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December 16, 2019

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

Re: Ex parte presentation, IB Docket No. 11-109; IBFS File Nos. SES-MOD-20151231-00981, SAT-MOD-20151231-00090, and SAT-MOD-20151231-00091, SAT-AMD-20180531-00044, SAT-AMD-20180531-00045, SES-AMD-20180531-00856

Dear Ms. Dortch:

Ligado Networks LLC (“Ligado”) submits these materials to substantiate the important role its mid-band spectrum can serve in 5G network deployments.

Mid-band spectrum refers to radio frequencies between 1 GHz and 6 GHz. Making more licensed mid-band spectrum available is essential to 5G for several reasons. First, today’s network grids are designed around sub-2 GHz spectrum, thereby allowing rapid and economical deployments of new sources of mid-band spectrum. Second, mid-band spectrum provides the critical combination of favorable propagation characteristics and wide-channel bandwidths. Third, 5G global vendors like Ericsson and Nokia have demonstrated how the lower portion of mid-band (specifically 1-2 GHz) benefits 5G operations in the higher portion of mid-band (2-6 GHz), as well as those in the 24-40 GHz bands.

Ericsson and Nokia have both conducted technical studies on L-Band spectrum that demonstrate how Ligado’s greenfield spectrum can help to address the coverage challenges of high frequency only 5G deployments. Both studies confirm that higher mid-band (2-6 GHz) offers larger blocks of spectrum to support super-fast 5G data speeds while lower mid-band spectrum (1-2 GHz) supports superior propagation, in-building penetration, and rapid 5G deployment onto existing sub-2 GHz network grids. Their studies also show that new 5G technology solutions can extend lower mid-band coverage benefits to higher mid-band deployments for high-speed throughput over a broader coverage area. Working in combination, mid-band spectrum in the 1-2 GHz and 2-6 GHz categories can enable a cost-efficient, broad-based, capacity-rich, and rapidly-deployed 5G solution.

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Please direct any questions to the undersigned.

Respectfully submitted,

_____/s/_____
Gerard J. Waldron
Counsel for Ligado Networks LLC

Attachment

cc: Chairman Pai
Commissioner O’Rielly
Commissioner Rosenworcel
Commissioner Carr
Commissioner Starks

Ligado UL and DL Decoupling study

Project Report



Executive Summary

5G deployments using only higher band spectrum are likely to face network challenges

- Uplink and downlink coverage can be materially different due to power differences as great as 1000x when comparing the levels used at the base station to those for end-user equipment¹
Because the uplink spectrum determines the coverage area for any given cell site, this power differential results in uneven user experience and creates handover issues between cell sites
- Higher band spectrum using TDD further degrades uplink coverage due to a lower allocation of time resources to uplink channels as compared to FDD
- Use of TDD on higher band spectrum also causes increased latency making it challenging for URLLC applications, which are a key part of the 5G future ²

The combined use of L-Band in the lower mid-band spectrum category with C-Band can address the challenges resulting from a higher mid-band only 5G deployment

- Lower mid-band uplink coverage can provide a larger coverage area for any given site due to its substantial advantage of 12 to 17 dB as compared to C-Band thereby allowing L-Band to correct the uplink/downlink coverage differential experienced by C-Band alone
- L-Band along with C-Band can be deployed using FDD which offers superior latency over a C-Band only TDD deployment thereby enabling network use of both frequencies to provide the best of both worlds for 5G deployments — the high capacity and low latency needed for URLLC applications
- Adding a dedicated FDD UL channel allows for more TDD resources to be allocated to the downlink increasing overall spectrum efficiency in the network³
- L-Band spectrum presents no complex challenges associated with intermodulation issues when used with C-Band allowing multiple uplink channels to be used simultaneously

Multiple technology options exist to use L-Band and C-Band together in network deployments

- Downlink / Uplink Decoupling, Carrier Aggregation, and Dual Connectivity are all technology options available for a unified deployment of L-Band and C-Band. Each of these technologies provides different capabilities allowing for flexibility in network deployment based on operator requirements.

Advantages of Greenfield Spectrum vs. Existing Spectrum

- The use of greenfield spectrum rather than the already-deployed spectrum has several benefits. Greenfield spectrum removes the need for burdensome 4G/5G coordination, increases aggregate network capacity, and, in the case of Ligado's L-Band, provides a nationwide opportunity for a seamless 5G network deployment

The combined use of spectrum in the lower mid-band and higher mid-band categories offers significant user experience benefits and performance improvements for 5G as compared to a higher



mid-band only deployment. The Ericsson analysis confirms multiple technology paths exist to utilize Ligado's spectrum with higher mid-band spectrum and shows that use of greenfield spectrum can provide the optimal solution for combined spectrum use for 5G.

Additional Notes:

1. *Uplink is the limiting link for any band.*
2. *Higher subcarrier spacing (SCS) in a TDD band compared to an FDD band may be used to overcome part of the TDD drawback with respect to latency*
3. *The TDD frame structure and thus the UL/DL fraction in mid-band are subject to regulatory requirements and/or agreements among operators.*

Nokia's Study on Ligado Lower Mid-Band Spectrum Solution to Address 5G Deployment Challenges

June 2019

About Nokia

We create the technology to connect the world. We develop and deliver the industry's only end-to-end portfolio of network equipment, software, services and licensing that is available globally. Our customers include communications service providers whose combined networks support 5.7 billion subscriptions, as well as enterprises in the private and public sector that use our network portfolio to increase productivity and enrich lives.

Through our research teams, including the world-renowned Nokia Bell Labs, we are leading the world to adopt end-to-end 5G networks that are faster, more secure and capable of revolutionizing lives, economies and societies. Nokia adheres to the highest ethical business standards as we create technology with social purpose, quality and integrity.

Nokia's Network Planning and Optimization (NPO) team developed this analysis through its own engineering expertise using standard engineering simulation tools, with inputs on Ligado lower mid-band spectrum provided by Ligado Networks. As part of this study, Nokia assessed the challenges of deploying 5G using only higher mid-band spectrum and how Ligado's lower mid-band spectrum can mitigate these challenges. Nokia also looked at various technology solutions available for deploying higher mid-band spectrum in conjunction with lower mid-band spectrum.

1 Executive Summary

- 1.1 5G deployments using only higher mid-band spectrum (e.g. C-band) and high band (>6 GHz and mmWave) will face challenges
 - Compared to currently deployed LTE networks on low band (<1 GHz) and lower mid-band spectrum (1-2 GHz), deployments in 5G using only higher mid-band spectrum (2-6 GHz) and high band (>6 GHz) will result in limited 5G coverage due to higher propagation and indoor penetration losses associated with spectrum in the higher bands. These differences, which can be mitigated in the downlink, are more crucial in the uplink, which determines coverage reach and the ability to use existing network grids built around <2 GHz spectrum.
- 1.2 Lower mid-band spectrum, when deployed along with higher mid-band spectrum, can help overcome 5G coverage challenges
 - Superior propagation characteristics of lower mid-band spectrum improve 5G coverage, both outdoor and indoor, as compared to 5G coverage when using only higher mid-band spectrum.
 - A cell site utilizing Ligado uplink band can cover an area roughly 4.8 times greater than C-band.
- 1.3 Ligado's greenfield spectrum, which will be commercially available once the FCC rules on the pending license modification application, in the lower mid-band provides operational and technical advantages as compared to harvesting already-deployed lower mid-band spectrum
 - There are practical challenges related to harvesting already-deployed 4G spectrum since initial 5G deployments are going to be in the same areas with the highest 4G LTE capacity needs.
 - Greenfield spectrum adds network capacity immediately while reducing operational challenges, allowing for accelerated 5G deployments with no impact to existing 4G LTE networks.
- 1.4 Various technology options are available for use of higher mid-band with Ligado's lower mid-band greenfield spectrum to accelerate lower-cost 5G deployments by making use of existing network grids designed around <2 GHz spectrum
 - This report examines 3GPP standard-technology solutions, E-UTRAN New Radio-Dual Connectivity (EN-DC), Carrier Aggregation (CA) and Supplemental Uplink (SUL) to combine lower and higher mid-band spectrum.
 - For example, if LTE uses 1800 MHz in EN-DC, then 5G cannot use 1800 MHz for supplemental uplink without network explicit resource sharing co-

ordination. This issue can be addressed by using a dedicated spectrum like Ligado's band for SUL.

- As a leading 5G infrastructure vendor, Nokia provides support and solutions for each of these technologies.

Combined use of spectrum in the lower mid-band and higher mid-band categories offers significant economic and operational advantages for 5G as compared to higher mid-band only deployment alternatives. The Nokia analysis confirms several technical paths exist to utilize Ligado's spectrum with higher mid-band spectrum to achieve a advantageous combination of lower-cost, more rapid, and better coverage reach in 5G deployments.