

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554**

In the Matter of

Expanding Flexible Use in Mid-Band Spectrum
Between 3.7 and 24 GHz

GN Docket No. 17-183

COMMENTS OF QUALCOMM INCORPORATED

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QUALCOMM Incorporated (“Qualcomm”) is pleased to comment on the *Notice of Inquiry* seeking to authorize additional flexible use mid-band spectrum between 3.7 and 24 GHz.¹ It is critically important that the FCC open the spectrum bands identified in the *Notice* as soon as possible so they can be incorporated into 5G mobile broadband networks. The Commission should open the 3.7-4.2 GHz band for licensed mobile use and, because of the much larger number of incumbents in the 5.9 to 7.125 GHz band and their varied uses to be protected, the Commission should extend the current 5 GHz unlicensed U-NII bands up to 7.125 GHz to support next generation technologies for unlicensed spectrum.

The end goal of this docket, as with virtually every FCC spectrum proceeding for the past two decades, is to enable better and faster mobile broadband connectivity for American consumers. The pressure on existing spectrum bands is ever-increasing, driven by the success and universal adoption of wireless technology, so enabling a steady stream of new spectrum is extremely important. FCC progress in this docket will continue driving economic growth and American 5G leadership, while positively impacting virtually every facet of American life.

¹ See Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz, *Notice of Inquiry*, FCC 17-104, GN Docket No. 17-183 (Aug. 3, 2017) (“*Notice of Inquiry*” or “*NOI*”).

INTRODUCTION & SUMMARY

The FCC's Mid-Band Spectrum *Notice of Inquiry* appropriately recognizes the explosive growth in wireless communications services and the concomitant need to make additional mid-band spectrum available for wireless communications.² Qualcomm welcomes the *Notice of Inquiry*, strongly supports the FCC's work to open additional spectrum bands for wireless use, and encourages the agency to move forward in this docket. Mid-band spectrum — not by itself, but in conjunction with low-band (sub-1 GHz) and high-band (millimeter wave) spectrum— is going to play an increasingly important anchor role in the deployment of 5G technology, and FCC action to keep a steady stream of spectrum flowing is essential to achieving and maintaining American leadership in 5G. To attain that goal, and to deliver the multi-gigabit connectivity that 5G portends, spectrum for 5G, in toto, needs to be low-band, mid-band, and high-band, using licensed, unlicensed, and shared regulatory paradigms.

First and foremost, it is imperative that the FCC allocate additional licensed spectrum for 5G services below 5 GHz. The U.S. is actually at a disadvantage in the sheer amount of licensed sub-6 GHz spectrum for 5G compared to other countries and regions. The 3.7-4.2 GHz band that the *Notice of Inquiry* identifies presents a prime opportunity to allocate 500 MHz of additional mid-band licensed spectrum, which is absolutely needed for 5G. In these Comments, Qualcomm provides options for licensed sharing with the incumbents in this band while the FCC carries out means of repacking current incumbent operations and/or clearing the band. It obviously would be best for the mobile industry, and for the U.S. Treasury, for the FCC to auction spectrum blocks to be cleared by a date certain.

² See, e.g., *NOI* at ¶¶ 6, 27.

Second, the FCC should extend the 5 GHz unlicensed bands to include the 5.925-7.125 GHz band (*i.e.*, the “6 GHz band”) on terms that will ensure the absence of harmful interference to the incumbent users of this band. The Part 15 rules governing broadband operations in the 5 GHz band, which unleashed unprecedented unlicensed device innovation and development of both broadband Wi-Fi and Gigabit LTE networks, can serve as a useful framework to extend unlicensed broadband access into the 6 GHz band. Thus, the FCC should issue a *Notice of Proposed Rulemaking* (“*NPRM*”) proposing to open the two 6 GHz portions identified in the *Notice of Inquiry* for unlicensed broadband services, enabling the band to be used for next-generation Wi-Fi (802.11ax), LTE Unlicensed (LTE-U/LAA/MultiFire), and the 5G New Radio (NR) variant under development for shared and unlicensed spectrum, 5G NR-U/SS (Unlicensed / Shared Spectrum), as well as technologies not yet even on the drawing board.

Third, Qualcomm encourages the FCC and NTIA to consider the sharing techniques presented herein as it looks at the bands identified in the *Notice of Inquiry* and beyond. Qualcomm believes that more efficient use of the mid-band and high-band spectrum resource can be realized where wireless systems with the same level of priority are time synchronized and use directional or spatial sensing techniques. Qualcomm, together with many other industry stakeholders, is developing these sharing techniques for 5G NR-SS to enable much more efficient and intensive spectrum use, and we are excited by the possibilities these enhanced tools offer in enabling better, faster mobile broadband.

Finally, to successfully open these mid-bands for intensive spectrum use, the FCC should require current incumbent licensees to confirm or promptly revise the technical data associated with their licenses in the FCC’s Universal Licensing System (“*ULS*”) database and International

Bureau Filing System (“IBFS”) database so the agency can best assess the most effective means of allowing new entrants into the bands. The FCC should set a firm deadline for such reviews to be completed, and any operations that are not confirmed within that period should not be accorded protection.

To meet consumers’ ever-increasing demand for mobile broadband connectivity, it is important for the FCC to make available additional low-, mid-, and high-band spectrum for flexible uses. The Commission has done outstanding work to unleash additional spectrum in the low and high bands, and begins with this *Notice of Inquiry* to identify a substantial amount of vital mid-band spectrum that is essential to achieving and maintaining American 5G leadership.

DISCUSSION

I. Qualcomm Strongly Supports FCC Action To Open Up More Licensed Spectrum Below 5 GHz For 5G Services

A. The 3.7-4.2 GHz Band Can Successfully Support Licensed Mobile Operations

The FCC should allocate additional mid-band spectrum below 5 GHz for licensed mobile services as soon as possible.³ The 3.7-4.2 GHz band offers promising attributes for mobile broadband — very good propagation characteristics to support broad coverage with less base stations than what high-band spectrum requires, and 500 MHz bandwidth to support much wider channels and higher throughput than what low-band spectrum typically offers.⁴ This band also is adjacent to the 3.5 GHz band (3550-3700 MHz) and provides opportunities for sharing equipment components across bands, keeping device costs low.

Qualcomm thus supports the FCC moving forward on the 3.7- 4.2 GHz band now. 5G services need additional licensed mid-band spectrum because this spectrum offers very good

³ See *NOI* at ¶¶19-20.

⁴ See *NOI* at ¶ 6.

operating range, can support service inside buildings and to rural areas of the country while supporting a reliable Quality of Service (“QoS”). The 3.7-4.2 GHz band presents the potential for harmonization with other countries that have made available or are making available some, or all, of this 500 MHz band for mobile broadband, including Japan, Brazil, and the EU (e.g., Italy, France, and the U.K).

The FCC should auction flexible use licenses with wide channelization (e.g., 100 MHz for increased performance by leveraging 5G’s inherent ability to use wide channels) and allow licensees to deploy in this band mobile, point-to-multipoint, and point-to-point operations over sizable geographic areas (e.g., Partial Economic Areas).⁵ In order to free up as much spectrum for licensed mobile use as soon as possible, the FCC should assess: (i) the benefits of repacking the current incumbent licensed users (i.e., satellite receivers and point-to-point transceivers), and (ii) the viability of moving these incumbents to other spectrum or other transmission means. The Commission may find that a combination of approaches would yield the best results.

B. Technical Challenges To Protecting Incumbent Satellite Receivers Can Be Addressed Via Spectrum Sharing Mechanisms While The Band Is Cleared

From the mobile industry’s perspective, the ideal approach to open the 3.7-4.2 GHz band for mobile use would be for virtually all incumbent satellite receivers and the limited number of existing point-to-point operations to move to other spectrum bands or switch to other transmission means (such as fiber-based connectivity). But even in a perfect world, that will not happen overnight. Existing incumbents in the 3.7-4.2 GHz band may be protected, in the interim, by exclusion zones based on accurate location information and operational parameters of

⁵ See NOI at ¶ 21.

the licensed incumbents. The FCC also should consider repacking to confine current incumbent users to a limited portion of the band.

The several thousand incumbent satellite ground receivers can be protected by new flexible use licensees through geographic separation. And protecting the limited number of point-to-point microwave licensees is a less challenging problem. In order to protect the current incumbents and assess the possibilities for enabling mobile operations, it is imperative that the FCC require these licensees to ensure that the technical parameters associated with their operations reflected on the FCC ULS and IBFS databases are accurate and remain up-to-date.

II. Qualcomm Supports Opening The 5925-7125 MHz Band For Unlicensed Broadband

Unlicensed spectrum delivers broadband Internet access in homes, businesses, libraries, and parks today by supporting increasingly higher quality audiovisual content, virtual reality and gaming, as well as numerous IoT devices, using Wi-Fi, Bluetooth, LTE Unlicensed and other wireless air interfaces. The 6 GHz band offers the best opportunity to support the expected growth of next generation unlicensed interfaces under development now and in the future.

A. The 6 GHz Band Can Support Next Generation Wireless Interfaces

The 1.2 GHz swath of unlicensed spectrum from 5.925-7.125 GHz can provide the additional broadband channels needed to support the successful growth of unlicensed wireless broadband across America over the coming decade, and Qualcomm supports FCC action to open the band for unlicensed broadband.⁶ Wideband channels (*e.g.*, 80 MHz, 100 MHz, and 160 MHz) will become increasingly important for the state-of-the-art applications and services that will use IEEE 802.11ax, LTE Unlicensed, and 5G NR-based shared spectrum technologies. Next generation unlicensed services are using wide channelization to provide high-throughput

⁶ See *NOI* at ¶¶ 29, 36.

applications that include ultra-HD video streaming, gaming, as well as augmented and virtual reality experiences. For instance, the current 5 GHz unlicensed band supports only a limited number of 160 MHz channels that these new applications use, so opening the 6 GHz band to unlicensed would enable the necessary bandwidth for these as well as completely new, currently unforeseen services and applications.

Unlicensed spectrum is critically important to supporting Gigabit LTE connectivity. There currently are 39 operators worldwide, including the four major U.S. operators, serving 1.2 billion LTE subscriptions in 23 countries deploying or trialing Gigabit LTE. A number of these operators are achieving Gigabit LTE speeds using LTE in unlicensed spectrum, an innovation pioneered by Qualcomm Technologies.⁷

In addition, the IEEE already has initiated efforts to extend the IEEE 802.11ax standard to the entire 5.925-7.125 GHz band.⁸ Given the importance and significant number of licensed incumbent users that require protection throughout the 6 GHz band,⁹ opening up the entire 1.2 GHz swath of spectrum will ensure that there are at least a few more available wide-band channels throughout the country for unlicensed operations to use. Unlicensed broadband operations can operate seamlessly within the interstices of the existing incumbents.

⁷ See Cristiano Amon, Qualcomm OnQ Blog, “The Gigabit LTE phenomenon, powered by Snapdragon” (Sept. 11, 2017) *available at* <https://www.qualcomm.com/news/onq/2017/09/11/gigabit-lte-phenomenon-powered-snapdragon>. See also Monica Allevan, “Telus fetes LAA test on live network in Canada,” Fierce Wireless, (Sep’t 29, 2017).

⁸ See IEEE, *P802.11ax PAR Modification*, Abstract (July 12, 2017) *available at* <https://mentor.ieee.org/802.11/dcn/17/11-17-0913-02-00ax-par-modification-to-support-6-ghz-band.docx>.

⁹ See *NOI* at ¶¶ 24, 32.

Recent studies have shown that the expected growth in use and deployment of unlicensed communications systems will exhaust the available spectrum capacity in the 5 GHz band, so additional spectrum allocations are needed now to support this growth.¹⁰ A Qualcomm study found that there is a need for more than 1.2 GHz of spectrum near the 5 GHz band in order to support multiple additional 160 MHz-wide channels in dense environments.¹¹ Because the 5.925-7.125 GHz band is adjacent to the current 5 GHz unlicensed workhorse bands, the 6 GHz band presents an ideal means of providing connectivity for next generation unlicensed services.

As explained in Section IV of these Comments, through working collaboratively with the wireless industry, standards organizations, and other stakeholders, the FCC and other regulators can explore means of more effective spectrum utilization in a portion of an unlicensed band if all unlicensed operations are time synchronized and share additional transmission data with other users of the band for coordination purposes. Because there currently is no unlicensed broadband allocation in the 6 GHz bands, standards bodies and regulators, including the FCC, should consider enabling such spectrum utilization optimization techniques in a portion of the 6 GHz band, thereby achieving greater capacity gains and improved mobile broadband performance for consumers than is possible today.

B. Unlicensed Broadband Operations Will Protect 6 GHz Incumbents from Harmful Interference

Opening the band to unlicensed access does not require any undue restrictions on incumbent operations, such as the tens of thousands of point-to-point licensees in the 6 GHz

¹⁰ See Rolf De Vegt, *et al.*, Qualcomm Incorporated “A Quantification of 5 GHz Unlicensed Band Spectrum Needs,” (Sept. 2016) available at <https://www.wi-fi.org/beacon/rolf-de-vegt/how-much-spectrum-does-a-user-need-for-1-gbps-wi-fi-coverage>; see also Wi-Fi Alliance, “Spectrum Needs Study” (Feb. 2017).

¹¹ See De Vegt, *et al. supra* n.10. at 20.

band. To ensure protection of these incumbents, they need to, at a minimum, ensure the information in the FCC's ULS database is and remains accurate. Unlicensed users can be regulated appropriately through, for example, limits on antenna gain and conducted power, to protect licensees based on the ULS database information. The FCC should seek comment on a range of options to allow unlicensed broadband use while protecting incumbents. Qualcomm believes that the optimal solution will be to employ different combinations of coexistence techniques in different parts of the 6 GHz bands because the type and amount of incumbent use across the 5.925-7.125 GHz band is not uniform.

Inserting licensed mobile operations in this band would be very difficult — if not impossible — due to the high number, importance, and variety of incumbents that already are licensed here on a primary basis. As the Commission notes in the *Notice of Inquiry*, Part 15 devices are designed to share spectrum with licensed services and must operate on a non-interference basis.¹² Existing Part 15 regulations have been successful in fostering more intensive spectrum utilization while protecting incumbents, and Qualcomm believes the Part 15 U-NII rules can be applied to the 6 GHz band and fully protect incumbent operations.

C. 6 GHz Unlicensed Broadband Devices Can Reuse Existing 5 GHz U-NII Device Components

Given that the 6 GHz band is adjacent to the existing 5 GHz U-NII bands, the wireless components used to support unlicensed broadband operations at 5 GHz can readily be extended to or reused for 6 GHz band operations — assuming that the FCC rules for 6 GHz unlicensed

¹² See *NOI* at ¶ 27. See also 47 C.F.R. § 15.5.

broadband are technically compatible with the 5 GHz U-NII rules.¹³ This leads to lower device costs and benefits consumers.

For example, certain active RF components, such as the low-noise amplifier (“LNA”) of the receive path and the power amplifier (“PA”) of the transmit path, can be shared for unlicensed operations throughout the 5 GHz and 6 GHz bands. Also, certain passive printed circuit board (“PCB”) components can be used on both bands, and antennas and antenna cabling can likewise be shared. Additionally, the entire analog baseband and the digital circuitry can be used across both bands. Aside from leading to lower device costs, using the same components for additional bands allows devices to include more functionality without increasing device size. Thus, it is important for the FCC to seek to allow a common baseline set of rules to apply across the 5 GHz and 6 GHz bands.

D. The Commission Can Help Enable Greater Use Of The 5 GHz Bands That Use Dynamic Frequency Selection (DFS)

While modification of FCC regulations governing DFS operations in the 5 GHz band is worthy of consideration, Qualcomm recommends that the FCC focus in the short term on means of streamlining the equipment authorization process for DFS testing. Qualcomm recommends that the FCC Laboratory seek input via the KDB process on means of revising the current test procedures with the goal of expediting DFS compliance testing, which is a limiting factor for equipment that seeks to use the U-NII-2 bands that require DFS. In this way, the wireless

¹³ See also *NOI* at ¶ 26 (Recognizing that “since the 5.925-6.425 GHz band is close to spectrum that [the FCC has] designated for Unlicensed National Information Infrastructure (U-NII) use, it may be possible and technically beneficial for U-NII devices to operate in both this band and the existing U-NII spectrum.”).

industry can work collaboratively with the Commission to further increase the use of the DFS bands.¹⁴

All of Qualcomm's 5 GHz IEEE 802.11 wireless chipsets support DFS operations, and their performance has been continually improving with each generation. In fact, we are unaware of any interference caused by devices that operate in the DFS bands where the equipment has been properly certified and installed. DFS technology works well and increased unlicensed use of these bands can be aided by revising certain aspects of the certification process that are overly burdensome and time consuming. At the same time, it is important to recognize that increased use of the DFS-constrained frequency bands will not alleviate the need for additional unlicensed spectrum capacity.

III. There Is Ongoing Technical Work To Assess The Opportunities To Open Up The 3.7-4.2 GHz, 6 GHz and Other Bands For Wireless Broadband Services

It is important to protect licensed incumbent services while enabling viable licensed mobile operations and unlicensed wireless services at 3.7-4.2 GHz and 6 GHz, respectively. Various interference mitigation aspects are being studied to protect FSS receivers in the 3.7-4.2 GHz band and point-to-point operations in the 6 GHz band from interference including limiting transmit power and antenna elevation.

At this point in time, the FCC and the communications industry writ large need to consider all options for opening the bands to mobile broadband, such as repacking current incumbents to a portion of the bands, moving current incumbents outside the bands of interest, and licensed sharing. Therefore, it is too early to propose specific paths forward, or mitigation measures, or FCC regulations to enable licensed or unlicensed access to the identified bands

¹⁴ See *NOI* at ¶ 30.

because such measures necessarily depend upon the potential for repacking, refarming, and sharing by incumbents as well as the allowable impact upon incumbent operations without causing interference — all of which are being assessed currently. Repacking of incumbents, for example, worked well in opening up the 700 MHz and 600 MHz bands for licensed mobile use, and refarming worked well to open up the PCS bands. Qualcomm believes these tools can work in the bands discussed in the *Notice of Inquiry*.

Qualcomm also is actively developing Cellular Vehicle-to-Everything (“C-V2X”) technologies to support next generation connectivity between vehicles and from vehicles to pedestrians, roadside infrastructure, and the network. We expect that additional dedicated mid-band spectrum will be needed for this purpose as the 5G NR version of this technology is developed. 5G NR-based C-V2X, which will be part of 3GPP Release 16, is expected to be a High Data Rate Ultra-Reliable Low Latency Communication (“URLLC”) system, relying on wideband channels, unicast and broadcast modes of operation, multiple antenna techniques, among other new techniques. It is being designed for advanced automotive use cases that extend beyond safety, such as sensor sharing, platooning, and sharing of intent/objects with proximate vehicles.

IV. Qualcomm Is Developing Enhanced Spectrum Sharing Technologies To Improve Spectrum Utilization

Qualcomm encourages the FCC to consider the sharing means provided in this Section as it considers opening up new bands for flexible use. Vertical sharing techniques can be used to enable sharing between systems that have some form of hierarchy in terms of priority. One such approach currently in use is the sharing between federal radar systems and unlicensed systems in the 5 GHz band, where unlicensed systems use DFS to sense and avoid the radars. Another approach, which has been standardized in the EU and is discussed below in Section IV.A, is

Licensed Shared Access (“LSA”) that allows licensed mobile operations when and where federal incumbent operators are not operating.

Horizontal sharing techniques are used today to enable access to spectrum by users who are in the same tier in terms of priority, such as sharing between LTE Unlicensed technologies and Wi-Fi in the 5 GHz bands. As explained below, Qualcomm believes that more effective use of the spectrum resource can be realized between systems that share on a horizontal basis where their operations are synchronized and use directional or spatial sensing techniques.

Finally, we believe that even greater spectrum utilization can occur when vertical and horizontal sharing techniques are combined, and we are continuing to explore new techniques to enable fair sharing among radios and tiers. These tools can improve coexistence between systems, increase the utilization of the bands, and benefit all users.

A. Licensed Shared Access Enables Vertical Sharing With Federal Incumbents

To the extent the FCC sees potential in a vertical sharing approach in future bands with licensed federal incumbent operations that require protection, it should look to the two-tier spectrum access framework known as Licensed Shared Access (“LSA”) that has advanced in Europe. The LSA two-tier structure is much simpler than the three-tier structure that the FCC has introduced into the 3.5 GHz band. LSA can support flexible use licenses using a secure interface between federal incumbent users to protect sensitive information, such as when and where incumbent operations are occurring. Moreover, implementation of two tiers under this framework is completely transparent to the end user device. The device is controlled by a base station that tells the device when and where it can operate.¹⁵ So from the perspective of the user

¹⁵ The flexible license holder’s Operations, Administration, and Maintenance (“OAM”) network system would know the status of incumbent operations and determine the interference limits within which operations can occur on a particular channel at a given time and location.

device, operating on a given spectrum band under LSA is like operating on any other band and does not require any device modifications.

The FCC can draw from the extensive technical standardization work on LSA that has been completed in Europe. LSA was developed in the European Conference of Postal and Telecommunications Administrations (“CEPT”) environment. In 2014, CEPT and the Radio Spectrum Policy Group (“RSPG”) developed a set of technical recommendations on the LSA methodology and sharing conditions.¹⁶ In addition, ETSI has finalized a detailed collection of LSA-related standards¹⁷ Several EU member states have successfully held LSA field trials. The FCC can leverage this extensive work as it looks to open up more spectrum for mobile broadband.

B. Horizontal Sharing Mechanisms Can Enable More Efficient Spectrum Utilization Among Multiple Users Operating With The Same Priority Level

Horizontal sharing can enable efficient spectrum sharing among users with the same priority level. Horizontal sharing among different systems with the same priority level may be

¹⁶ RSPG “Opinion on LSA,” RSPG13-538; ECC Report 205 on LSA, defining and analyzing the LSA concept (Feb. 2014); ECC Recommendation ECC/REC/(14)04 on “Cross-border coordination for MFCN and between MFCN and other systems in the frequency band 2300-2400 MHz” (May 2014); ECC Decision ECC/DEC/(14)02 on ‘Harmonised conditions for MFCN in the 2300-2400 MHz band’ (June 2014); CEPT Report 055 - Technical conditions for wireless broadband usage of the 2300-2400 MHz frequency band; CEPT Report 056 - Technological and regulatory options for sharing between WBB and the relevant incumbent services/applications in the 2.3 GHz band; CEPT Report 058 - Technical sharing solutions for the shared use of the 2300-2400 MHz band for WBB and PMSE.

¹⁷ TR 103 113 System Reference Document on “Mobile broadband services in the 2300 MHz -2400 MHz frequency band under LSA regime”; ETSI TS 103 154 “System requirements for operation of Mobile Broadband Systems in the 2300 MHz -2400 MHz band under LSA”; TS 103 235 “System Architecture and High Level Procedures for operation of LSA in the 2300 MHz-2400 MHz band”; TS 102 379 defines details of architectural elements: content of the LSA Spectrum Resource Availability Information (LSRAI) and the protocols on the LSA interface between LSA Controller (LC) and LSA Repository, and is based on the System Requirements, the System Architecture and High Level Procedures.

based on interference avoidance through channel selection, energy sensing, or coordination. Coordination can occur using over-the-air communications, via a geo-location database, or even a backhaul link. One potential outcome of coordination is synchronizing different networks and hence being able to allocate resources on a more deterministic but load dependent fashion.

Channel selection is a useful technique employed by WLAN systems, such as Wi-Fi, as well as in unlicensed systems that use LTE Unlicensed technologies. In cases where there is high demand and a large number of nodes deployed, co-channel sharing is inevitable because there are not enough channels available. As we have shown in our filings relating to the 5 GHz band, these techniques do achieve fair sharing of spectrum.

We are actively developing new techniques to provide even better performance for all users. Use of multiple antennas is becoming increasingly common in wireless systems that use higher frequency bands, such as 5 and 6 GHz. These antenna systems allow the transmission links to become highly directional, and by exploiting this directionality — through sensing the channel occupancy based on the intended direction of transmission — it is possible to significantly improve spectrum reuse and greatly increase overall system capacity.

Combining spatial sharing with network synchronization allows for fair sharing and greatly improved overall network performance, particularly with extremely high loading conditions. These tools can support horizontal sharing between multiple users, each of whom can support a defined Quality of Service (“QoS”).

It also is possible to combine both vertical and horizontal sharing approaches to achieve even greater spectrum utilization. A depiction of this combined approach is shown below in Figure 1.

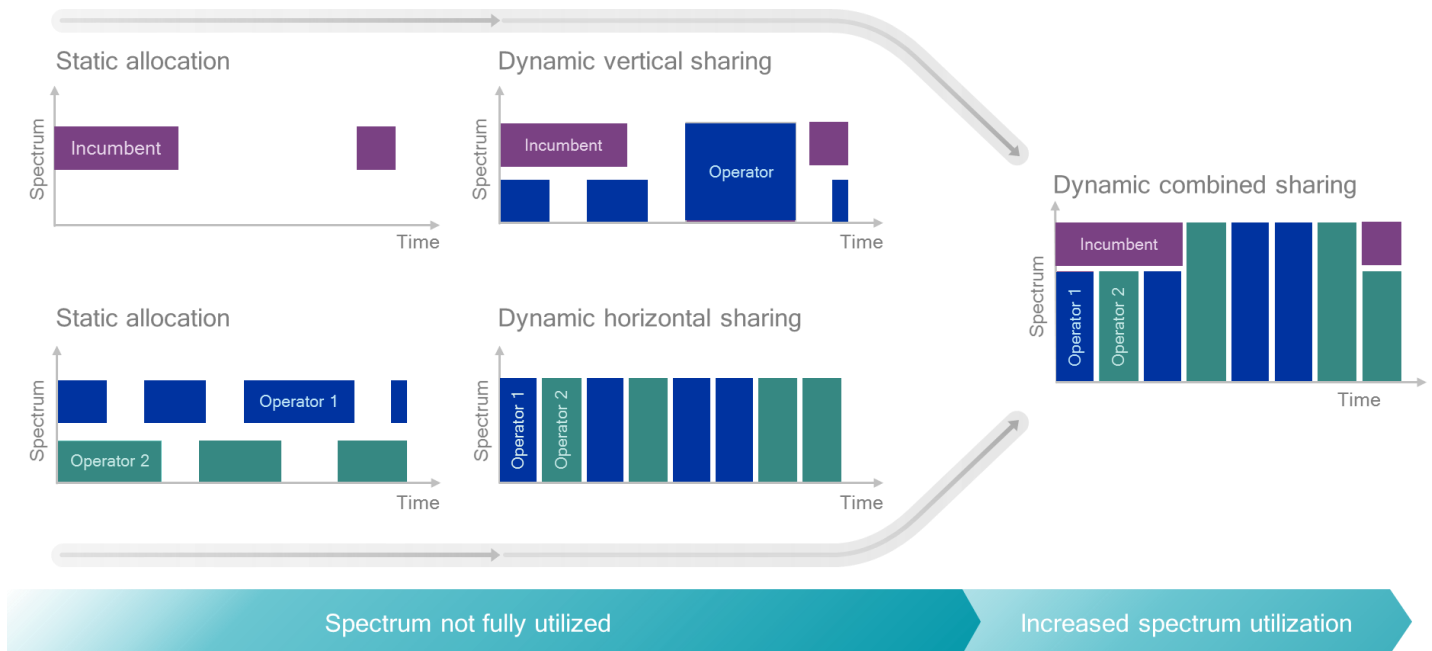


Figure 1. Dynamic Combined Vertical and Horizontal Spectrum Sharing

In addition, Qualcomm is exploring coordinated multipoint sharing (“CoMP”) techniques that use highly focused beam steering and time-division multiplexing to enable multiple operators to simultaneously communicate on the same channel and in the same geographical area. We believe that coordinated sharing, if properly carried out, can vastly increase spectrum efficiency and value. CoMP enables guaranteed and tiered spectrum access to support services that require a given QoS.

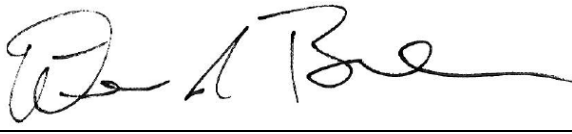
Qualcomm is actively developing all of these tools simultaneously and collectively through working with many industry stakeholders to explore these and related ideas, and we are hopeful they will be part of future 5G spectrum sharing interfaces.

CONCLUSION

Qualcomm encourages the FCC to promptly issue an *NPRM* proposing to open the 3.7-4.2 GHz and the 6 GHz bands for wireless services in accordance with these Comments. There is no question that 5G networks will require additional licensed mid-band spectrum resources to support next generation enhanced mobile broadband, massive IoT, and mission critical services, and the bands identified in the *Notice of Inquiry* are a necessary initial collection of such resources. Amending the existing Part 15 rules to permit flexible unlicensed broadband use in the 6 GHz band, with robust protection for incumbents' current and future operations, will drive rapid consumer adoption of new unlicensed device capabilities, maximize economies of scale, and support forthcoming industry standards.

Respectfully submitted,

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