

JONES DAY

51 LOUISIANA AVENUE, N.W. • WASHINGTON, D.C. 20001.2113
TELEPHONE: +1.202.879.3939 • FACSIMILE: +1.202.626.1700

DIRECT NUMBER: (202) 879-3630
BOLCOTT@JONESDAY.COM

June 30, 2016

VIA ELECTRONIC FILING

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

**Re: *Written Ex Parte Notice*
GN Docket No. 14-177, IB Docket Nos. 15-256 and 97-95;
RM-11664; and WT Docket No. 10-112**

Dear Ms. Dortch:

The Commission's Spectrum Frontiers proceeding provides an unparalleled opportunity to make new spectrum available for advanced communications systems and services, including terrestrial 5G and next-generation satellite broadband offerings.¹ The unique millimeter wave ("mmW") bands that are the subject of this proceeding, with propagation characteristics that permit shared access to large amounts of available spectrum, can enable a range of consumer broadband offerings to help address the nation's urban wireless capacity crunch as well as its most intractable broadband access issues.

The Boeing Company ("Boeing") and the satellite industry have been working for decades to advance technologies in the mmW bands that the wireless industry now also seeks to harness for terrestrial 5G applications. The V-band, in particular, offers tremendous opportunities for a new generation of affordable broadband satellite services that can connect all Americans regardless of location at data rates that substantially exceed the Commission's current benchmarks. Consistent with this critical public policy objective, Boeing recently filed an application with the Commission seeking authority to launch and operate a non-geostationary satellite orbit ("NGSO") satellite system that would operate in V-band fixed-satellite service ("FSS") spectrum to provide low-latency, very high data-rate broadband service throughout the United States and around the world.

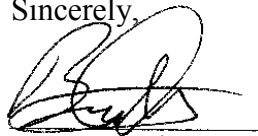
¹ See *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, Notice of Proposed Rulemaking, GN Docket No. 14-177, IB Docket No. 15-256, RM-11664 and WT Docket No. 10-112 (Oct. 23, 2015).

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Importantly, the Commission need not and should not be forced make a choice between terrestrial 5G and satellite broadband services in mmW frequencies. The same technologies that make broadband mmW systems possible (such as beam-forming and phased-array antennas), also makes co-primary spectrum sharing in many of these spectrum bands fully achievable. To further advance the Commission's public record with respect to the opportunity for nationwide broadband access and co-primary spectrum sharing between terrestrial 5G and broadband satellite systems, Boeing has prepared the attached White Paper on the important spectrum management, technological leadership, broadband access, competition policy and related issues raised in this proceeding.

Thank you for your attention to this matter. Please contact the undersigned if you have any questions.

Sincerely,

A handwritten signature in black ink, appearing to read "Bruce A. Olcott", written over a horizontal line.

Bruce A. Olcott

Counsel to The Boeing Company

Attachment



WHITE PAPER

**SATELLITE AND 5G SHARING
AT THE SPECTRUM FRONTIER –
CHARTING A NEW BROADBAND FUTURE**

THE BOEING COMPANY

June 30, 2016

On March 7, 2016, Chairman Thomas Wheeler, speaking at the 19th Annual Satellite Leadership Dinner in Washington, D.C., implored the satellite industry “to work with the mobile industry and quickly come back to us with realistic sharing ideas for the coexistence of satellite and mobile” in the Commission’s “Spectrum Frontiers” proceeding. The satellite industry, and The Boeing Company in particular, took this message to heart and engaged with renewed determination to identify measures that can facilitate highly efficient, shared use of spectrum resources in millimeter wave (“mmW”) bands.

In the upper mmW bands (including the 37.5-40 GHz band), where new 5G and satellite systems are under development, substantial opportunities exist to deploy both terrestrial and satellite broadband services throughout the United States. As Chairman Wheeler acknowledged, the satellite and terrestrial wireless industries must “work diligently to resolve the technical details necessary for sharing scarce spectrum across the spectrum chart, so that a variety of technologies can work together in deploying broadband and maximizing the benefits of high-speed connectivity.” The benefits of these efforts can be transformational if industry is given sufficient time to work through outstanding technical issues.

Chairman Wheeler has also observed that “access to broadband is a powerful motor for lifting people from poverty and reducing economic inequalities.” For this reason, maximizing broadband access in the United States and around the world remains a critical public policy priority. From extending advanced communications services to all Americans to the U.S. Global Connect Initiative, which has become part of U.S. law by virtue of an Executive Order issued by President Obama on June 24, 2016 and which seeks to bring an additional 1.5 billion people online by 2020, the Chairman has correctly concluded that “satellites will be crucial to the success of both efforts.”

Next-generation satellite constellations have the potential to achieve the Commission's goals of universal affordable broadband access and other important public policy objectives, including extending U.S. leadership in aerospace and advanced communications technologies, but only if the Commission adequately accommodates new satellite broadband operations. These new satellite systems can share downlink (earth station receive) spectrum effectively with terrestrial 5G networks using operational provisions that the Commission must otherwise adopt to facilitate 5G services. Reasonable measures such as power limitations that the Commission itself proposed and relaxation of provisions restricting satellite user terminal receive operations in the 37.5-40.0 GHz band, would not constrain the deployment of 5G networks but would bring tremendous public benefits in the form of ubiquitous broadband access and increased competition throughout the United States and around the world.

Although the Commission is understandably eager to accelerate the market availability of 5G offerings, it should carefully consider the powerful public interest benefits associated with satellite-delivered broadband access and the potential for sharing between terrestrial and satellite services in developing a spectrum access regime governing the upper mmW bands. Premature action that could foreclose significant opportunities for spectrum sharing and broadband deployment in these bands should be avoided. Given the early stage of technological development of 5G services in the upper mmW frequencies, the Commission should continue to consider rules for the 37.5-40.0 GHz band together with other bands in a Further Notice of Proposed Rulemaking to advance U.S. leadership across a range of broadband technologies, enhance competition in advanced communications services, and facilitate the deployment of truly ubiquitous broadband access in this proceeding.

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SATELLITE AND 5G SHARING AT THE SPECTRUM FRONTIER – CHARTING A NEW BROADBAND FUTURE

The Commission’s “Spectrum Frontiers” proceeding provides an unparalleled opportunity to make new spectrum available for advanced communications systems and services, including terrestrial 5G and next-generation satellite broadband offerings.¹ Unconstrained by the significant level of incumbent deployment, the Commission should consider new spectrum sharing approaches in the upper portions of the millimeter wave (“mmW”) band (*e.g.*, the V-band, including 37.5-40.0 GHz) that would accommodate terrestrial and satellite services on a co-primary basis. New systems and services contemplated for these bands remain in early stages of development and can readily adjust to spectrum sharing provisions developed in the context of this proceeding.

As a leader in aerospace and communications technologies, including satellite solutions currently operating in upper mmW frequencies on advanced government systems, The Boeing Company (“Boeing”) is developing a non-geostationary satellite orbit (“NGSO”) system that would operate in V-band fixed-satellite service (“FSS”) spectrum, including the 37.5-40.0 GHz band, and that would provide very high data-rate broadband connectivity throughout the United States and globally. The application for this broadband satellite system was recently filed with the Commission and filings for this U.S. satellite system have already been submitted to the International Telecommunication Union (“ITU”).

¹ See Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, *Notice of Proposed Rulemaking*, GN Docket No.14-177, IB Docket No. 15-256, RM-11664 and WT Docket No. 10-112 (Oct. 23, 2015) (“*Spectrum Frontiers NPRM*”).

Boeing shares the Commission’s desire to extend U.S. leadership in advanced communications services, and believes this objective should embrace a wide range of technologies, including satellite-delivered broadband and terrestrial 5G applications. Accordingly, Boeing has developed a sharing proposal for the 37.5-40.0 GHz band that would enhance spectrum efficiency, increase competition and facilitate deployment of broadband services throughout the United States and around the world.

Boeing believes, however, that it may be premature to adopt spectrum access rules for the 37.5-40.0 GHz band that could preclude deployment of its satellite-based broadband solution. The record of this proceeding does not yet contain sufficient information to make a fully informed decision regarding the potential for spectrum sharing and an appropriate spectrum access regime in this band. Therefore, the Commission should consider spectrum access rules for this and other upper mmW bands in a Further Notice of Proposed Rulemaking to make the most informed decisions possible with respect to these critical issues.

I. The Commission Should Seize the Opportunity to Deliver Affordable, Ubiquitous, High-Quality Broadband Access Throughout the United States

One of the Commission’s most important public interest goals today is to foster widespread and affordable access to broadband Internet access services.² The 2010 *National Broadband Plan*

² Section 706 of the Telecommunications Act of 1996 requires the Commission to study the availability of “advanced telecommunications capability to all Americans” and to take immediate corrective steps if such capability is not “being deployed to all Americans in a reasonable and timely fashion.” 47 U.S.C. § 1302; *see also* 47 U.S.C. § 1302(d)(1) (“The term ‘advanced telecommunications capability’ is defined, without regard to any transmission media or technology, as high-speed, switched, broadband telecommunications capability that enables users to originate and receive high-quality voice, data, graphics, and video telecommunications using any technology.”).

called broadband “the great infrastructure challenge of the early 21st century.”³ Today, six years later, while the Commission has striven mightily and taken great strides, an intractable “broadband gap” persists between those with access to affordable and reasonably comparable broadband Internet access service and those without.⁴

Next-generation satellite systems operating in the upper mmW bands can offer ubiquitous broadband Internet access rivaling the performance of terrestrial fiber, even as existing terrestrial providers deploy services in these bands. For example, the NGSO satellite system proposed by Boeing would provide broadband Internet access service at very high data rates anywhere in the United States. Other GSO and NGSO satellite systems are also under development in these bands. Given the amount of spectrum available with few incumbents and nascent usage, the upper mmW bands constitute a unique opportunity for the Commission to embrace new, forward-thinking sharing approaches that will greatly enhance the public interest benefits of these bands.

By developing rules that maximize the potential for shared co-primary satellite and 5G access to the 37.5-40.0 GHz band, the Commission at last could close the broadband gap once and for all. In adopting an innovative spectrum sharing approach that leverages the band’s unique propagation characteristics and the non-interfering, receive-only nature of satellite user

³ Federal Communications Commission, Omnibus Broadband Initiative, *Connecting America: The National Broadband Plan* (2010) (“*National Broadband Plan*”), at xi (available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-296935A1.pdf). The Commission explained that broadband “is a modern necessity of life, not a luxury. It ought to be found in every village, in every home and on every farm in every part of the United States.” *Id.* at 338.

⁴ Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act, GN Docket No. 15-191, *2016 Broadband Progress Report*, FCC 16-6, 31 FCC Rcd 699, ¶ 126 (2016) (“*2016 Broadband Progress Report*”).

terminal operations at these frequencies, the Commission also can show global leadership across various communications technologies and advance its spectrum management, broadband access, competition and other important public policy objectives. With the right spectrum access choices, the Commission – and U.S. consumers – really can have it all.

A. Next-Generation Satellite Systems Operating in Upper mmW Frequencies Can Deliver Broadband Internet Access Nationwide

Under the Communications Act of 1934, as amended, the Commission must ensure that those living in rural, insular, and high cost areas have access to telecommunications and information services, including broadband Internet access service, that is “reasonably comparable to those services provided in urban areas.”⁵ Through the Connect America Fund (“CAF”), the Commission has committed over \$30 billion in high cost universal service support over the next decade to expand affordable broadband access within the United States.⁶ Even with the Commission’s commitment of prodigious universal service support, broadband options available to rural consumers, schools, libraries, and health care providers often remain limited and expensive. For those users, the Commission has recognized that alternatives to terrestrial

⁵ 47 U.S.C. § 254(b)(3).

⁶ See FCC Press Release, *Carriers Accept Over \$1.5 Billion in Annual Support from Connect America Fund to Expand and Support Broadband for Nearly 7.3 Million Rural Consumers in 45 States and One Territory*, Aug. 27, 2015 (available at: https://apps.fcc.gov/edocs_public/attachmatch/DOC-335082A1.pdf); see also Connect America Fund, WC Docket No. 10-90, *Report and Order, Order and Order on Reconsideration, and Further Notice of Proposed Rulemaking*, FCC 16-33, 31 FCC Rcd 3087, ¶¶ 60, 146 (2016); Connect America Fund, WC Docket No. 10-90, *Report and Order, Declaratory Ruling, Order, Memorandum Opinion and Order, Seventh Order on Reconsideration, and Further Notice of Proposed Rulemaking*, FCC 14-54, 29 FCC Rcd 7051, ¶ 35 (2014).

service, such as satellite, are likely to be the most viable option for reaching Americans living in remote areas of the nation.⁷

The benefits of satellite-delivered broadband access can now be realized in upper mmW frequencies because significant advances in satellite and phased-array antenna technologies enable extraordinary spectrum re-use and low-cost user terminals, resulting in a ubiquitous broadband offering with a compelling business case that can compete effectively with existing terrestrial offerings. For example, the Boeing system's low-Earth orbit ("LEO") architecture and use of thousands of small spot beams per satellite that each re-use all available FSS spectrum would result in broadband connectivity with latency, speeds and system capacity rivalling terrestrial options virtually anywhere in the nation. Such affordable, nationwide broadband satellite alternative can only be realized, however, if the Commission adopts rules allowing Boeing and others to compete in rural and urban areas alike, and allowing access to all available FSS spectrum (including the 37.5-40.0 GHz downlink band) on a co-primary, shared basis.

Beyond the universal service benefits, next-generation satellite systems operating in upper mmW frequencies can also increase broadband competition and capacity. For decades, the Commission has based its policies on the central tenet that competition among service providers best serves the public interest, and has therefore worked tirelessly to create conditions ripe for the emergence of greater market competition. This approach is no less important with respect to the advanced broadband communications services at issue in this proceeding, particularly when

⁷ Connect America Fund, WC Docket No. 10-90, *Report and Order and Further Notice of Proposed Rulemaking*, FCC 11-161, 26 FCC Rcd 17663, ¶ 30 (2011) (allocating "at least \$100 million per year to ensure that Americans living in the most remote areas in the nation, where the cost of deploying traditional terrestrial broadband networks is extremely high, can obtain affordable access through alternative technology platforms, including satellite and unlicensed wireless services") ("*USF/ICC Transformation Order*") (subsequent history omitted).

balancing the potential for localized deployment of terrestrial 5G and ubiquitous nationwide and global deployment of satellite broadband access. Enhancing broadband competition, particularly from nationwide satellite providers with service delivery costs that are independent of customer location or population density, will help bridge the digital divide by allowing consumers in rural and remote regions of the country and the world to enjoy the same very high data-rate connectivity at the same cost as those living in urban areas.

Although the *Spectrum Frontiers NPRM* seeks to facilitate U.S. leadership in 5G services, it does not appear to adequately address the need for additional competition in the overall broadband marketplace and may inadvertently risk exacerbating market concentration in broadband wireless services. The record in this proceeding is virtually devoid of new entrants expressing an intention of becoming terrestrial 5G providers. Rather, 5G is generally viewed as a terrestrial mobile overlay that is likely to be deployed by existing wireless service providers in urban areas. CTIA itself dispels any notion that 5G may introduce sorely needed competition in wireless services, predicting that 5G systems will be used “primarily for adding capacity and high-speed data”⁸ to existing networks in areas “with the greatest population density.”⁹

In view of these considerations, the Commission should carefully weigh the public interest benefits of all systems and services contemplated in the upper mmW bands. Boeing has submitted substantial technical information regarding the ability of 5G and satellite downlink/earth station receive-only operations to coexist in the 37.5-40.0 GHz band without undue constraints on either

⁸ Letter from Brian M. Josef, Assistant Vice President, Regulatory Affairs, CTIA, to Marlene H. Dortch, Secretary, Federal Communications Commission, at 2 (May 24, 2016) (also stating that 5G systems are “unlikely to deliver extensive coverage in a market, but instead will be best suited . . . in densely populated areas”).

⁹ Letter from Scott K. Bergmann, Vice President, Regulatory Affairs, CTIA, to Marlene H. Dortch, Secretary, Federal Communications Commission, at 2 (May 20, 2016).

service. The Commission can maximize the benefits to U.S. consumers by ensuring that spectrum access rules in this and other upper mmW bands enable the full implementation of satellite and terrestrial broadband offerings.

B. Satellite-Delivered Broadband Can Help Meet U.S. Policy Goals Globally

Recognizing the importance of broadband Internet access service in improving educational, economic, civic, cultural, and health care opportunities, the United States has recently launched the Global Connect Initiative, which seeks to bring an additional 1.5 billion people worldwide online by 2020.¹⁰ President Obama issued an Executive Order on June 24, 2016 mandating that the Global Connect Initiative be institutionalized in U.S. law¹¹ and this call has been echoed around the world. The United Nations has set a goal to “[s]ignificantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020.”¹² The World Bank’s recent *Digital Dividends* report found that “[n]early 6 billion people do not have high-speed internet, making them unable to fully participate in the digital economy” and called for nations to “invest in infrastructure and pursue reforms that bring greater competition to telecommunications markets, promote public-private partnerships, and yield effective regulation.”¹³

¹⁰ See Catherine Novelli, Under Secretary of State for Economic Growth, Energy, and the Environment, “*The Global Connect Initiative: Making the Internet a Development Priority*,” Jan. 25, 2016 (available at: <https://blogs.state.gov/stories/2016/01/25/global-connect-initiative-making-internet-development-priority>).

¹¹ See Executive Order – Global Entrepreneurship, June 24, 2016 (available at: <https://www.whitehouse.gov/the-press-office/2016/06/24/executive-order-global-entrepreneurship>).

¹² United Nations General Assembly, Seventieth Session, Resolution 70/1, *Transforming Our World: The 2030 Agenda for Sustainable Development*, U.N. Doc. A/RES/70/1, at 21 (Oct. 21, 2015).

¹³ World Bank Group, *World Development Report 2016: Digital Dividends*, DOI: 10.1596/978-1-4648-0671-1, at xiii (2016).

Only satellite systems have the global geographic reach necessary to make broadband Internet access available and affordable on this scale. History and current experience reinforce the challenges in building out the last mile – whether wired or wireless – to remote locations. Many areas also lack affordable access to the necessary *middle* mile connections to Internet exchange points located in urban centers. Next-generation NGSO satellite systems can bridge the global broadband gap by providing services directly to end-users, schools, libraries and similar community centers, thereby reaching unserved and underserved users worldwide as soon as the system is activated.

Development and implementation of broadband satellite systems in upper mmW bands can also help extend U.S. technological leadership in aerospace design and manufacturing, implementation of advanced satellite communications systems and services, and NGSO system launch and operations capabilities. For example, the proposed NGSO satellite system would not only result in high-skilled design, manufacturing and network operations jobs in the United States but also many more jobs necessary to bring the resulting global satellite broadband offering to market. Throughout the process, supporting and ancillary industries including telecommunications backhaul, launch services, and construction and others would realize tremendous benefits from development and implementation of new global satellite communications system. These important U.S. economic and technological benefits would be eclipsed by the public welfare benefits of providing all U.S. consumers with access to affordable, very high data-rate broadband services regardless of their location.

A Commission decision in the Spectrum Frontiers proceeding that facilitates FSS receive-only user terminal access to mmW frequencies would not only bring competitive Internet access to millions of American, extend U.S. leadership in advanced communications technologies and

other direct economic benefits, but it also has the potential to bring broadband access to *billions* of people around the world. By making well-considered spectrum management decisions in this proceeding that enable multiple broadband service offerings to share the upper mmW bands, the Commission can lead the way for transformational nationwide and global access to broadband Internet connectivity.

C. Realizing the Full Benefits of Satellite Broadband in the Upper mmW Bands Requires Access to All Available FSS Downlink Spectrum

The provision of a competitive, nationwide broadband offering requires very high data rates and very large aggregate system capacity to accommodate consumer demand and service expectations in densely populated urban areas, as well as rural and remote regions of the country. There is also significant asymmetry in broadband traffic, with multiple times more data being delivered to users (e.g., Internet search results, video streaming, etc.) than transmitted by users (e.g., Internet search queries, file uploads, etc.). In the satellite broadband context, this means that the availability of downlink spectrum is a limiting factor in system design and service provision, and that access to the maximum amount of downlink spectrum is critical to maximizing data rates and aggregate system capacity.

Fortunately, there is a substantial amount of contiguous FSS downlink spectrum from 37.5-42.5 GHz available to be harnessed for V-band satellite connectivity. The LEO orbital architecture, advanced beam-forming capabilities and sophisticated transmission plan of the Boeing satellites would reuse this spectrum many thousands of times over the United States to provide extraordinary system capacity and serve anticipated demand even in the most densely populated regions. Each satellite would also cover urban and rural areas at the same time, allowing Boeing to locate gateway earth stations in rural areas while using all available downlink spectrum for service to user terminal receivers in urban and suburban regions. This highly

efficient approach maximizes data rates and system capacity to enable a truly competitive, nationwide satellite-delivered broadband offering.

The commercial and operational viability of satellite broadband in the upper mmW bands depends largely on access to all available FSS downlink spectrum and, again fortunately, the receive-only nature of user terminal operations in the 37.5-40.0 GHz band means that permitting co-primary access to the band will have no material adverse impact on 5G deployment. Not only can this spectrum be shared with 5G networks, it can also be shared with other satellite service providers. When weighed against the *de minimis* impact to future 5G operations, the enormous public benefits satellite-delivered broadband weigh heavily in favor of permitting user terminal access to all available downlink spectrum, including the 37.5-40.0 GHz band.

D. Additional Information Is Warranted Regarding Spectrum Access Policies for the 37.5-40.0 GHz Band and Other Upper mmW Frequencies

Boeing fully supports examination of spectrum access policies in the mmW bands. Premature adoption of spectrum access and service rules for the 37.5-40.0 GHz band, however, may be incompatible with the Commission’s overarching goal to design a flexible, “future-proof” framework that will accommodate the rapid pace of innovation with respect to the potential uses of this band.¹⁴ Furthermore, the considerations underlying the Commission’s reasons for moving quickly in this proceeding, as articulated in the *Spectrum Frontiers NPRM*, actually militate in favor of a more deliberate approach to this band.

First, while the Commission cited the rapid pace of technological development, stating that “waiting to develop service rules could result in delays” that would “affect the United

¹⁴ *Spectrum Frontiers NPRM*, ¶ 3.

States' leadership in mobile communications,"¹⁵ so too could premature adoption of rules that foreclose adoption of innovative solutions now on the drawing boards of companies such as Boeing.¹⁶ Second, the Commission cited the need to "provide equipment manufacturers and service providers with specific guidance as they design equipment and service offerings," but spectrum access rules are no substitute for international technical standards that remain under development.¹⁷ Third, the Commission sought a "flexible regulatory approach," consistent with its policy of "technological neutrality," but in this context neutrality means facilitating 5G and non-interfering, receive-only satellite access to mmW spectrum, as well as sufficient time to develop appropriate spectrum sharing approaches that support deployment of multiple systems and services to better serve the public interest. Finally, although the Commission suggests a desire to establish U.S. leadership in 5G technology, the United States should exercise even broader leadership across multiple broadband technologies and look for ways to extract even greater public interest benefits from this spectrum than 5G will deliver alone.

There are also important differences in spectrum use and sharing issues between the 37.5-40.0 GHz satellite downlink band and other bands under consideration in the proceeding. For example, in the 28 GHz band, FSS earth stations are conducting widespread uplink (transmit) operations and, as clearly demonstrated in the record, the terrestrial wireless community has identified this spectrum as a priority band for initial 5G deployment. In contrast, the record of this proceeding is neither complete nor clear with respect to contemplated terrestrial systems and services in the 37.5-40.0 GHz band. Moreover, the spectrum sharing considerations are vastly

¹⁵ *Id.*, ¶ 24.

¹⁶ *Id.*

¹⁷ *Id.*

different in FSS earth station uplink (transmit) bands from those in FSS earth station downlink (receive) bands.

Uncertain 5G deployment plans and undefined operational characteristics provide a limited basis on which to establish new spectrum access rules, particularly when weighed against competitive, nationwide satellite broadband service. As a result, although the Commission may adopt spectrum access rules at this stage of the proceeding in bands where satellite and terrestrial uses are more fully defined, it should further consider an appropriate approach for the 37.5-40.0 GHz band to allow time for industry to create a more fulsome record regarding technical and operational sharing characteristics in this and other upper mmW frequencies.

Boeing believes that a comprehensive review of spectrum options in the 37.5-40.0 GHz band and other upper mmW bands is required to ensure the 5G, satellite and other services can be deployed in the most efficient and effective manner. Although the Commission is currently considering a limited range of frequencies identified in the *Spectrum Frontiers NPRM*, it acknowledges that a range of other spectrum bands are being considered for 5G deployment by the international community.¹⁸ A broader examination should include these other bands with an eye towards maximizing 5G deployment opportunities while minimizing adverse impacts on other allocated services.

For example, adopting 5G spectrum access rules in the 37.5-40.0 GHz band (which overlaps half of all available V-band FSS downlink spectrum) without considering the status of paired FSS uplink spectrum could significantly undermine the potential for satellite broadband services or have other unintended consequences. This is particularly important to avoid unnecessarily “stranding” paired satellite spectrum that otherwise could be brought to bear to

¹⁸ *Spectrum Frontiers NPRM*, ¶¶ 13-14.

address the nation’s most pressing broadband access requirements. In addition, advanced spectrum access techniques could allow more efficient and intensive spectrum sharing in various satellite uplink bands.¹⁹ Similarly, satellite uplinks bands could be examined for potential indoor 5G terrestrial operations because they would be far less susceptible to potential interference from outdoor, upward-pointing user terminal transmissions.

U.S. leadership need not be limited to the bands under consideration in the *Spectrum Frontiers NPRM* but rather can and should be exhibited across a range of bands. The Commission should carefully consider the needs of U.S. consumers and closely examine the public benefits that proposed systems and services will bring to market using mmW spectrum. In balancing these interests, the Commission can demonstrate true global leadership that embraces a range of communications technologies and serves important U.S. public policy objectives.

II. Satellite and Terrestrial 5G Systems Can Share V-Band Spectrum on a Co-Primary Basis with Appropriate Service Rules

In adopting mmW spectrum policy for the future of the United States, the Commission should recognize the substantial public benefits associated with shared non-interfering, receive-only satellite user terminal access to the 37.5-40.0 GHz band. Recent advances in antenna technology and large amounts of spectrum available and unconstrained by significant deployment allow the Commission to consider new and innovative spectrum sharing approaches that can accommodate both terrestrial 5G and satellite services in this and other mmW bands.

As the President’s Council of Advisors on Science and Technology (“PCAST”) observed in its 2012 Report to the President, spectrum sharing is an “essential element” of the Federal

¹⁹ Because terrestrial networks typically are less power-limited and have much shorter transmission paths than satellite systems, it may be easier for 5G to consider deployment in even higher mmW bands that may be less suitable for FSS user terminal operations.

spectrum architecture and “[t]echnology innovations of recent years make this transformation eminently achievable.”²⁰ These findings are equally true with respect to spectrum available for non-federal services. The systems and services contemplated for these higher bands remain in early stages of development and can adjust to sharing provisions developed in this proceeding. Thus, the Commission need not default to old spectrum access approaches but, consistent with the policies underlying the PCAST Report and President Obama’s Memorandum on wireless innovation and spectrum sharing,²¹ can instead explore modern sharing mechanisms that maximize spectrum efficiency, competition and broadband access for all Americans.

A. Advances in Antenna Technologies and mmW Operational Characteristics Enable New Satellite/5G Sharing Opportunities

In the 15 years since the Commission considered the technical provisions for terrestrial and satellite operations in upper mmW bands, antenna technologies, waveforms and concepts of operation have advanced dramatically. Low-gain, omnidirectional mobile device antennas and simple sectorized base station antennas associated with legacy mobile services are being replaced by phased-array, beam-forming antennas that can better direct the energy associated with 5G terrestrial links. In addition, next-generation satellite systems will employ satellite and earth station phased-array antennas to greatly improve transmit and receive directivity, sidelobe discrimination and link performance.

²⁰ President’s Council of Advisors on Science and Technology (“PCAST”), Report to the President, *“Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth”* (July 2012) (available at: https://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf) (“PCAST Report”).

²¹ See Presidential Memorandum – Expanding America’s Leadership in Wireless Innovation, June 14, 2013 (available at: <https://www.whitehouse.gov/the-press-office/2013/06/14/presidential-memorandum-expanding-americas-leadership-wireless-innovation>).

The propagation properties of the mmW bands (high path loss, limited building penetration, etc.) and the operational characteristics of planned 5G services (transmission ranges of 100-200 meters, down-tilted base stations, etc.) also provide spectrum sharing opportunities not previously available. The urban focus of 5G deployment suggests that 5G/satellite sharing in urban areas will be the principal co-frequency spectrum access issue, and that satellite operations in suburban and rural areas will be a much easier spectrum sharing case. Boeing has submitted the results of its analyses in the record of this proceeding, which demonstrate that satellite user terminal receive operations can coexist on a co-primary basis with 5G operations in the 37.5-40.0 GHz band with reasonable operational provisions embodied in terrestrial service rules.²²

Sharing between these new systems and services is not subject to the outdated legacy assumptions of satellite/terrestrial incompatibility that led to the existing “soft segmentation” approaches, which limit satellite user terminal access to the 37.5-40.0 GHz band. Because FSS satellite downlink transmissions and user terminal receive-only operations would not cause interference or constrain 5G deployment, limiting satellite access to the band is no longer justifiable. This is particularly true when weighed against the significant public benefits associated with new satellite broadband operations in upper mmW spectrum.

B. Spectrum Auctions and Secondary Market Mechanisms Are Unnecessary in the Context of Non-Interfering, Receive-Only Satellite Access to the 37.5-40.0 GHz Band

The auction and secondary markets proposals offered in the *Spectrum Frontiers NPRM* appear rooted in outdated assumptions of incompatibility between satellite and terrestrial services.

²² See, e.g., Letter from Bruce A. Olcott, Counsel to The Boeing Company, GN Docket No. 14-177, IB Docket Nos. 15-256 and 97-95; RM-11664; and WT Docket No. 10-112 (June 6, 2016), at Attachment 1; See, e.g., Letter from Bruce A. Olcott, Counsel to The Boeing Company, GN Docket No. 14-177, IB Docket Nos. 15-256 and 97-95; RM-11664; and WT Docket No. 10-112 (May 9, 2016), at Attachment 1.

Traditionally employed to assign rights to exclusive terrestrial use of spectrum, auctions are not appropriate where a shared “overlay” use of spectrum is possible and in any event are impermissible in the satellite services context.²³ The Commission’s proposal to auction exclusive-use, geographic area licenses in the 37.5-40.0 GHz band on a county-by-county basis is also likely to guarantee that existing terrestrial mobile wireless providers will obtain exclusive control of the mmW bands necessary to provide service to users.²⁴

Furthermore, it is not justifiable to make satellite providers beholden to their terrestrial broadband counterparts when seeking non-interfering, receive-only access to provide nationwide advanced broadband services. The Commission can permit access to spectrum licensed to other services where such use would have no adverse effects on the licensed service.²⁵ In this case, proposed FSS satellite downlink/user terminal receive-only operations would have no interference impact on contemplated terrestrial uses of the band and thus resort to secondary market mechanisms is neither appropriate nor necessary.

Regardless of how the Commission assigns terrestrial licenses in this 37.5-40.0 GHz band, it should do so subject to operating rules that authorize receive-only satellite user terminal “overlay” operations. Satellite broadband offerings with very high data rate performance would be

²³ *Spectrum Frontiers NPRM*, ¶ 134. As Boeing and others have explained, requiring satellite operators to participate in spectrum auctions would clearly violate the Open-market Reorganization for the Betterment of International Telecommunications Act (“*ORBIT Act*”), which 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.” See, e.g., Reply Comments of the Boeing Company, GN Docket No. 14-177, *et al.*, at 11-13 (Feb. 26, 2016); EchoStar Satellite Operating Corporation, Hughes Network Systems, LLC, and Alta Wireless, Inc., GN Docket No. 14-177, *et al.*, at 36-37 (Jan 29, 2016).

²⁴ See *id.*, ¶¶ 30, 42 and 51.

²⁵ For example, Part 5 and 15 of the Commission’s rules contemplate the possibility of access to licensed spectrum for non-interfering *transmissions* without licensee consent.

a welcome competitive alternative for the delivery of broadband access to all Americans. Preserving satellite access to the 37.5-40.0 GHz FSS downlink band would bring additional broadband competition and capacity to U.S. consumers without unduly constraining the potential for 5G deployment in the band.

C. Appropriate Service Rules Will Enable Satellite and 5G Services to Operate on a Co-Primary Basis in the 37.5-40.0 GHz Band

Co-primary sharing of V-Band and mmW spectrum among satellite and terrestrial 5G providers is not only possible, but will best fulfill one of the principal objectives of the *Spectrum Frontiers NPRM*: to develop “rules that will enable flexibility in the uses and technologies that might be deployed in these bands in a way that also promotes coexistence between these different uses and technologies.”²⁶ To achieve this goal, the Commission should take the following steps:

First, the Commission should remove its prohibition on the operation of receive-only satellite user terminals in the band. Receive operations in the band cannot cause interference to 5G networks. The only issue is whether the user terminals can tolerate potential interference from 5G transmit operations. As discussed herein and in various *ex parte* submissions, primary satellite user terminal receive operations are compatible with terrestrial 5G operations that adhere to applicable service rules and no additional protection is required to address outlier cases of potential interference. Satellite diversity, screening, nulling and other mitigation techniques can be employed to enable such receive operations.

Second, the Commission should permit satellites to downlink in the 37.5-40.0 GHz band at the PFD levels that were adopted global by the ITU for this spectrum, rather than the 12 dB tighter limit adopted in the United States more than a decade ago. This outdated restriction was adopted

²⁶ *Spectrum Frontiers NPRM*, ¶ 2.

prior to development of the advanced mmW technologies that now make co-primary spectrum sharing between satellite and terrestrial services possible, and Boeing has demonstrated that satellite downlink transmissions at the internationally recognized level would have no material adverse impact on terrestrial operations in the band.

Finally, the Commission should adopt certain reasonable operating provisions that are otherwise necessary to govern 5G deployment. These provisions should include: (i) base station power limits similar to those proposed in the *Spectrum Frontiers NPRM*; (ii) use of power control; (iii) sidelobe isolation/beam forming requirements; and (iv) disclosure of base station locations to enhance potential interference identification and mitigation.²⁷ Such operating provisions would not unduly constrain 5G deployment but would allow shared co-primary satellite access to the 37.5-40.0 GHz band for satellite broadband receive operations.

Satellite user terminals could be blanket-licensed for receive-only operations as an “overlay” in the band regardless of the spectrum access regime adopted by the Commission to assign terrestrial licenses, and applicable service rules can be fully factored into 5G applications or spectrum auction decisions. Although gateway earth stations could be authorized in the band pursuant to site-specific licenses, such gateway facilities will typically be located away from urban centers and thus are unlikely to be affected by potential 5G deployment. In sum, FSS access to the 37.5-40.0 GHz band would in no way diminish 5G use of the shared spectrum but would bring about significant public benefits including ubiquitous broadband access, enhanced competition and increased spectrum efficiencies that would inure to consumers throughout the United States and around the world.

²⁷ The first three of these rules have already been proposed by the Commission. *See, e.g., Spectrum Frontiers NRPM*, ¶¶ 271-89.

III. Conclusion

The Spectrum Frontiers proceeding provides an unparalleled opportunity to enable competitive broadband services throughout the United States, as well as new 5G mobile applications in urban areas. Next-generation satellite systems can be accommodated, along with 5G services, through the adoption of appropriate spectrum sharing rules in upper mmW frequencies, including the 37.5-40.0 GHz band. The amount of available spectrum, combined with system design, propagation characteristics and sharing technologies, would enable these services to operate effectively in the same spectrum bands.

By preserving satellite access to mmW spectrum, the Commission will further a range of public interest objectives that cannot be addressed by 5G technologies alone. Satellite-delivered broadband services in these bands can only become a reality, however, if the Commission affords industry sufficient opportunity to work through associated sharing and spectrum policy issues in the subject frequencies. Other spectrum bands may provide even greater opportunity for satellite and 5G deployment.

The promise of both next-generation satellite broadband and 5G terrestrial mobile service is within grasp, so long as the Commission adopts spectrum access rules and related policies that facilitate the implementation of all of these new systems in the Spectrum Frontiers proceeding.