zero-degree elevation angle assumed by Mr. Peters in 2016. This is because of a factor not fully known in 2016 but well-established today: at low angles, NGSO systems cannot provide the service customers expect. Thus, reviews of the Starlink system indicate that the service is of unacceptable quality at low elevation angles, primarily due to obstructions.[41] Notably, Starlink's installation guide shows the importance SpaceX attaches to avoiding obstructions, as shown by the following diagram, reproduced from the Starlink setup instructions:[42]

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[37] *Id.* at 3899 ¶ 127.

[38] *Id.* at 3903 ¶ 135.

[39] First Peters Study at 32 n.82 (emphasis added, internal citations omitted).

[40] *SpaceX Third Modification Order*, 36 FCC Rcd. at 7996 ¶ 1 n.3.

[41] *See* Nilay Patel, *Starlink Review: Broadband Dreams Fall to Earth*, Verge (May 14, 2021), https://www.theverge.com/22435030/starlink-satellite-internet-spacex-review ("Starlink requires near-perfect line of sight to its satellites, which are often fairly low in the sky . . . even a *single tree* blocking the dish's line of sight to the horizon will degrade and interrupt your Starlink signal.").

[42] Starlink Install Guide at 2.

The same emphasis on avoiding obstructions is found in the responses to customer complaints offered by SpaceX's own personnel. One customer, for example, complained of "pretty frequent dropouts during usage" despite having a "small amount of obstructions" nearby. The Starlink team responded: "as the satellite passes quickly overhead, if there is a branch or pole between the dish and satellite you'll usually lose connection."[43] Starlink continued, "obstructions generally cause outages and not reduced speeds," and went on to recommend "[t]he satellites clump up around 53 degrees latitude (north and south). So I would focus on keeping that part of the sky clear as we keep improving this!"[44]

At the same time, the Starlink instructions illustrate a conviction that customers will not need to receive service at low angles. The installation guide specifically states: "[e]nsure your Starlink is installed within 35 degrees of vertical."[45] While the antenna could be adjusted (electronically and mechanically) to track satellites at various angles, the instructions show clearly that SpaceX expects the bulk of its signals to come from high angles in the sky. In fact, 35 degrees from vertical means that the elevation angles in the other direction from the tilt cannot be low—assuming a mechanical tilt of 15 degrees, the possible elevation angles in the other direction would likely be 60 degrees or higher.[46] What is more, the Starlink instructions are agnostic as to the orientation of the 35 degree-from-vertical-tilt. This suggests that SpaceX is comfortable with a minimum elevation angle as high as 60 degrees in all directions. This is consistent with the quality complaints voiced about transmission at oblique angles, as well as the fact that one of the most popular orbital planes of the Starlink system over the U.S. consists of

[43] 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.

[44] *Id.*

[45] Starlink Install Guide at 2.

[46] Since the antenna can electronically steer down to a 40 degree elevation angle in all directions, it can steer off boresight by 50 degrees (90-40=50). If the mast is mounted 35 degrees off vertical then with no mechanical tilt the boresight of the antenna (and mast) will be at an elevation angle of 55 degrees (90-35=55). Assuming the antenna can also tilt mechanically by up to 15 degrees, then the boresight can be adjusted to 70 degrees (55+15=70). Then, with the antenna's 50 degree off-boresight electronic steering ability, the antenna would be able to see down to 20 degrees in the direction of the tilt (70-50=20), but only to 60 degrees in the opposite direction (70+20-30=60). In this case, the first 20 degrees of the 50-degree steering ability gets the antenna to zenith (70+20=90) and the remaining 30 degrees gets it down to 60 degrees elevation angle in the azimuth direction opposite the tilt (90-30=60).

satellites orbiting from east to west at 53°.[47] That latitude is high up in the sky for most U.S. households. This is no wonder, since higher elevation angles mean lower latency, less path loss, and perhaps most important, lower likelihood of obstructions.

All of this is also consistent with the distribution of elevation angles used in the RKF Study, which assumes that "most Starlink terminals will have look angles of between 55 and 85 degrees."[48] But it is the extent of the service problems, and the resulting customer dissatisfaction, that were previously unknown.[49]

C. *The Peters Studies Did Not Consider Recent Technical Advances that Facilitate Sharing*

Relevant developments since 2016 mitigate the interference potential found then, and indeed mitigate even further the minimal interference potential predicted by the RKF Study; conversely, nothing that has happened since pulls in the other direction of more interference. SpaceX does not argue anything does.

"Horizon nulling," enabled by advanced beam forming antenna systems, is a prominent example. 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, the RKF Study did not take into account horizon nulling and still showed that a very low percentage of

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[47] SpaceX's third modification application places 1,584 satellites at 53 degrees inclination and another 1,584 satellites at 53.2 degrees inclination. Application for Modification of Authorization for the SpaceX NGSO Satellite System, IBFS File No. SAT−MOD−20200417−00037, Narrative at 4, Table 2 (Apr. 17, 2020). This means that about 72% of the satellites in the constellation will "peak" at 53 degrees latitude.

[48] RKF Study at 24. While SpaceX has submitted its own claimed distribution of angles, supposedly reflecting "reality," Reply Comments of Space Exploration Holdings, LLC, WT Docket No. 20-443, GN Docket No. 17-183, at 9 (July 7, 2021), it has never answered the points made by DISH. Among other things, SpaceX's own distribution shows that most elevation angles are higher than 40 degrees; indeed, 90-degree elevation angles occur at least as frequently as 85-degree angles. Moreover, if SpaceX's claimed distribution depicts the present or past, it reflects only a fraction of Starlink's total 4,408 licensed satellites. Additional in-orbit satellites will naturally enable SpaceX to increase elevation angles even further. *See* DISH Aug. 29 Letter at 21; *see also* Letter from David Marshack, RKF Engineering Solutions, LLC, to Marlene Dortch, FCC, WT Docket No. 20-443, at 7 (Aug. 9, 2021) ("SpaceX's distribution appears to reflect Starlink's present-day, less-than-fully-deployed system that is still in beta service.").

[49] The Peters Studies did extend to a scenario where the NGSO antennas were capable of rejecting 30 dB-equivalent interfering signals. First Peters Study at 33 ("[E]ven 30 dB of antenna discrimination by the NGSO receiver would still require more than a kilometer of separation distance between the 5G mobile device and the NGSO receiver when the 5G mobile device was operating with an EIRP of 23 dBm per 24 MHz."). But the more up-to-date antenna pattern used in the RKF Study on the basis of SpaceX's own filings, combined with 55-85 degree angles, suggest even better antenna discrimination, on the order of 35 dB.

NGSO dishes would potentially exceed the -8.5 dB I/N threshold. Horizon nulling would improve these results even further.

D. *The 2016 Peters Studies Did Not Consider NGSO Business Plans*

Finally, unlike the worst-case 2016 analysis, the RKF Study takes into account the business model for each service. For example, as Elon Musk himself has observed on several occasions, Starlink is not suitable for densely populated urban areas because its beams will not have sufficient capacity.[50] By contrast, terrestrial wireless services, particularly 5G services, provide a massive boost to areas where capacity is needed most. This duality results in a natural separation, reducing the probability of interference. And in the rare cases where interference occurs, it can be easily managed because NGSO systems would still have access to hundreds of megahertz of other spectrum outside of the 12 GHz band (and up to 15,050 MHz of other spectrum in the case of SpaceX).[51]

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The Commission should allow MVDDS licensees to provide a higher-power, two-way 5G terrestrial service in the band, including for fixed, mobile and backhaul applications.

Respectfully submitted,

/s/ Pantelis Michalopoulos
Pantelis Michalopoulos
Counsel to DISH Network Corporation

[50] *See* DISH August 29, 2021 Letter at 18-19.

[51] DISH July 14 Letter at 7.