VIA ECFS

December 9, 2021

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

Re: *Ex Parte* Presentation, *Expanding Flexible Use of the 12.2-12.7 GHz Band*, WT Docket No. 20-443

Dear Ms. Dortch,

RKF Engineering Solutions, LLC (RKF) was engaged to conduct a scientific study assessing the feasibility of coexistence between a non-geostationary orbit fixed-satellite service (NGSO FSS) system and nationwide terrestrial 5G services in the 12.2-12.7 GHz (12 GHz) band. Our study was filed on May 7, 2021 and concluded that coexistence is eminently feasible.[1] It was and is the only engineering analysis to have been prepared in response to this proceeding.

Among the claims we have examined is the assertion by SpaceX that it must have unfettered access to the 12 GHz band because other spectrum bands in which it is authorized to operate — particularly the swath at 10.7-11.7 GHz — are effectively unusable for NGSO FSS. We have continued our engineering analysis in recent months. Our results, which further refute these claims, are summarized below.

* * *

The Federal Communications Commission has repeatedly found that NGSO FSS operations can use the 10.7-11.7 GHz band alongside Fixed Service (FS) and Radio Astronomy Service (RAS) operators.[2] SpaceX, OneWeb, and other satellite licensees accepted NGSO FSS authorizations on the basis of their ability to share the 10.7-11.7 GHz band with other systems.[3] But SpaceX and OneWeb now assert that the 10.7-11.7 GHz band is so encumbered that no meaningful

[1] Comments of RS Access, LLC, WT Docket No. 20-443 and GN Docket No. 17-183, Appendix A, at 48-54 (filed July 7, 2021) ("RKF NGSO Study")

satellite services can take place there and that anything less than unfettered access to the 12 GHz band will derail their planned service offerings.[4]

On behalf of RKF, I am writing to correct the record and reiterate what the FCC has time and again found: NGSO FSS can use the 10.7-11.7 GHz band without material impairment from either FS or RAS operations. In brief, RKF's analysis shows that FS sites are far fewer, far less consequential, and much more readily accommodated than SpaceX and its allies now claim. Likewise, even a cursory review of the RAS allocation at 10.6-10.7 GHz demonstrates that the ten observatories in the contiguous United States (CONUS) are in largely remote areas and are highly unlikely to require geographically expansive — much less nationwide — exclusion zones to guard against weak adjacent-channel space-to-Earth services, as SpaceX has claimed is the case.

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[2] *See, e.g.*, *Amendment of Parts 2 and 25 of Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band*, Report and Order, 16 FCC Rcd 4096 (2001) ("[W]e find that these [ITU] [power flux density (PFD)] limits [derived from the operating characteristics of a majority of the FS links in the 10.7-12.75 GHz band] are adequate to protect the vast majority of terrestrial FS operations in the 10.7-11.7 GHz band from NGSO FSS satellite transmissions"); *id.* (identifying multiple coordination techniques, such as "geographic separation, frequency separation, time sharing and power limitations," to protect sensitive radioastronomy facilities and "requir[ing] NGSO FSS applicants to coordinate and reach a mutually acceptable agreement with the RAS facilities that use the 10.6-10.7 GHz band to ensure that these facilities are adequately protected from interference"); *Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, Report and Order and Further Notice of Proposed Rulemaking, 32 FCC Rcd 7809 ¶ 25 (2017) ("*2017 NGSO FSS R&O*") (permitting blanket licensing of FSS earth stations in the 10.7-11.7 GHz band on a secondary basis). Note US131 of the Table of Frequency Allocations identifies thirteen radio astronomy observatories that must be protected by NGSO FSS operations in the 10.7-11.7 GHz band. 47 C.F.R. § 1.106 Note US131. Ten of these observatories are located in the contiguous United States. Two of the other three observatories are sited in Hawaii and the U.S. Virgin Islands, and the third, Arecibo, is no longer in operation. *See, e.g.*, Press Statement 20-010, NSF begins planning for decommissioning of Arecibo Observatory's 305-meter telescope due to safety concerns, National Science Foundation (Mar. 3, 2021), https://bit.ly/3lEl6Vc.

[3] *See, e.g.*, SpaceX Services, Inc., Grant, IBFS File No. SES-LIC-20210708-01019 (granted Nov. 10, 2021); SpaceX Services, Inc., Grant, IBFS File No. SES-LIC-20190211-00151 (granted Mar. 13, 2020); WorldVu Satellites Limited, d/b/a OneWeb, Grant, IBFS File No. SAT-LOI-20160428-00041 (granted June 23, 2017); OneWeb, Grant, IBFS File No. SES-LIC-20190930-01217 (granted Apr. 27, 2021); OneWeb, Grant, IBFS File No. SES-LIC-20190930-01237 (granted Apr. 29, 2021); Kepler Communications Inc., Order, IBFS File No. SAT-PDR-20161115-00114 (granted Nov. 15, 2018).

[4] *See, e.g.*, Reply Comments of Space Exploration Holdings, LLC, WT Docket No. 20-443 and GN Docket No. 17-183, at 2-3 (filed July 7, 2021) ("SpaceX Reply Comments"); Comments of OneWeb, WT Docket No. 20-443 and GN Docket No. 17-183, at 17-18 (filed May 7, 2021) ("OneWeb Comments").

Negligible Effects of Fixed Service Operations

SpaceX has made misleading statements about the FS encumbrance on the 10.7-11.7 GHz band and its effect on the company's NGSO FSS operations. For example, SpaceX claims that a review of the FCC's databases "revealed more than 880,000 [FS] links" in the 10.7-11.7 GHz band and that having to avoid these "widespread terrestrial deployments" will destroy "vital flexibility" SpaceX claims to need to provide service if NGSO FSS systems must also share the 12 GHz band with 5G services.[5]

Not so.

First, contrary to SpaceX's claim, the FCC Universal Licensing System (ULS) does not show 880,000 FS "links" in the 10.7-11.7 GHz band.[6] The number SpaceX should have used is approximately 162,000 frequency transmit paths — less than a fifth of the number SpaceX purports to have found.[7] Exactly how SpaceX arrived at 880,000 FS links in the 10.7-11.7 GHz band remains something of a mystery. Only 69,000 FS call signs are authorized to use the 10.7-11.7 GHz band. And while each FS call sign can include multiple communication paths from one point to another, any of which could align unfavorably with NGSO FSS operations, nothing in the FCC's publicly available ULS database comes close to supporting SpaceX's claim that there are 880,000 such paths.

Context matters when analyzing ULS data. Here, the context is to identify FS frequency transmission paths that could cause exceedance events to Starlink user terminals. The ULS database tables that SpaceX may have used show separate entries for each of a transmitter's licensed variations in frequency, power, modulation, and polarization.[8] For purposes of

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[5] SpaceX Reply Comments at 11.

[6] The Commission's Part 101 rules define a microwave link "as a simplex communications circuit between two points utilizing a single frequency/polarization assignment. A duplex communications circuit would require two links, one link in each direction." 47 C.F.R. § 101.3. FS links are also colloquially understood to be the physical infrastructure composing a point-to-point network. Given the ambiguity in SpaceX's methodology and definitions, this letter largely avoids the use of the term "link."

[7] Because the overwhelming majority of point-to-point microwave systems are duplex communications circuits, RKF estimates that fewer than 80,000 pairs of microwave towers operate in the 10.7-11.7 GHz band. This figure is less than 10% of the "880,000 [FS] links" SpaceX purports to have found.

[8] For example, the "FR" table indicates multiple frequencies and/or EIRPs by specifying unique "Frequency Numbers" for each call sign, location and antenna, and the "EM" table specifies different "Digital Modulation

interference analysis, however, only distinct licensed frequencies are relevant — counting each of the other variations generates a large number of seeming encumbrances, which may have some rhetorical value to SpaceX but *do not* represent additional interference threats to NGSO FSS systems and are wholly irrelevant to an interference analysis.

For example, many FS sites support adaptive power levels and modulation so the transmitter can optimize performance in the face of changing radiofrequency conditions (each of which being a different communications path),[9] but changes in modulation and power *do not* represent different interference threats because only the highest EIRP is relevant from an interference perspective. Similarly, many FS links use both vertical and horizontal polarization, which ULS depicts as two separate communications paths.[10] Here too, however, the different polarizations *do not* represent two separate interference threats for a system like Starlink that uses a circular polarization, which is incompatible with linear polarization in any direction.[11] Once the various forms of duplication are addressed, the actual number of contextually relevant FS communications paths in the 10.7-11.7 GHz band is 161,774.

Second, relatively weak NGSO space-to-earth signals are highly unlikely to cause performance degradation to relatively powerful terrestrial FS transmissions. Both the ITU and the FCC recognized the manifest empirical differences between satellite and terrestrial systems when they adopted PFD levels designed to protect FS operations in the 10.7-11.7 GHz band.[12] SpaceX will not need to modify its NGSO FSS operations to protect FS operations on a case-by-case basis because observing the ITU and FCC limits will protect FS operations in the 10.7-

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Rates" and "Digital Modulation Types" for each call sign, location, antenna and frequency. *See* FCC, ULS Data File Format (last visited Dec. 1, 2021), https://bit.ly/2ZNLXXp.

[9] *See, e.g.*, FCC Universal Licensing System, KAI95 Path 5 and KAZ43 Path 7.

[10] *See, e.g.*, FCC Universal Licensing System, WLU981 Paths 5 and 6.

[11] One situation where different types of transmissions along the same communications path would affect interference considerations is when a transmission path includes multiple channels on different frequencies. In such a case, each frequency would represent a unique threat of interference and a single pair of towers could have multiple frequency transmission paths listed in ULS. *See, e.g.*, FCC Universal Licensing System, KAS72 Path 1 and WLU981 Path 2.

[12] *See* ITU Rad. Reg., Article 21, Table 21-4; 47 C.F.R. § 25.208(b) (the values are the same but stated in different bandwidths).

11.7 GHz band from harmful interference.[13] Any claim by NGSO FSS authorization holders' to the contrary[14] is difficult to credit: modifying NGSO satellite transmissions to protect specific FS receivers is wholly unnecessary because the ITU/FCC PFD limits ensure that already weak signals from space stay well below the interference threshold for relatively strong, narrowly focused FS signals on the ground.

Third, FS operations *could* cause interference to NGSO FSS user terminals, which are secondary to FS in the 10.7-11.7 GHz band — in theory. Such interference from FS operations could affect NGSO FSS performance and reduce the amount of downlink spectrum available to affected NGSO FSS user terminals. But in practice, the risk of interference from FS to NGSO FSS user terminals is low. Not surprisingly, however, the purported consequences of spectrum sharing SpaceX has conjured up obscure the unlikely and highly attenuated effects that potential interference would have in real-world conditions.[15]

[13] *See* 47 C.F.R. § 25.208(b); ITU Rad. Reg., Article 22; *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 ¶ 97.o (2020).

[14] Comments of Space Exploration Holdings, LLC, WT Docket No. 20-443 and GN Docket No. 17-183, at 22 (filed May 7, 2021) ("SpaceX Comments"); OneWeb Comments at 17-18. OneWeb's reference to "large deployments of fixed links that significantly constrain the use of the 10.7-11.7 GHz band" probably means that interference from dense fixed link deployments would cause interference to NGSO receivers, not that NGSO space-to-earth transmissions would interfere with the fixed service, but OneWeb's language obscures the nature of the interference claim so both issues are addressed here.

[15] *See* Letter from David Goldman, Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, WT Docket No. 20-443 and GN Docket No. 17-183, at 7 (filed Sept. 27, 2021) ("Interference at -8.5 dB causes a desense of 0.57 dB, that is 0.32 dB more than baseline. An SNR reduction of 0.32 dB causes a throughput reduction per downlink beam of about 17.5 Mbps over time. If SpaceX were to provision throughput commensurate with industry standards per user, high-power terrestrial use would prevent service to multiple users per beam. That translates to a loss of approximately 30,000 users in the United States at a cost to SpaceX on the order of $35M per year just for its first-generation constellation.").

SpaceX itself may have best described how implausible FS interference into NGSO FSS user terminals is when it wrote in support of just such a co-frequency allocation during the NGSO FSS allocation and service rules proceeding:

> [NGSO FSS] interference from FS is unlikely, given that the potentially interfering FS transmitters typically radiate in a horizontal or near-horizontal direction using narrow-beam antennas, while NGSO receiving user terminals only have significant gain in high elevation directions and low gain towards the horizon. . . . An additional mitigating step could be to reposition an affected user terminal to another side of a natural or man-made obstacle (e.g., a building) to block the interfering FS signal. By using such strategies, NGSO operators can continue to provide service to subscribers at a high level of quality and reliability notwithstanding FS operations in this band.[16]

[16] Letter from William M. Wiltshire, Counsel, SpaceX, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 16-408, at 2 (Aug. 3, 2017); *see id.* at 1 ("One key recommendation that SpaceX and other satellite operators have endorsed is that the Commission allow the deployment of blanket-licensed NGSO user terminals in the United States on a secondary basis with respect to the terrestrial Fixed Service ("FS") in the 17.8-18.3 GHz band"). The techniques SpaceX described in its 2017 filing resemble the techniques 5G and NGSO FSS operators would use to coexist with 5G in the 12 GHz band. In the nearly five years that have passed since SpaceX 2017 filing, 3GPP's current-generation 5G NR standards have come to incorporate an even more robust suite of proven coexistence solutions, such as beam forming, massive MIMO, and horizon nulling, that increase wireless broadband performance while reducing the risk of interference to co-frequency operations. *See, e.g.*, Letter from V. Noah Campbell, CEO, RS Access, LLC, to Marlene H. Dortch, Secretary, FCC, WT Docket No. 20-443, Attach. B (filed Sept. 21, 2021) (identifying some of the systemic improvements to mobile broadband technologies in recent years). Of course, if SpaceX's claim about its ability to modify NGSO FSS operations to avoid particular fixed link channels or, alternatively, to detect potential interference and switch to less encumbered channels, were true, then SpaceX could apply the same mitigation measures in support of satellite-terrestrial coexistence in the 12 GHz band, too. Curiously, however, SpaceX never seems to contemplate applying the same coexistence engineering it says it must use below 12.2 GHz above 12.2 GHz. *See, e.g.*, SpaceX Comments at 27 ("To accommodate the myriad users in these [below 12.2 GHz] bands, NGSO FSS operators must lower power levels, work around large geographic exclusion zones, split spectrum, or entirely avoid channels in which they are nominally authorized to operate. Yet, despite these limitations, NGSO FSS operators like SpaceX have developed cutting-edge technologies that allow them to provide advanced broadband services to consumers.").

The Commission subsequently cited this rationale to support both adding a secondary FSS allocation in the 17.8-18.3 GHz band and permitting blanket NGSO FSS user terminal licensing in the 17.8-18.3 GHz and 10.7-11.7 GHz bands:

> [W]hile terrestrial use of this [17.8-18.3 GHz] band is significant, there are areas, particularly rural areas, where terrestrial deployment is less dense and by using mitigating techniques like siting considerations, off-axis rejection, and shielding, we expect FSS earth stations will be able to operate successfully without receiving harmful interference. Even if a mobile-service allocation is introduced in the future, there would still be areas where FSS earth stations would be able to deploy, as terrestrial deployment would not likely cover 100 percent of U.S. territory. . . . We agree that blanket licensing in the 10.7-11.7 GHz downlink band is appropriate . . . . Regarding the 10.7-11.7 GHz band, the same mitigation techniques noted above in the 17.8-18.3 GHz, 19.3-19.4 GHz, and 19.6-19.7 GHz bands are available to earth station operators.[17]

As SpaceX has noted in other contexts, the beamwidth of FS transmitters is typically very narrow, which would require an NGSO FSS terminal to be situated very near the FS site's transmission path for an interference-to-noise (I/N) exceedance event to occur. Antenna orientation further mitigates the risk of an exceedance event: as would be the case with interference from 5G terrestrial mobile operations into NGSO FSS user terminals in the 12 GHz band, NGSO FSS user terminal antennas in the 10.7-11.7 GHz band look skyward and have some rejection in the direction of interfering signals from terrestrial transmitters. Even if a terminal were affected (despite the narrow beamwidth of the FS transmitter and the horizontal orientation of most of the FS antennas), the consequences for the NGSO FSS operator are not nearly as dire for NGSO FSS operations as SpaceX portrays.

Fourth, to quantify the prior points, RKF conducted substantial analyses contemporaneously with its comprehensive examination of the feasibility of sharing between NGSO FSS and 5G operations in the 12 GHz band.[18] RKF has developed a robust model of FS operations in the 10.7-11.7 GHz band to assess SpaceX's claims, extracting and assembling data for each of the roughly 162,000 frequency transmit paths from the FCC's ULS database, including each transmitter's precise latitude/longitude coordinates, EIRP, and antenna height above ground

[17] *2017 NGSO FSS R&O* ¶¶ 7, 25.

[18] RKF NGSO Study at 48-54.

level. To analyze whether any Starlink terminals might experience an I/N exceedance event, RKF used the center frequency and bandwidth of the FS link as identified in the ULS database and relied on the transmitter and receiver latitude, longitude, and above-ground-level data from the ULS and their terrain heights from a three-arcsecond Shuttle Radar Topography Mission (SRTM) database to determine the direction of each FS link's boresight. Leveraging techniques developed and approved in the FCC's 6 GHz proceeding, RKF employed ITU-R Recommendation F.1245 to model the FS transmitter antenna pattern.[19] For those FS transmitters that ULS identifies as supporting adaptive modulation, coding, and power, RKF analyzed the FS frequency transmit paths with the *highest* EIRP because doing so would result in the largest amount of potential interference and thus present a worst-case result for coexistence. RKF assumed this worst-case circumstance even though most FS transmitters with higher-order modulations typically operate with *lower* EIRP.[20] RKF then used the same generous estimate of 2.5 million Starlink terminals used elsewhere in the RKF NGSO Study to model the potential for interference from FS into NGSO FSS user terminals in the 10.7-11.7 GHz band.

RKF also found that the vast majority of FS transmit paths involved only one frequency transmission path and, thus, a worst-case circumstance involving those FS transmit paths would likely affect only one of the four 250-megahertz channels in the 10.7-11.7 GHz band. RKF also found that the percentage of Starlink terminals affected by FS frequency transmit paths in the 10.7-11.7 GHz band would be minimal: the overwhelming majority of all Starlink terminals would not exceed I/N = -8.5 dB due to FS transmissions. An issue of such limited likelihood and such attenuated effect represents a situation that good-faith coordination can readily resolve.

In sum, the effect of FS operations in the 10.7-11.7 GHz band on co-frequency NGSO FSS operations is negligible.

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[19] Recommendation ITU-R F.1245-3, *Mathematical model of average and related radiation patterns for point-to-point fixed wireless system antennas for use in interference assessment in the frequency range from 1 GHz to 86 GHz*, ITU (Jan. 2019).

[20] Modulation and EIRP are typically inversely correlated because fixed service operations need some back-off to avoid the kind of amplifier saturation that might otherwise result in non-linearity effects in higher modulation given the greater peak-to-average ratio of higher modulations compared to lower modulations. Of the links with multiple modulations, therefore, the modeled links likely correspond to the lower modulation; however, RKF used the highest EIRP irrespective of the modulation level to which it corresponded.

Negligible Effects of Radio Astronomy Service Operations

Neither SpaceX nor OneWeb have presented clear data or explanation regarding the Radio Astronomy Service's effects on their proposed NGSO FSS offerings.[21] For example, SpaceX has occasionally claimed that protecting RAS operations in the 10.6-10.7 GHz band renders the 10.7-10.95 GHz band "not useable at all" for NGSO FSS.[22] But at the same time, SpaceX has consistently sought and received authority to operate user terminal downlinks throughout the 10.7-12.7 GHz band.[23] OneWeb has pursued similarly contradictory approaches.[24] Throughout the licensing process and this proceeding, these parties never identify the size and scope of the purported constraint that RAS operations impose on NGSO FSS.[25] Absent more detailed — and more compelling — information about the size, scope, duration, and reasonableness of the limitations RAS sites ostensibly impose on NGSO FSS operations, the mere existence of another

[21] Note US131 of the Table of Frequency Allocations requires NGSO licensees to coordinate with specific radio astronomy observatories before commencing operations "to achieve a mutually acceptable agreement regarding the protection of the radio telescope facilities operating in the band 10.6-10.7 GHz." 47 C.F.R. § 2.106 Note US131.

[22] SpaceX Reply Comments at 10 ("And in this case, the lowest channel RKF includes is not useable at all because it actually serves as a guard band to protect adjacent-band radio-astronomy operations."); *see also* Letter from David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., to Marlene H. Dortch, Secretary, FCC, WT Docket No. 20-443 and GN Docket No. 17-183, Attachment, at 6 (filed Aug. 2, 2021) ("10.7-10.95 GHz – currently unusable to protect Radio Astronomy[.]").

[23] Letter from David Marshack, Managing Director and Chief Operating Officer, RKF Engineering Solutions, LLC, to Marlene H. Dortch, Secretary, FCC, WT Docket No. 20-443, at 8 (filed Aug. 9, 2021) ("[A]ll of SpaceX's blanket earth station applications state that Starlink user terminals "will transmit in the 14.0-14.5 GHz band and receive in the 10.7-12.7 GHz band.") (citing Narrative, Application of SpaceX Services, Inc., SES-LIC-20190211-00151, at 1 (filed Feb. 11, 2019)).

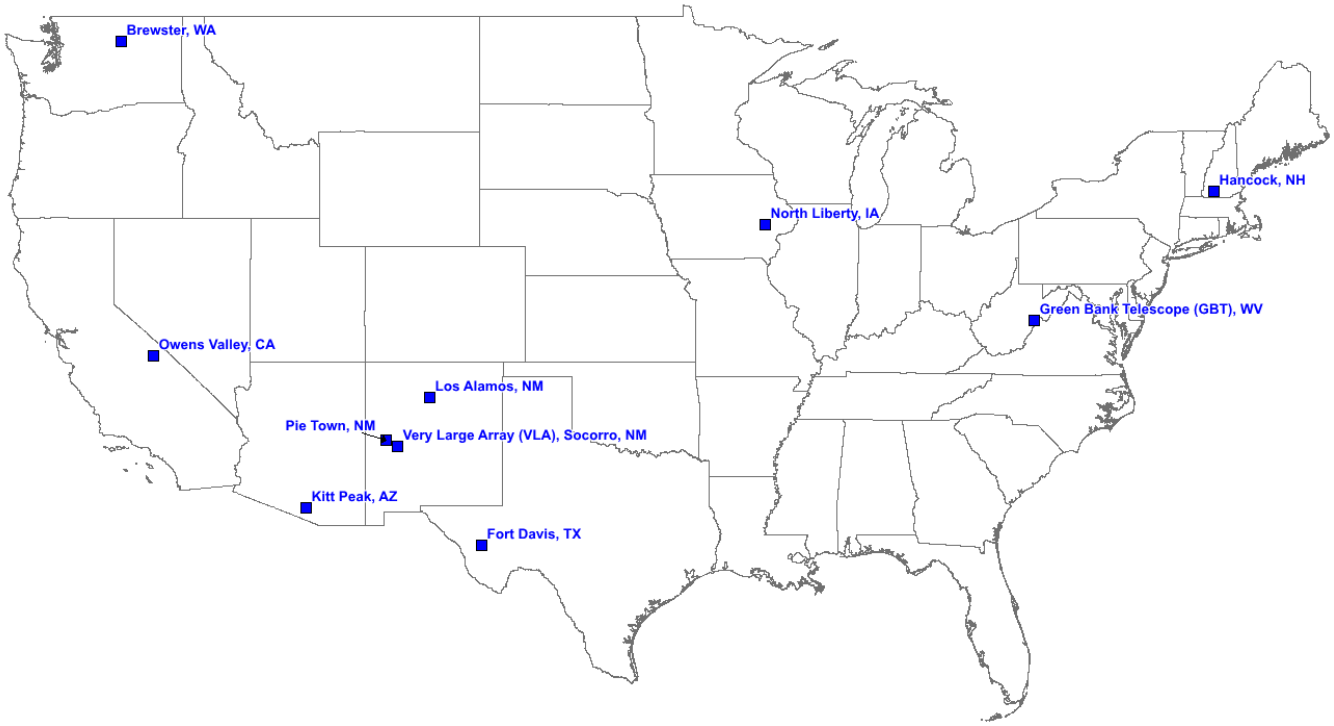
[24] *Compare* OneWeb Comments at 18 ("[T]he requirement to protect the Radio Astronomy Service in the 10.6-10.7 GHz band constrains NGSO systems from using the lower part of the 10.7-11.7 GHz band over all of the United States."), *with* Matt Daneman, LEO Boom Increasingly Concerns Radio Astronomy, Communications Daily (June 17, 2021), https://bit.ly/3fuYT9g ("OneWeb has worked closely with the community and determined that it will protect the radioastronomy sites in 10.6-10.7 GHz primary allocation by not transmitting in the adjacent frequency channel when a OneWeb satellite is in the visibility of the radioastronomy receiver.").

[25] *See, e.g.*, Letter from, David Goldman, Director of Satellite Policy, Space Exploration Technologies Corp., WT Docket No. 20-443 and GN Docket No. 17-183 (filed Sept. 27, 2021) (alluding to unspecified "constrain[ts]" in the 10.7-10.95 GHz band as a result of RAS operations and criticizing RKF for not better describing the effects that the non-public practices SpaceX has agreed to implement for the benefit of RAS may have on SpaceX's operations).

service in the 10.6-10.7 GHz band cannot override the Commission's obligation to maximize the use of limited spectrum resources in the public interest.[26]

SpaceX, in particular, has employed rhetoric that outruns the facts regarding the encumbrance RAS may impose on its operations. To begin, *there are only ten RAS observatories in the entire CONUS*, most of which are in remote areas, such as the desert southwest, as shown in Figure 1 below.

Figure 1: Ten RAS Observatories Use the 10.6-10.7 GHz Band in CONUS



To protect the limited number of RAS observatories, SpaceX suggests that it and the RAS community agreed that SpaceX would completely forgo use of the 250-megahertz channel from 10.7-10.95 GHz.[27] While SpaceX has disclosed next to nothing about the duration or scope of the arrangements it has reached with the RAS community, the Commission can safely eliminate two possibilities. *First*, RAS operations almost certainly would not need a *nationwide*, 250-megahertz guard band to protect against adjacent channel NGSO FSS transmissions.

[26] 47 U.S.C. § 303(g) ("[T]he Commission from time to time, as public convenience, interest, or necessity requires, shall . . . [s]tudy new uses for radio, provide for experimental uses of frequencies, and generally encourage the larger and more effective use of radio in the public interest[.]").

Second, the record of this proceeding shows that SpaceX and other NGSO FSS licensees almost certainly would not forgo 250 megahertz of user downlink spectrum in perpetuity without publicly voicing objections to the FCC.

All reasonable inferences from the facts available on the record suggest that any NGSO FSS impairment at 10.7-10.95 GHz is much more temporally and geographically limited than SpaceX's statement that the band segment is "not useable at all" suggests.[28] Indeed, SpaceX has offered no support for its proposition that the RAS community has indefinitely impaired NGSO FSS use of the 10.7-10.95 GHz any more than reasonably required to protect RAS.

SpaceX, of course, could eliminate all doubt and either provide details of its agreements with the RAS community or, at a minimum, provide calculations quantifying the degree of impairment the ten RAS observatories located in CONUS would impose on its NGSO FSS operations. The ITU provides numerous documents for evaluating adjacent-band interference to RAS, including:

- Recommendation ITU-R RA.517-4 - *Protection of the radio astronomy service from transmitters operating in adjacent bands*;
- Recommendation ITU-R M.1583-1 - *Interference calculations between non-geostationary mobile-satellite service or radionavigation-satellite service systems and radio astronomy telescope sites*; and
- Recommendation ITU-R RA.1631 - *Reference radio astronomy antenna pattern to be used for compatibility analyses between non-GSO systems and radio astronomy service stations based on the epfd concept*.[29]

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[27] See supra note 22.

[28] SpaceX Reply Comments at 10. If SpaceX had been forced by RAS to permanently surrender the use of 250 megahertz of spectrum nationwide, one would expect SpaceX to issue a much more direct and forceful protest of this development instead of seemingly confining its concerns to off-hand remarks in submissions on unrelated issues affecting other frequency bands.

[29] Recommendation ITU-R RA.517-4, *Protection of the Radio Astronomy Service from Transmitters Operating in Adjacent Bands*, ITU (May 2006); Recommendation ITU-R M.1583-1, *Interference calculations between non-geostationary mobile-satellite service or radionavigation-satellite service systems and radio astronomy telescope sites*, ITU (Oct. 2007); Recommendation ITU-R RA.1631, *Reference radio astronomy antenna pattern to be used for compatibility analyses between non-GSO systems and radio astronomy service stations based on the epfd concept*, ITU (May 2003).

Using these recommendations, SpaceX could identify the potential magnitude of the constraints required on NGSO FSS use of spectrum near 10.7 GHz to protect RAS in 10.6-10.7 GHz. The exact exclusion zone required would vary by numerous factors, such as the range of elevation angles used by RAS antennas. But even exclusion zones with radii between 25 kilometers (for the more resilient RAS antennas) and 100 kilometers (for the less resilient ones) would mean less than 1% of the U.S. population would be located inside the exclusion zones.[30] In other words, even assuming generous exclusion zones around the ten RAS facilities in CONUS would leave 99% of the U.S. population wholly unaffected by RAS operations.[31] This general estimate, of course, provides just an approximation of what actual calculations by SpaceX or other NGSO FSS authorization holders would demonstrate. SpaceX is one of the few parties able to dispel what uncertainty remains, and it has presented no such calculations to date. Nor has SpaceX even provided basic information on its obligations under the NSF coordination agreement. Requiring SpaceX to document the nature and scope of any RAS constraint it may face due to its adjacency to 10.6-10.7 GHz would eliminate the uncertainty that SpaceX continues to try to use as leverage to derail the authorization and deployment of innovative new services in the 12 GHz band.

* * *

SpaceX and other NGSO FSS operators have made unfounded claims about the extent and effect of FS and RAS encumbrances on NGSO FSS systems in the 10.7-11.7 GHz band. The claims cannot withstand scrutiny. RKF's analysis shows that FS sites are far fewer, far less consequential, and much more readily accommodated than SpaceX and its allies now claim. Likewise, even a cursory review of the RAS allocation at 10.6-10.7 GHz demonstrates that the ten observatories in CONUS are in largely remote areas and are highly unlikely to require

[30] RAS receivers operate using very narrow beams directed toward space, which means that the susceptibility of any given RAS receiver to interference is a function of emissions occurring in the RAS antenna sidelobes, rather than the size of the RAS antenna. *See, e.g.*, Recommendation ITU-R RA.517-4, *Protection of the Radio Astronomy Service from Transmitters Operating in Adjacent Bands*, ITU (May 2006). In the absence of that detailed information, the size of each RAS exclusion zone was presumed to be proportional to the size of the RAS antenna, and the exclusion zones identified here were made proportional to the ratio between the nation's largest RAS antenna at Green Bank, WV and the land area of the National Radio Quiet Zone that surrounds that facility. *See* 47 C.F.R. § 1.924(a)(1). This assumption is not intended to establish the resiliency of any particular RAS receive location, but simply to capture some of the variability that will exist among different RAS observatories as a result of antenna-specific RAS performance considerations and site-specific morphological and topological conditions.

[31] To the extent I/N exceedance events from FS operations occur at all, some small portion of this 1% may already have been unavailable for use in the 10.7-10.95 GHz band as a result of FS operations.

geographically expansive — much less nationwide — exclusion zones to guard against weak adjacent-channel space-to-Earth services, as SpaceX has claimed is the case. In short, nothing about the unfounded speculation SpaceX and its allies have injected into the record disturbs the Commission's well-established conclusion that RAS, FS, and NGSO FSS operations can successfully coexist below 12.2 GHz.

Please contact me with any questions about this submission.

Sincerely,

/s/ David Marshack

Managing Director and Chief Operating Officer
RKF Engineering Solutions, LLC