

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of)
)
Use of Spectrum Bands Above 24 GHz For) GN Docket No. 14-177
Mobile Radio Services)
)
Establishing a More Flexible Framework to) IB Docket No. 15-256
Facilitate Satellite Operations in the 27.5-28.35)
GHz and 37.5-40 GHz Bands)
)
Petition for Rulemaking of the Fixed Wireless) RM-11664
Communications Coalition to Create Service)
Rules for the 42-43.5 GHz Band)
)
Amendment of Parts 1, 22, 24, 27, 74, 80, 90,) WT Docket No. 10-112
95, and 101 To Establish Uniform License)
Renewal, Discontinuance of Operation, and)
Geographic Partitioning and Spectrum)
Disaggregation Rules and Policies for Certain)
Wireless Radio Services)

To: The Commission

**REPLY COMMENTS OF
THE BOEING COMPANY**

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SUMMARY

As a world leading designer and manufacturer of aircraft, satellites and space systems, The Boeing Company (“Boeing”) has substantial experience with developing and deploying state-of-the-art aerospace technology and reliable, high-speed communications systems. Boeing supports the Commission’s goal of facilitating more efficient and intensive use of higher frequency bands. Continued development of the mmW band, however, should not come at the expense of the current and future satellite operations that play a critical role in the national broadband market. The Commission should therefore take steps to facilitate sharing in those spectrum bands that are suitable for co-existence of satellite and terrestrial operations, and should judiciously refrain from attempting to introduce terrestrial wireless into the core satellite bands needed for continuing service and future expansion.

In the 28 GHz Ka-band, a key growth band for satellite, the Commission should unlock the full potential of satellite service by elevating FSS gateway operations to primary status and permitting user terminals, including earth stations in motion, on a secondary, non-interference basis. This approach would provide the regulatory certainty needed for continued investment in satellite services, and would avoid the cumbersome and legally suspect process of auctioning satellite spectrum, which would be contrary to the ORBIT Act. The 3.7-4.2 GHz C-band band and the 42.0-42.5 GHz band are also vital satellite bands, and were correctly omitted from the *Notice* as being unsuitable for 5G due to significant and incompatible spectrum use. The Commission should focus on FSS in these bands, including adopting its longstanding proposal to authorize FSS operations in the 42.0-42.5 GHz band.

In the 37 and 39 GHz bands sharing may be feasible, but sharing plans for these bands must ensure regulatory certainty for future satellite operations. The Commission should not

accept proposals that are based on an assumption that satellite users will “migrate” out of the band as 5G use grows. We suggest that other bands, such as the 24.25-27.5 GHz and 31.8-33.4 GHz bands, may be technically suitable and would offer globally harmonized alternative bands for 5G operations.

Boeing supports expanding Part 15 unlicensed operation into the 64-71 GHz band in order to provide much needed unlicensed spectrum for consumers and manufacturers. Additionally, authorizing Part 15 operations in the 57-71 GHz band onboard aircraft would benefit end users and aircraft operators without increasing the risk of interference to radio astronomy.

Ultimately, in realizing the promise of 5G, the Commission must be mindful that terrestrial 5G service enters into an existing national infrastructure of critical services and intensively used spectrum, including by satellite services, which play a crucial role as both a source of competition in the wireless broadband market and a key input to terrestrial wireless networks. Providing a stable regulatory environment for current and future satellite operations will serve the Commission’s goal of facilitating more efficient and intensive use of higher frequency bands and the development and provision of new communications services for the benefit of consumers.

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To: The Commission

**REPLY COMMENTS OF
THE BOEING COMPANY**

The Boeing Company (“Boeing”) provides these reply comments in response to the Commission’s Notice of Proposed Rulemaking (“*Notice*”) examining the use of higher frequency bands for next-generation wireless services, including mobile, satellite, and other uses.¹ Boeing supports the Commission’s goal of establishing a plan to facilitate the efficient and intensive use of the bands above 24 GHz. At the same time, the Commission must bear in mind that future 5G services will be entering into an existing infrastructure of critical services and intensively

¹ Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, et al., GN Docket No. 14-177, *Notice of Proposed Rulemaking*, FCC 15-138 (Oct. 23, 2015) (“*Notice*”).

used spectrum, including by satellite services, which play a crucial role as both a source of competition in the wireless broadband market and a key input to terrestrial wireless networks.

Boeing is a global leader in the design and manufacture of commercial and military aircraft, satellites and space systems, and related communications systems. Boeing therefore has a keen interest and long experience in the development of a well-considered spectrum policy that facilitates not only current operations, but the investment in the future growth of national and international telecommunications infrastructure. Boeing therefore urges the Commission to act judiciously and craft a framework for the higher bands that builds on the demonstrated success of satellite and unlicensed technologies while it introduces the next generation of licensed terrestrial wireless.

In the 27.5-28.35 GHz (“28 GHz”) band, satellite gateway earth stations have long operated on a co-primary status, secondary only to LMDS systems. The spectrum already identified for satellite services in the Ka-band has become increasingly saturated, and the 28 GHz band is a primary near-term growth band for satellite operations. The Commission should not compromise critical satellite services by introducing ubiquitous terrestrial wireless operations in this band.

Instead, the Commission should enhance the ability of the fixed-satellite service (“FSS”) to more fully utilize the 28 GHz band by maintaining the primary status of gateway earth stations and permitting satellite user terminals on a secondary non-interference basis. Doing so would harness the ubiquitous coverage and spectrum efficiency of satellite to make intensive use of this band to compete with and enable other terrestrial broadband technologies. This approach also avoids the cumbersome and legally uncertain hybrid licensing and auction proposal, which has been widely criticized in the comments.

In contrast to the 28 GHz band, comments that addressed the 37.0-38.6 GHz (“37 GHz”) and the 38.6-40 GHz (“39 GHz”) bands show relative agreement that sharing between satellite and terrestrial wireless services may be feasible. Such “sharing” proposals, however, cannot be premised on limiting satellite systems to grandfathered usage or presuming that satellite operations will eventually “migrate” out of the band. Instead, the Commission should take the time required to craft a forward-looking policy, informed by the results of the ITU process and the relative advantages and disadvantages of interference mitigation options such as coordination zones and sub-band or geographic separation.

Commenters propose a range of other bands as potential additional spectrum for 5G operations, some of which are quite feasible while others are deeply flawed. Some of these bands, such as the 24.25-27.5 GHz and 31.8-33.4 GHz band, offer substantial advantages and challenges that can be addressed through carefully crafted rules and ongoing technology innovation. Other bands, such as the 3.7-4.2 GHz band and the 42.0-42.5 GHz band were wisely omitted from the *Notice* as being unsuitable for 5G due to significant and incompatible spectrum use, including substantial existing satellite operations. The Commission should not allow such scattershot spectrum proposals to distract from the development of a coherent and forward-looking policy in bands that are best suited for its goals.

Finally, Boeing joins with the near consensus of commenters that advocate for Part 15 unlicensed use in the 57-71 GHz bands. Terrestrial unlicensed use of the 64-71 GHz band will provide a powerful and flexible tool for the development of the next generation of connected devices and machine-to-machine communication, benefitting both industry and end users. Likewise, permitting unlicensed use of the 57-71 GHz band onboard aircraft would open up new frontiers for high-rate, short-distance wireless communications, increasing aircraft efficiency and

enabling new services for airline operators and for the hundreds of millions of passengers every year.

These measures will promote the Commission's goal of facilitating more efficient and intensive use of higher frequency bands and the development and provision of new communications services for the benefit of consumers.

I. THE TERRESTRIAL COMMENTERS DISREGARD THE IMPORTANT ROLE OF SATELLITE NETWORKS IN PROVIDING UBIQUITOUS MILLIMETER WAVE SERVICES, PARTICULARLY IN RURAL AND REMOTE AREAS

Without a doubt, consumers and industry continually demand more from communications technology. Each new generation of communications infrastructure must provide greater bandwidth and better spectrum efficiency. In this proceeding, however, commenters for the terrestrial wireless industry appear to imply that the benefits of millimeter wave ("mmW") communications are available solely through terrestrial mobile service.² In fact, the higher bandwidth and spectrum efficiency promised by 5G advocates are hallmarks of all next generation technologies that harness mmW spectrum, including advanced satellite communications.³ Contrary to the implicit stance of many commenters, the premise of this proceeding is not simply to annex as much spectrum as possible for future, as-yet-undefined 5G

² Comments of AT&T, GN Docket No. 14-177, at 5 (Jan. 29, 2016) ("*AT&T Comments*") ("harnessing both revolutionary and evolutionary technologies to transform existing notions of connectivity"); Comments of Verizon, GN Docket No. 14-177, at 5 ("*Verizon Comments*") (Jan. 29, 2016) (equating "investment and innovation in the mmW bands" with terrestrial mobile).

³ Comments of the Satellite Industry Association, GN Docket No. 14-177, at 3-4 ("*SIA Comments*") (Jan. 29, 2016).

services.⁴ Instead, the Commission’s stated goal is to foster “the next generation of wireless services,”⁵ which certainly includes—but is not limited to—5G mobile services.

Any plan for the mmW bands must take into account the incumbent satellite services that already provide nationwide broadband coverage today. Satellite is an important competitor in the market for residential broadband delivery and is uniquely suited to providing broadband to remote locations, mobility applications, and emergency services. Satellite service is also a fundamental input to 5G infrastructure, providing backhaul and the ubiquitous coverage that will be required by the Internet of Things.⁶ Thus, satellite plays a unique and vital role in the nation’s broadband infrastructure, and the 5G proposals that would marginalize satellite services in the mmW bands are short-sighted and unworkable.

The United States has always been a leader in satellite technology. To preserve U.S. leadership in this industry, the Commission must continue to make the regulatory investment to assure satellite services have access to spectrum over the large areas that they excel at serving. No service can thrive without regulatory certainty. The Commission therefore has a statutory

⁴ Comments of T-Mobile USA, Inc., GN Docket No. 14-177, at 15 (“*T-Mobile Comments*”) (Jan. 29, 2016) (characterizing the “primary goal of this proceeding” as creating “opportunities for terrestrial use of the millimeter wave band”); Comments of Straight Path Communications Inc., GN Docket No. 14-177, at 27 (Jan. 29, 2016) (“*Straight Path Comments*”) (“the principal goal of this proceeding [is to] facilitate mobile use of the mmW bands for 5G”).

⁵ *Notice*, ¶ 1.

⁶ Comments of Inmarsat, GN Docket No. 14-177, at 2-3 (“*Inmarsat Comments*”) (discussing current use for broadband backhaul and future use in robust IoT connectivity); Comments of O3b Limited, GN Docket No. 14-177, at 3-5, 10-11 (Jan. 29, 2016) (“*O3b Comments*”), Comments of Echostar Satellite Operating Corporation, Hughes Network Systems, LLC, and Alta Wireless, Inc., GN Docket No. 14-177, at 4-5 (Jan 29, 2016) (“*Echostar Comments*”).

public interest obligation to provide regulatory certainty that ensures the future of both satellite and terrestrial mobile services.⁷

II. UBIQUITOUS DEPLOYMENT OF TERRESTRIAL MOBILE IN THE 28 GHZ BAND WOULD STIFLE CRITICAL CURRENT AND FUTURE SATELLITE OPERATIONS WITHOUT PROVIDING SUITABLE SPECTRUM FOR 5G

Facilitating the promise of 5G requires spectrum dedicated to terrestrial mobile, but merely “throwing spectrum” at such applications will not produce the desired result. 5G arrives into an existing national broadband infrastructure that it will both complement and rely upon. In the 27.5-28.35 GHz (“28 GHz”) band, ubiquitous terrestrial mobile would be incompatible with existing and future satellite operations. The band is also not globally harmonized, and would not provide a large enough block of contiguous or harmonized spectrum to achieve the Commission’s stated goals for terrestrial 5G. The Commission should therefore follow the international consensus developed at WRC-15 and decline to pursue 5G in the 28 GHz band. Instead, the Commission should focus on protecting existing satellite operations and fostering the benefits of next generation services being brought online, while looking elsewhere for 5G spectrum.

A. Satellite is Co-Primary in the 28 GHz Band, Secondary only to LMDS, and is Consistent with the International Allocation

Some commenters appear to argue that satellite networks do not have any right to protection in the 28 GHz band, or characterize FSS as having secondary status in the band.⁸ There is no question, the Notice claims, that “FSS operators constructed their facilities knowing

⁷ *SIA Comments* at 8.

⁸ *T-Mobile Comments* at 16, *Comments of CTIA*, GN Docket No. 14-177, at 32 (Jan. 29, 2016) (“*Comments of CTIA*”); *Comments of Cisco Systems, Inc.*, GN Docket No. 14-177, at 5-6 (Jan. 29, 2016) (“*Cisco Comments*”).

that their operations would be on a secondary basis.”⁹ But this secondary status is in regards to LMDS licensees only and not, as many 5G proponents imply, to future 5G terrestrial mobile.¹⁰ Arguments that satellite has “secondary status” in the band or that FSS operations lack protection are disingenuous because they fail to acknowledge that Fixed Services, FSS, and Mobile are each co-primary in the 27.5-29.5 GHz band.¹¹ Proposed future 5G mobile services have no presumption of priority over equally allocated—and already operating—satellite services. Boeing urges the Commission to reject “sharing” proposals for the 28 GHz band that would limit satellite use of the band to gateway earth stations, as such a scheme would effectively cripple future use of 28 GHz by satellite.¹²

Not only is satellite already making use of the 28 GHz band today, many factors suggest that the 28 GHz band is better suited to satellite operations than to the proposed 5G operations. The band is adjacent to an existing FSS satellite band and is already being used by FSS gateways in the United States. Moreover, the band is heavily used to provide a broad range of FSS services in other ITU regions, making it particularly well suited for continued FSS growth.

On the other hand, the 28 GHz band is not today being used by mobile, and it would not in any case offer the full “exclusive use” or substantial and globally contiguous band that 5G

⁹ *Notice* at ¶ 137.

¹⁰ *CTIA Comments* at 32 (noting that “existing FSS licensees were aware when they acquired their licenses that they were authorized only on a secondary basis”).

¹¹ 47 C.F.R. § 2.106; *Notice*, ¶ 27.

¹² *AT&T Comments* at 12-13; *O3b Comments* at 12-12 (noting that the proposed rules would “thwart investment in FSS, which has already demonstrated highly efficient and productive use of the 28 GHz band”); *SIA Comments* at 15 (“limiting protection to a subset of earth stations that are “in operation and providing service” prior to the auction provides little comfort to satellite operators, who cannot make necessary infrastructure investments without being certain that their plans will be supported by sufficient spectrum and ground infrastructure when faced with subscribership and consumer demand for higher capabilities on their satellite networks”).

proponents are seeking.¹³ The 28 GHz band is less than one gigahertz, and 5G advocates acknowledge that it would not offer the block size generally associated with efficient 5G operations.¹⁴

Given these factors, the US should recognize the success of satellite in the 28 GHz band that commenters have identified and follow the WRC-15 consensus and preserve the 28 GHz band for satellite use on a harmonized basis worldwide.¹⁵ Contrary to CTIA's comments,¹⁶ international harmonization is critical to spectrum efficiency, interference protection, economies of scale, and future spectrum planning. Further, consistent deviations from the international

¹³ *AT&T Comments* at 13 (observing that “[d]edicated spectrum for exclusive use is still the ‘gold standard’ preferred to meet the expected demand from future 5G networks”).

¹⁴ *See, e.g., T-Mobile Comments* at 11 (noting that “larger spectrum block sizes are attractive for millimeter wave communications” but acknowledging that the 28 GHz band has “only 850 megahertz available”).

¹⁵ Citing Comments of Avanti Communications Group, GN Docket No. 14-177, at 5 (Jan. 29, 2016) (“*Avanti Comments*”); Comments of ESOA, GN Docket No. 14-177, at 7-8 (Jan. 29, 2016) (“*ESOA Comments*”); *O3b Comments* at 12, Comments of the Global VSAT Forum, GN Docket No. 14-177, at 2 (Jan. 29, 2016) (“*GVF Comments*”); *Inmarsat Comments* at 5-6. ViaSat and SES suggest that with proper planning and a suitable coordination framework, earth station facilities may be able to coexist with 5G services in the 28 GHz band. *See* Comments of ViaSat, Inc., GN Docket No. 14-177, at 8 (Jan. 29, 2016) (“*ViaSat Comments*”); Comments of SES Americom, Inc., GN Docket No. 14-177, at 5-6 (Jan. 29, 2016) (“*SES Comments*”). Nonetheless, Boeing believes that the superior solution is to follow the WRC-15 consensus and pursue 5G in other bands.

¹⁶ *CTIA Comments* at 10 (“international harmonization should not serve as a barrier”); *but see id.* at 9 (acknowledging that harmonization of mmW spectrum bands “will enable the wireless industry – and consumers – to reap significant benefits. International harmonization of millimeter wave spectrum bands ‘would drive down equipment costs, which would benefit consumers in the United States and abroad.’ International harmonization also will promote ‘global interconnection, roaming, and interoperability,’ simplify antenna design, and minimize interference”).

consensus weaken the US negotiating position. Even proponents recognize that “much of the world currently has allocated this band to FSS use.”¹⁷ The Commission should do likewise.

B. Satellite Services Already Use the 28 GHz Band Efficiently and Intensively to Provide High-Bandwidth Service, Including to Users and Locations that 5G Services Cannot

Some comments in the record appear to disregard—or directly deny—that satellite services are highly spectrum efficient. In fact, the nature of satellite technologies permits satellite network operators to use and reuse spectrum in ways not feasible for terrestrial systems.¹⁸ For instance, FSS satellites with steerable beams can direct capacity where and when it is needed most, whether in response to population growth, special events, or natural disasters.¹⁹ More generally, the highly directional nature of FSS earth stations and the interference protections of the Commission’s two-degree spacing policy permit multiple competing satellite providers to offer service using the exact same spectrum, even to customers living next door to one another. This level of spectrum reuse is simply not possible with terrestrial providers, and is unsurprisingly ignored in the comments.

In fact, some commenters appear to fundamentally misrepresent, or perhaps simply misunderstand, the technical basis for the spectrum efficiency of satellite services. The technical analysis offered by Straight Path, for example, is simplistic and flawed.²⁰ To illustrate its contention that it is “significantly more spectrum efficient” to provide 5G with terrestrial

¹⁷ Comments of Intel Corporation, GN Docket No. 14-177, at 6 (Jan. 29, 2016) (“*Intel Comments*”).

¹⁸ *O3b Comments* at 3.

¹⁹ *Inmarsat Comments* at 2-3.

²⁰ See *Straight Path Comments* at 27-29.

rather than satellite systems, Straight Path characterizes the spectrum efficiency of various satellite networks.²¹ Straight Path’s essential argument in this comparison, however, appears to be the basic principle that reducing cell size fosters spectrum re-use and thus raises the spectrum efficiency of a communications technology. This principle applies equally to satellite as it does to 5G, and satellite networks take advantage of this by using increasingly focused spot beams. Furthermore, because FSS satellite earth stations are highly directional, multiple competing satellite service providers can re-use the same spectrum to serve customers in the same geographic area, even in the same building. In this respect, satellite service can achieve spectrum efficiency many times that of terrestrial wireless service. This is the essence of the Commission’s longstanding two-degree spacing policy, and has resulted in exceedingly high spectrum efficiency by FSS operators.

Straight Path is also incorrect in asserting that terrestrial wireless is necessarily less expensive to deploy. Citing the “comparatively high cost of satellites”, Straight Path compares the cost of “several hundred million dollars per satellite” to “less than a hundred thousand dollars per cell site.”²² Tellingly, however, Straight Path continues on to compare the *coverage* of “a few tens of satellite spot beams” (*i.e.* one satellite) to “a few hundred thousand cell towers” (*i.e.* an entire nationwide terrestrial wireless network infrastructure). Straight Path is correct that only a single satellite is necessary to provide high speed, high-bandwidth service covering the entire country,²³ whereas hundreds of thousands of cell towers would be required to achieve equivalent coverage with terrestrial wireless. Straight Path is therefore demonstrably incorrect

²¹ *Id.* at 27.

²² *Id.* at 29.

²³ *Id.*

in arguing that satellite service is either spectrally or economically inefficient. In fact, satellite is a critical component in the drive for ubiquitous broadband, and can efficiently and effectively provide service to locations and users for whom it is impossible or economically infeasible to provide wired or 5G service.²⁴

C. Contrary to the Commission’s Claim, the Proposed 28 GHz Auction Scheme Would Be Inconsistent with the ORBIT Act

The Open-market Reorganization for the Betterment of International Telecommunications Act (“ORBIT Act”) expressly prohibits the Commission from “assign[ing] by competitive bidding orbital locations or spectrum used for the provision of international or global satellite communications services.”²⁵ Further, it requires the President to “oppose in the International Telecommunication Union and in other bilateral and multilateral fora any assignment by competitive bidding of orbital locations or spectrum used for the provision of such services.”²⁶ Congress adopted this prohibition with good reason, recognizing that international satellite systems, many of which are based in the United States, must secure landing rights in many countries. The global framework for international spectrum access is based on reciprocity, and deviations from established procedures could have a global impact not limited to

²⁴ Notice, ¶ 33, *SES Comments* at 5, *SIA Comments* at 5-6.

²⁵ Notice, ¶ 134.

²⁶ 47 U.S.C. § 647.

this one frequency band.²⁷ If the United States were to employ auctions to grant licenses for international satellite services, other countries would inevitably follow suit, creating a balkanized and uncertain international spectrum environment that would disrupt the deployment of satellite services.²⁸

Given this strong legal and policy basis for prohibiting the auction of satellite spectrum, the assertion that a satellite service provider is merely “acquiring a terrestrial license”²⁹ creates an unnecessarily murky and inconsistent regulatory fiction.³⁰ Commenters aligning with the Notice on this argument repeat the assertions of the Notice but provide no legal analysis to support it.³¹ Requiring FSS operators to bid for the “protection” necessary to operate is in practice indistinguishable from offering FSS spectrum for auction, and produces the same risks to efficient and predictable satellite deployment that led Congress to disallow the practice in the ORBIT Act.³²

²⁷ Letter from Satellite Industry Association to Senate Commerce Committee Chairman John McCain, dated November 11, 2003 (“*SIA ORBIT Act Letter Letter*”).

“Section 647 was premised upon the understanding that if the United States were to employ auctions to grant licenses for international satellite services, other countries would inevitably follow suit. The result would be a cascading series of sequential auctions, which would be disruptive to the already lengthy planning process for the development of satellite networks, and would have a potentially devastating effect upon the delivery of, and access to, global satellite services.”

²⁸ See Comments of the Satellite Industry Association, United States Spectrum Management Policy for the 21st Century, NTIA Docket No. 040127027-4027-01 (Mar. 18, 2004).

²⁹ Comments of Ericsson, GN Docket No. 14-177, at 21 (Jan. 29, 2016) (“*Ericsson Comments*”).

³⁰ *Echostar Comments* at 36-37.

³¹ See, e.g. *Intel Comments* at 5-6, *Ericsson* at 21.

³² See, *SIA ORBIT Act Letter*.

Among other problems, the fiction of this approach is immediately evident if two FSS providers bid for the same spectrum or geographic area. Technically, only one of them could win the auction even though both could have easily shared the spectrum if the auction had never been held.

The unnecessarily complicated and legally questionable nature of the proposed “Upper Microwave Flexible Use Service” (“UMFUS”) plan for the 28 GHz band is further evidence that auctions and/or secondary markets are inappropriate ways to promote satellite operations in the band.³³ Instead, the Commission would be “far better served by acknowledging the obvious”³⁴ and adopting a more straightforward approach that directly achieves its goals, by elevating 28 GHz earth station operations to primary status in the band.

D. FSS Earth Station Operations Should Be Elevated from Secondary to Primary Status

Given the value of satellite in the 28 GHz band—and the value of the 28 GHz band for satellite—as well as the international consensus against 5G in this band, the Commission should not adopt the UMFUS plan. As noted above, the UMFUS plan is likely to substantially disrupt existing and future satellite operations in this critical spectrum without providing a major contribution to 5G spectrum. SES, for example, is halfway through construction of a new high-throughput satellite system that will require a number of new gateways, and it cannot bring this system to market without a clear path to licensing them on a primary basis.³⁵ Other satellite providers are currently providing service using gateway and other earth stations in this band in

³³ *GVF Comments* at 6; *Inmarsat Comments* at 5-6; *SIA Comments* at 14.

³⁴ *Echostar Comments* at 32-33.

³⁵ *SES Comments* at 4.

and around the United States. Growth of these services requires assurance that new, interference-protected gateways can be built and, where appropriate, other earth station operations can be permitted.³⁶ The clearest and most legally certain way to achieve this goal is to conform to the international consensus and not attempt to introduce terrestrial 5G into this band, instead raising FSS earth stations to co-primary status.

E. FSS User Terminals Should Be Permitted in the 28 GHz Band

Given the arguments against terrestrial 5G deployment in the 28 GHz band, Boeing joins with other members of the satellite industry in urging the Commission to move forward with its proposal to repeal the restriction on FSS user terminals in the 28 GHz band.³⁷ As ViaSat notes, “the types of uses that easily can be coordinated with LMDS operations is far greater than when the Commission adopted the 28 GHz Band Plan twenty years ago,” when it originally concluded that it was not practical for ubiquitously-deployed earth stations to operate in the same band as LMDS.³⁸ The Commission noted that deployment of earth stations could be reconsidered when sharing became more feasible.³⁹ Several techniques could facilitate this sharing, including

³⁶ *Avanti Comments* at 5; *ESOA Comments* at 6, 8; *O3b Comments* at 13-14; *AT&T Comments* at 12.

³⁷ *Notice*, ¶ 147.

³⁸ *ViaSat Comments* at 17-18.

³⁹ *See* In the Matter of Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission’s Rules to Redesignate the 27.5- 29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed-Satellite Services, CC Docket No. 92-297, 11 FCC Rcd 19005, 19010 ¶ 10 n.13, 19015-6 ¶ 27, 19025 ¶ 45 (1996) (“28 GHz *First Report and Order*”).

traditional coordination agreements and exclusion zones as well as the database mechanism suggested by ViaSat, which would be modeled on the TV White Spaces process.⁴⁰

5G commenters that oppose FSS user terminals in the 28 GHz band do so on the basis that such terminals could interfere with 5G operations.⁴¹ However, as noted above, the 28 GHz band is better suited for—and already being used by—satellite operations. Thus, the Commission should strongly consider committing to fully realizing the potential of satellite service in this band by permitting all types of FSS earth stations to operate in the band.

F. Earth Stations in Motion Should Be Permitted in the 28 GHz Spectrum

The same regulatory and technical reasons that support deployment of user terminals in the 28 GHz band also suggest that earth stations in motion should be permitted in the band.⁴² Earth stations on moving platforms is a mature technology with more than a decade of non-interfering operation aboard ships, vehicles, and aircraft, extending the reach of broadband services to these platforms. These represent the most sophisticated and closely managed FSS terminals, and they can be operated successfully without causing interference to other spectrum users. No party filing comments in this proceeding has provided any evidence suggesting otherwise.

III. ANY SHARING REGIME IN THE 37 GHZ AND 39 GHZ BANDS MUST PROVIDE REGULATORY CERTAINTY TO CURRENT AND FUTURE SATELLITE OPERATIONS

Unlike the 28 GHz band, commenters show relative agreement that sharing between satellite and terrestrial wireless services may well be feasible in the 37.0-38.6 GHz (“37 GHz”)

⁴⁰ *ViaSat Comments* at 18.

⁴¹ *Verizon Comments* at 24; *Ericsson Comments* at 22.

⁴² *Notice*, ¶ 159.

and the 38.6-40.0 GHz (“39 GHz”) bands. Thus, the Commission should act carefully to establish a regime that provides the regulatory certainty required for the growth of both of these services.

The satellite industry has been proceeding with concrete plans to launch networks using the 37 and 39 GHz bands, but satellite investment cannot continue under the regulatory uncertainty that would result from the proposed hybrid auction and license approach.⁴³ Indeed, multiple parties including representatives of satellite and terrestrial wireless have expressed their substantial dissatisfaction with the “overlay” or “hybrid licensing” proposals.⁴⁴ Nor can satellite use of the bands grow under the threat of proposals that are based on an assumption that satellite users will “migrate” out of the band as 5G use grows.⁴⁵ Again, any “sharing” regime that proposes to remove satellite from currently-used or future growth spectrum does not provide the necessary regulatory certainty and is not in fact a sharing plan at all.

Although these frequency bands are essential elements of broadband growth in the near future, both for satellite and terrestrial, Boeing urges the Commission to take the time required to develop a workable and enduring plan for these bands. To avoid the potential for significant reassessments in just a few years, the Commission should not finalize its decisions on these bands until the relevant ITU-R study process has sufficiently advanced and the path to global consensus on these bands has become clearer.

⁴³ *SIA Comments* at 17-18.

⁴⁴ *CTIA Comments* at 11; *see also Intel Comments* at 13; *Ericsson Comments* at 7; Comments of XO Communications, LLC, GN Docket No. 14-177 et al., at 10 (Jan. 29, 2016); Comments of PCIA, GN Docket No. 14-177 et al., at 10-11 (Jan. 29, 2016); Comments of Mobile Future, GN Docket No. 14-177 et al., at 11 (Jan. 29, 2016) (“*Mobile Future Comments*”) (noting that “[a] monumental collection of legal, technical, and practical issues would need to be resolved in order to create and implement a functional hybrid licensing framework”).

⁴⁵ *Cisco Comments* at 6-7.

The record shows some support for at least two potential approaches to coordination and protection that could allow sharing between satellite and terrestrial wireless service in the 37 GHz and 39 GHz bands. Boeing is continuing to review the potential implications of these proposals but provides its preliminary comments below.

Coordination Zones: Satellite providers note first that satellite earth stations could share with 5G mobile services using small coordination zones to protect such stations.⁴⁶ Coordination zones are common, effective, and a well understood tool. Under this proposal, satellite downlink earth station sites would be afforded interference protection through coordination zones, and satellite user terminals could also potentially operate in the band.⁴⁷ Many 5G proponents concur that satellite networks should be permitted to operate downlink user terminals in the 37 and 39 GHz bands, albeit on a secondary basis.⁴⁸ Given this strong initial agreement between representatives of terrestrial wireless and satellite services, Boeing urges the Commission to explore this proposal as a starting point for its plans in the 37 and 39 GHz bands.

Sub-Band or Geographic Separation: Another proposed strategy supported by some commenters is sub-band or geographic segmentation.⁴⁹ Although this approach may provide some regulatory certainty, it may also leave all operators with insufficient spectrum to adequately meet demand. Such an approach in particular should not be finalized and the bands should not be designated for 5G until the ITU studies are sufficiently mature.

⁴⁶ *SES Comments* at 6, *ViaSat Comments* at 13.

⁴⁷ *Echostar Comments* at 30.

⁴⁸ Comments of the Telecommunications Industry Association, GN Docket No. 14-177, at 13-14 (Jan. 29, 2016) (“*TIA Comments*”); *Cisco Comments* at 6-7.

⁴⁹ *Echostar Comments* at 31-32.

IV. ADDITIONAL BANDS MERIT CONSIDERATION, BUT PROPOSALS THAT DISRUPT INCUMBENT SATELLITE OPERATIONS ARE NOT VIABLE

Commenters have identified a number of additional bands that may be suitable for 5G and for sharing with incumbent services. Some of these bands, such as the 24.25-27.5 GHz and 31.8-33.4 GHz band, offer substantial advantages and challenges that can be addressed through carefully crafted rules and increasing technology. Boeing supports taking the time required to study the constraints and opportunities in these bands to craft a spectrally-efficient, workable sharing environment, taking advantage of the relatively greenfield status in these bands. Other bands, such as the 3.7-4.2 GHz band (“C-band”) and the 42.0-42.5 GHz band were wisely omitted from the *Notice* as being unsuitable for 5G due to significant and incompatible spectrum use. The Commission should not allow such scattershot spectrum proposals to distract from the development of a coherent and forward-looking policy in those bands that are best suited for its goals.

A. The C-Band is Not an Appropriate Candidate for 5G

Boeing strongly opposes the suggestion of Nokia that the Commission should examine the C-band for 5G use.⁵⁰ C-band was not considered at all in this Notice, which focused specifically on spectrum above 24 GHz. Additionally, such a proposal runs counter to the international consensus of WRC-15, which explicitly adopted a position of “No Change” in the band 3600-4200 MHz.⁵¹ This band is being actively used by satellite operators to provide critical services that often cannot be replicated using other satellite spectrum bands. For

⁵⁰ Comments of Nokia, GN Docket No. 14-177, at 13 (Jan. 29, 2016) (“*Nokia Comments*”).

⁵¹ WRC-15 adopted a limited footnote for use of 3600-3700 for IMT in a few Region 2 countries (Canada, Colombia, Costa Rica and the United States), but the Nokia proposal falls outside of this narrow exception.

example, C-band satellite communications are not significantly impaired by rain attenuation and other factors that make the C-band uniquely important for essential communications services that cannot be compromised by natural events. Therefore, C-band satellite communications networks should not be disrupted in a scattershot search for additional spectrum that can be annexed for 5G.

B. The 42.0-42.5 GHz Band is Not a Suitable Candidate for 5G and Should Instead Be Identified for FSS

The proposal of T-Mobile to investigate the 42.0-42.5 GHz band for 5G is similarly unproductive.⁵² As the Commission explains, this band was explicitly omitted from the Notice based on concerns about sharing with the radioastronomy service (“RAS”).⁵³ In nonetheless proposing this band, T-Mobile has not provided any technical analysis, or even a proposal, as to how new 5G services could share with satellite or RAS. Instead, the Commission should expand satellite operations into this band to complement the efforts of the satellite industry, which is already designing and preparing to deploy broadband communications networks in the immediately adjacent 40.0-42.0 GHz band.

C. The 24.25-27.5 GHz and 31.8-33.4 GHz Bands May Be Technically Suitable and Globally Harmonized Alternative Bands for 5G

Boeing concurs with the comments of the satellite industry, which note that the 24.25-27.5 GHz, and 31.8-33.4 GHz bands may provide a set of technically suitable and globally harmonized alternative bands for terrestrial 5G.⁵⁴ As the Global VSAT Forum explains, the first of these bands subsumes the allocations at 24.25-24.45 GHz and 25.05-25.25 GHz already

⁵² *T-Mobile Comments* at 8.

⁵³ *Notice*, ¶ 79.

⁵⁴ *GVF Comments* at 4.

identified in the Notice.⁵⁵ The bands also satisfy the Commission's five criteria of large swaths of contiguous spectrum, international harmonization, compatibility with incumbent use, and providing the potential for a wide variety of concurrent services.⁵⁶ Thus, Boeing recommends that the Commission consider these bands, but cautions that any introduction of terrestrial wireless into these bands should protect incumbent BSS and FSS feeder link operations.

Parties representing both satellite and terrestrial wireless further agree that the 31.8-33.4 GHz band shows substantial merit as a suitable band for 5G services, and should be explored for this purpose.⁵⁷ In particular, this band was the most widely supported band for IMT/5G during WRC-15, and a substantial portion of this band (31.8-33.0 GHz) was also recommended for 5G use by CITELE.⁵⁸ It also provides a large block of 1200 MHz of contiguous spectrum, which is 50 percent greater than the 800 MHz of spectrum proposed in the Notice and should allow greater scope for development of 5G services.⁵⁹ All parties recognize that this band presents multiple challenges for 5G deployment,⁶⁰ but the ITU-R is slated to complete its sharing studies on this band in advance of WRC-19, which will provide a clearer basis for evaluating these challenges and how sharing can be implemented.⁶¹ Given the interest in this more promising frequency band from terrestrial wireless and satellite operators, Boeing

⁵⁵ Notice at ¶ 61.

⁵⁶ GVF Comments at 4 (citing Notice, ¶ 61).

⁵⁷ Avanti Comments at 7, T-Mobile Comments at 6.

⁵⁸ T-Mobile Comments at 6 (noting that the 31.8-33 GHz band was recommended by CITELE and ITU. The 33-33.4 GHz band was recommended by ITU).

⁵⁹ Avanti Comments at 7.

⁶⁰ Notice, ¶ 73-74.

⁶¹ Avanti Comments at 7.

recommends the Commission continue to carefully consider it as a viable choice and closely monitor the sharing studies to be carried out by the ITU.

V. PART 15 UNLICENSED USE OF THE 57-71 GHZ BAND IS BROADLY SUPPORTED

Commenters from multiple industries recognize the enormous potential of unlicensed use in the 57-71 GHz band. As one of the world's leading manufacturing companies, as well as a leader in aircraft design and in-flight communications systems, Boeing urges the Commission to permit unlicensed use of this band both on the ground and within aircraft cabins.

A. Terrestrial Part 15 Unlicensed Operation Should be Permitted in the 64-71 GHz Band

There is wide agreement across industries that the 64-71 GHz band should be used for unlicensed services, as is already the case for the 57-64 GHz band.⁶² It is inappropriate to consider the band (or portions of it, such as 64-71 GHz) for licensed use, as some 5G proponents propose.⁶³ Arguments that this proposal would create too much unlicensed spectrum again undervalue unlicensed spectrum.⁶⁴ In fact, the need for unlicensed spectrum is at least as great as

⁶² Comments of NCTA, GN Docket No. 14-177, at 3-4 (Jan. 29, 2016) (“*NCTA Comments*”); Comments of the Information Technology Industry Council, GN Docket No. 14-177, at 5 (Jan. 29, 2016); *Straight Path Comments* at 6, Comments of the Wi-Fi Alliance, GN Docket No. 14-177, at 5-6 (Jan. 29, 2016); Comments of Qualcomm Incorporated, GN Docket No. 14-177, at 14-15 (Jan. 29, 2016); Comments of Google Inc., GN Docket No. 14-177, at 6-7 (Jan. 29, 2016); NCTA would further propose a relaxation of the Part 15 power limits on the basis that the band could be used for outdoor, high-power, directional point-to-point backhaul links, as well as short range indoor technologies like WiGig and WirelessHD, and short range outdoor networks. *NCTA Comments* at 6.

⁶³ *AT&T Comments* at 17; *Verizon Comments* at 13, *T-Mobile Comments* at 14, *CTIA Comments* at 17, *Nokia Comments* at 17.

⁶⁴ *Verizon Comments* at 13, *T-Mobile Comments* at 14-15, *CTIA Comments* at 18. Some recommend limiting the unlicensed portion to 64.0-66.0 GHz. *CTIA Comments* at 19; *Nokia Comments* at 17-18; *Ericsson Comments* at 19; *Mobile Future Comments* at 16.

for licensed spectrum. Instead of a handful of licensed operators, unlicensed spectrum can benefit countless service providers and end users.

Boeing believes that exclusion zones where required are a reasonable condition on unlicensed operation in the band, could be effectively implemented, and could adequately protect radioastronomy in the adjacent band.

B. Unlicensed Operations Can Be Permitted On Board Aircraft in the 57-71 GHz Band Without Harming Critical Weather Forecast Satellite Systems

Boeing has been participating in discussions with the FCC, NTIA, and the scientific community regarding the introduction of unlicensed wireless operations aboard aircraft in the 57-64 GHz. The aviation industry relies heavily on accurate and comprehensive weather information and Boeing is therefore extremely cognizant about the importance of this issue.

Boeing, however, questions the assumptions and analysis that CORF makes regarding the propagation characteristics of WiGig radio frequencies inside aircraft, which CORF itself acknowledges “are somewhat tentative.”⁶⁵ Specifically, CORF raises concern that

there are few places within an aircraft to transmit a direct [line of sight (“LOS”)] signal to a laptop located in the aircraft. This means that transmission/access points will likely bounce signals off of the walls of the aircraft (or even the somewhat reflective windows) – potentially spraying RF power with high antenna gain much higher than 3 dB directly out of the aircraft.”⁶⁶

In reality, the optimal location of WiGig access points on aircraft is within the ceiling, pointing straight down toward passenger laptops (and directly away from satellites above). Rather than using a single wireless access point broadcasting widely throughout the aircraft,

⁶⁵ Comments of the National Academy of Sciences’ Committee on Radio Frequencies, GN Docket No. 14-177, at 14 (Jan. 29, 2016).

⁶⁶ *Id.*

commercial aircraft are equipped with multiple (often as many as twenty) low power access points situated just above passenger seats. Each WiGig access point would be highly directional (transmitting at about 10 dBm, with a resulting antenna gain of about 30 dBm eirp).

As ITU recommendations indicate, modern aircraft can be expected to provide 35 dB of fuselage attenuation,⁶⁷ particularly across the top of an airplane in the direction of weather satellites. Even aircraft windows are demonstrated to provide attenuation levels of 25 dBm,⁶⁸ which is arguably more than sufficient given the fact that only much weaker side lobe transmissions (reduced by 10 dB or more) from WiGig access points would be directed near the windows. Passenger laptops equipped with wireless WiGig capabilities would operate at even lower power levels, further ensuring that such transmissions would not be detected by weather satellites in orbit.

Given these facts, Boeing does not support CORF's arguments that WiGig systems in aircraft should be subject to a formal licensing regime, or restricted from using WiGig Channel 1 (57.24-59.4 GHz). Instead, the Commission should authorize unlicensed WiGig operations within aircraft on all WiGig channels throughout the 57-71 GHz band. Access to all available channels is necessary because of the underlying nature of aircraft, with one hundred or more aircraft passengers simultaneously using WiGig channels.

⁶⁷ See Compatibility analysis between wireless avionic intra-communication systems and systems in the existing services in the frequency band 4 200-4 400 MHz, Report ITU-R M.2319, Annex 1, Table A-1.4 (Nov. 2014).

⁶⁸ See Technical characteristics and spectrum requirements of Wireless Avionics Intra-Communications systems to support their safe operation, Working Party 5B, Report ITU-R M.2283-0 at 22, Table 5; see also Annex 3 (Dec. 23, 2013).

VI. CONCLUSION

Boeing supports the Commission's goal of facilitating more efficient and intensive use of higher frequency bands. This undertaking should not, however, come at the expense of current and future satellite operations, which play a critical role in the national broadband market and will also be a key component to future terrestrial 5G infrastructure. The Commission must therefore take steps to facilitate sharing in those bands that are suitable for co-existence of satellite and terrestrial operations, and to judiciously refrain from attempting to introduce terrestrial wireless into core satellite bands needed for continuing service and future expansion.

In the 28 GHz Ka-band, a key growth band for satellite, the Commission should unlock the full potential of satellite service by elevating FSS gateway operations to primary status and permitting user terminals, including earth stations in motion, on a secondary, non-interference basis. This approach would provide the regulatory certainty needed for continued investment in satellite growth, and would avoid the cumbersome and legally suspect process of auctioning satellite spectrum. The 42.0-42.5 GHz band is also not suitable for terrestrial 5G, and the Commission should adopt its longstanding proposal to authorize FSS operations in this band.

Sharing may be feasible in the 37 and 39 GHz bands, but such sharing must ensure regulatory certainty to future satellite operations. The Commission should not accept proposals that are based on an assumption that satellite users will "migrate" out of the band as 5G use grows.

Boeing supports expanding Part 15 unlicensed operation into the 64-71 GHz band in order to provide much needed unlicensed spectrum for consumers and manufacturers. Authorizing Part 15 operations in the 57-71 GHz band onboard aircraft would also benefit end users and aircraft operators without increasing the risk of interference to radio astronomy.

Together, these measures will promote the Commission's goal of facilitating more efficient and intensive use of higher frequency bands and the development and provision of new communications services for the benefit of consumers.

Respectfully submitted,

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