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April 2, 2019
VIA ECFS

Marlene H. Dortch
Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, DC 20554

REDACTED – FOR PUBLIC INSPECTION

Re: Notification of Oral *Ex Parte* Presentation
Applications of T-Mobile US, Inc. and Sprint Corporation for Consent to Transfer Control of Licenses and Authorizations; WT Docket No. 18-197

Dear Ms. Dortch:

Pursuant to Section 1.1206(b) of the Commission's Rules, 47 C.F.R. § 1.1206(b), notice is hereby provided of an oral *ex parte* communication in the above-captioned docket. On March 29, 2019, Ankur Kapoor, Vice President, Network Technology, Karri Kuoppamaki, Vice President, Technology Development and Strategy of T-Mobile US, Inc. ("T-Mobile") and other representatives of T-Mobile and Sprint Corporation ("Sprint")[1] (collectively "the Applicants") met with members of the FCC Transaction Team (a list of FCC participants is provided in Attachment A).

During the meeting, the Applicants discussed the presentation attached as Attachment B that provides additional details about the engineering model and assumptions used to develop it. The Applicants discussed that no additional low- or mid-band spectrum is scheduled for auction for the foreseeable future and therefore acquisition of low- or mid-band spectrum is not considered a

[1] Those representatives included Kathleen O'Brien Ham and Steve Sharkey of T-Mobile, R. Michael Senkowski, Nancy Victory (by phone) and Thomas Dombrowsky of DLA Piper LLP, George Cary and Daniel Culley of Cleary Gottlieb Steen & Hamilton, LLP, Joshua Soven of Wilson Sonsini, Tom Peters of Hogan Lovells US LLP, Chris Helzer of Quadra Partners LLC, Vonya McCann of Sprint, Regina M. Keeney and A. Richard Metzger of Lawler, Metzger, Keeney & Logan, LLC, Matthew Hendrickson of Skadden, Arps, Slate, Meagher & Flom LLP, Bradley Lui of Morrison & Foerster LLP, and Johanna Thomas of Jenner & Block LLP.

solution in the engineering model. The Applicants also discussed the limitations associated with millimeter wave band spectrum. Similarly, the Applicants noted the limited benefits that could be drawn from unlicensed spectrum to address capacity and congestion, as well as uncertainties around unlicensed spectrum usage.

Use of layer management, that will allow New T-Mobile to manage the 2.5 GHz spectrum together with other 5G low- and mid-band spectrum, was also addressed. The Applicants discussed how the uplink spectrum from other bands would be used to [redacted] To provide further details on this issue, attached with this filing as Attachment C is a white paper discussing layer management in a more granular fashion. Also, the Applicants have included on the attached DVD a detailed link budget for the 2.5 GHz band.

In addition, the Applicants demonstrated that small cells are accurately forecasted in the engineering model and that New T-Mobile will enable avoidance of the expense of both cell splits and small cell deployments. The Applicants also discussed why nothing in 5G requires departing from fundamental LTE-based modeling concepts—concepts such as throughput and load relationship, capacity expansion strategy, link budget, among others, will be the same. Small cells are deployed in the current networks and the engineering model accurately captures their impact.

The Applicants reviewed the information provided as Document 20 [redacted] as documentation for the engineering model.[2] This document includes the description of License Assisted Access (LAA), gains associated with LAA, and how it is used in the engineering model that has been submitted to be conservative. As a supplement to this document, attached to this filing as Attachment D is a detailed description of the assumptions. A spreadsheet used to derive the LAA capacity and gains is included on the attached DVD. In ordinary business course, LAA gains are not applied due to uncertainties discussed as shown in Attachment E.

There was also a discussion about congestion and average speed metrics used by the engineering model, especially during the integration period in 2019-2020. Attached to this filing as

[2] *Ex Parte* Presentation, WT Docket No. 18-197, filed Sept. 17, 2018 (Follow on documentation production and slight revision of the engineering model); Response to August 15, 2018 General Information and Document Request from the Federal Communications Commission, WT Docket No. 18-197, filed Sept. 5, 2018.

Attachment F is a white paper that describes in detail the methodology used (to supplement prior Document 5 that was provided as documentation to the engineering model).[3]

Finally, the Applicants discussed Dynamic Spectrum Sharing ("DSS"), a new feature that is under development. DSS facilitates the migration from LTE to 5G by assigning both technologies simultaneously on the same shared block of spectrum. While it has some potential to reduce fixed costs associated with refarming, the incremental benefit of DSS is limited to sharing within a portion of a five megahertz LTE block. Moreover, DSS in 5G is unlikely to be available for commercial use in the near term. The Applicants have provided as Attachment G a white paper with more details on DSS.

This filing contains information that is "Highly Confidential" pursuant to the Protective Order filed in WT Docket No. 18-197.[4] Accordingly, pursuant to the procedures set forth in the Protective Order, a copy of the filing is being provided to the Secretary's Office, including the DVD.[5] In addition, two copies of the Highly Confidential Filing are being delivered to Kathy Harris, Wireless Telecommunications Bureau, with a copy of the DVD. A copy of the Redacted Highly Confidential Filing is being filed electronically through the Commission's Electronic Comment Filing System.

Please direct any questions regarding the foregoing to the undersigned.

Respectfully submitted,

DLA Piper LLP (US)

/s/ Nancy J. Victory

Nancy J. Victory
Partner

cc: David Lawrence
Kathy Harris

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[3] *Id.*

[4] Applications of T-Mobile US, Inc., and Sprint Corporation for Consent to Assign Licenses, Protective Order, WT Docket No. 18-197 (June 15, 2018).

[5] The DVD also contains back-up data for the 5G loading curve, which was requested by the Transaction Team at a recent meeting on that subject.

Linda Ray
Catherine Matraves
Jim Bird
David Krech

ATTACHMENT A

LIST OF FCC PARTICIPANTS

David Lawrence
Charles Mathias
Catherine Matraves (by phone)
Charles Clancy
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Weiren Wang
Murtaza Nasafi (by phone)
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Marcus Maher (by phone)

ATTACHMENT B

PRESENTATION DECK

No Low- or Mid-Band Licensed Spectrum Available, mmWave Use Limited

Low-band → **Unavailable**
- No foreseeable low-band auctions

Mid-band → **Unavailable**

CBRS →
- No auction scheduled
- Power restrictions limit macro-cell use, poor substitute for other mid-band spectrum

C-Band, EBS, 3450-3550 MHz →
- No regulatory certainty; no auction scheduled
- Amount, timing, technical rules, service rules uncertain

mmWave → **Limited Use**
- Poor and variable propagation
- Essentially no in-building coverage
- Usability limited to specific use cases

Limited Benefit from Unlicensed Spectrum, Particularly in Model Period

- **Ordinary business course does not use gains from unlicensed spectrum in capacity planning**
- **Limited gains even in best case scenario**
  - Would have to be split between 5G and LTE, so gains limited to spectral efficiency improvement
- **Best case scenario unlikely during model period**
  - Hardware subject to additional costs; during model period, unlicensed spectrum deployment will require radio separate from licensed 5G small-cell radio
  - No chipset or handset support on vendor roadmaps; significant penetration unlikely until end of model period
  - Neither Ericsson nor Nokia roadmaps include radio technology support
  - Amount of addressable traffic subject to offload is limited, particularly when deployed in conjunction with mmWave
    - Poor propagation and Wi-Fi interference limits benefits to in-building traffic
    - Low power limits, typically 30 dB less than macro-cellular bands

New T-Mobile addresses propagation differences between bands with layer management

- **Layer management: New T-Mobile will manage 2.5 GHz together with other 5G mid- and low-band spectrum**
  - Near cell site, NTM will allocate 2.5 GHz resources as primary to maximize the performance and capacity of 2.5 GHz
  - Uplink from other bands will be used to compensate for 2.5 GHz propagation losses
    - Farther from cell site, other mid-band and low-band spectrum will be utilized
  - Sprint current plans do not have advantage of using other mid- or low-band to compensate making model conservative

Small cells are accurately forecasted in the model

- **The model shows extensive use of small cells for standalone T-Mobile**
  - Model shows that by 2024, there will be [redacted] small cells required to address the demand which is roughly equivalent to TMO's share of ~621K small cells projected by CTIA source for 2024
  - Standalone T-Mobile may not be able to execute on forecasted small cells due to deployment challenges and may be forced to rely on higher cost solutions because of jurisdictional and other challenges
- **With the combined assets of New T-Mobile, we can avoid the expense of both cells splits & small cell deployments**

Nothing in 5G requires departing from fundamental LTE-based modeling concepts

- **Concepts such as throughput and load relationship, capacity expansion strategy, link budget, etc., will be the same**
- **Small cells are deployed in current network, and the LTE model accurately captures their impact**
  - More density does not change the fundamental modeling concepts
  - Small cells are a mature technology and there are no small-cell specific 5G changes

Dynamic Spectrum Sharing

- Dynamic Spectrum Sharing (DSS) is under development to facilitate the migration from LTE to 5G and improve operational efficiency by assigning LTE and 5G simultaneously on the same shared block of spectrum
- DSS only provides a capacity benefit if either technology is not using all the capacity that would be allocated to it in a dedicated manner
- The network model is tying 5G adoption to spectrum re-farming, in other words spectrum is re-farmed to 5G as it's not needed by LTE busy-hour demand
- The incremental 5G benefit is limited to a portion of a 5 MHz LTE block
  - Some of that spectrum is still used by LTE, so only up to [redacted] can provide additional benefit to 5G (not accounting for efficiency losses related to DSS)
  - By end of the modeling period this is [redacted] relative to the total amount of spectrum allocated to 5G

ATTACHMENT C

LAYER MANAGEMENT IN MULTI-FREQUENCY NETWORKS

Layer Management in Multi-frequency Networks

Abstract

The mature T-Mobile LTE network has multiple frequency bands that are managed collectively for optimal efficiency through Layer[i] Management, the ability to [redacted] to deliver maximum efficiency and the best customer experience. This document describes the Layer Management methods that T-Mobile uses today in the ordinary course of business. These practices will be extended to 5G with similar and evolved features, and the New T-Mobile network will use them to [redacted].

Using Layer Management, the multi-frequency New T-Mobile 5G network will achieve greater performance in the 2.5GHz band than Sprint would on a standalone basis. This additional gain from the strategy is not included in the Network Engineering Model

Layer Management Methods

Layer Management uses two main mechanisms to allocate users and traffic between bands and optimize efficiency and customer experience in the network:

1 [redacted]

2. [redacted].

1. Active Load Balancing feature

Active Load Balancing allows for an optimal distribution of active customers and their traffic across different frequency bands[iii], maximizing Quality of Experience and Efficiency. The network relies on the eNodeB[iv] air interface scheduler and inter eNodeB connections to actively and constantly balance the cell load. The following diagram shows the steps that take place to perform the optimal traffic redistribution:

[redacted]

The feature constantly monitors the cell load and balances load based on the network settings to improve cell quality. The RF signal strength reported by the UEs on the cell is evaluated by the eNodeB. Offload candidates are selected and suitable UEs are moved to the target cell, resulting in overall quality improvement. This feature allows the network to keep the right traffic in the right layer and to leverage all bands for optimal performance.

Cell-edge benefits

The mechanism is particularly impactful for UEs at the cell edge. Such UEs will be the top candidates for reallocation and will benefit from the higher quality from the target cell. With the proper tuning, T-Mobile has successfully leveraged the feature to minimize traffic at the cell edge, making the higher bands with lower propagation benefit from the improved coverage of the lower bands. The figure below illustrates the complementary effect across bands with the proper Load Balancing. The Cell Edge area and traffic are effectively minimized by leveraging lower bands:

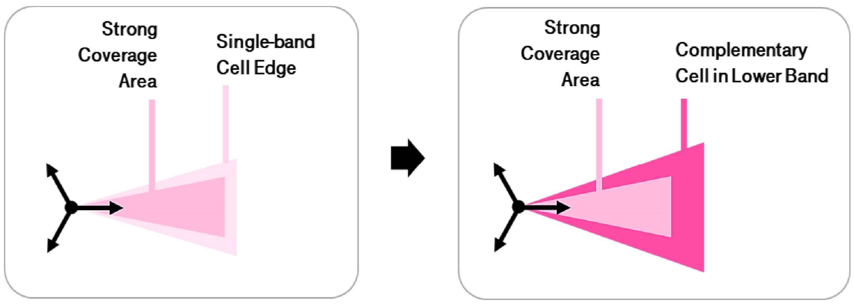

Figure: Cell edge benefit with Active Load Balancing feature

2. Coverage-based Inter-frequency Handover

Coverage-based Inter-frequency handover is designed to ensure the proper cell transitions as the users change location or are affected by other dynamic signal power effects such as moving obstacles. A device in a connected state will need to move to partner cells when the signal strength of the serving cell degrades, as controlled by pre-defined thresholds. The UE[v] is constantly reporting its RF conditions to the eNodeB. The latter evaluates the measurement reports received and provides the UE with a list of neighbor cells to facilitate the search for the best partner cell. Once a suitable neighbor cell is found, the eNodeB informs the UE to move to the neighbor cell. This is called the "handover" process, which can happen between all spectrum bands.

Cell-edge benefits

The figure below shows the inter-frequency handover between cells within the same sector. This allows for bands with higher propagation to support the traffic that would otherwise remain on the cell edge of the bands with lower propagation. This is the same complementary principle at the Cell Edge achieved with Active Load Balancing. This compensation for propagation differences effectively increases the efficiency and quality of the cells. It complements Active Load Balancing with transitions that are initiated by UE condition changes in addition to Cell-Loading level changes.

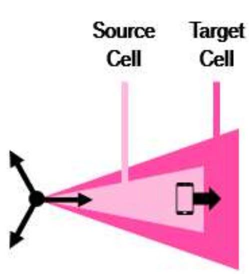

Figure: Inter-Frequency Handover within the same site

Layer Management Results on the T-Mobile Network

The mature Load Balancing practices in the T-Mobile network are a fundamental part of its superior performance and efficiency. [redacted]

Active Load Balancing and Inter-frequency handovers jointly reallocate Cell-edge traffic between different frequency bands and optimize cell load. Improved Efficiency and Customer Experience is observed in higher throughput in every frequency band. The PCS addition complements the AWS band in a manner akin to the way it will complement 2.5GHz spectrum in 5G in the New T-Mobile Network, delivering results greatly superior to those obtained with a single-band deployment.

[redacted]

Figure: Typical throughput increase results from frequency band additions

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[i] The term Layer is used to refer to both frequency and technology sections of a network. This document uses it to refer to frequency layers.

[ii] Sector refers to the geographic regions covered by directional antennas that divide a site (a site typically has three sectors). A sector is split into cells for each frequency band. For example, a three-sector site with PCS, AWS, and 700MHz has nine total cells

[iii] T-Mobile LTE network uses PCS, AWS, and 700MHz band in different combinations across the network

[iv] eNodeB is the term used in LTE to refer to the base station.

[v] UE stands for User Equipment and refers to the mobile device used on the network.

ATTACHMENT D

DOCUMENT 20a LAA GAINS CALCULATION

20a. LAA Gain Calculations Supporting Documentation

Section 2 of *Document 20. LTE Feature Set Description and Gains* describes the usage of LAA to opportunistically expand LTE connectivity by expanding to a large portion of the 5 GHz unlicensed spectrum. This document provides further supporting documentation on how the LAA gain calculation was derived.

The effective LAA capacity gain model takes into consideration the following factors:
(numerals correspond with sections in the model)

[redacted]

I. 3GPP Specification Evolution Over time

We assessed 3GPP specifications and incorporated expectations of technology availability of single channel, carrier aggregation (CA) of contiguous channel pairing and CA of multi-channel non-contiguous channel pairing in LAA over time. The summation of bandwidth from these three sources formed the basis of total available bandwidth from LAA technology that we could expect to utilize over time. This component of the model forms one of three limiting factors for LAA bandwidth. The other two being congestion impact (II) and space constraint (IV).

II. LAA Channel (UNII-1, UNII-2 and UNII-3) Congestion Over Time

Starting with the expected total available bandwidth from LAA bands UNII-1, UNII-2 and UNII-3, we formed assumptions on the level of congestion over time of the bands. [redacted] Given these assumptions, we formed an expectation of total available bandwidth from the LAA bands incorporating assumptions on congestion. This component of the model forms one of three limiting factors for LAA bandwidth. The other two being technology availability (I) and space constraint (IV).

III. Duty Cycle Factors

As we projected greater utilization of LAA bandwidth over time, we did not want to presume that our ability to utilize the additional bandwidth was 100%. The duty cycle factor was created to model the mechanic of diminishing returns (i.e. as we utilize more bandwidth, we will not be able to reap the full incremental benefits of the increased bandwidth). The practical reasoning behind this mechanic is based on the coordination principle employed by LAA called listen before talk (LBT). As more competing users utilize the same channels, the amount of time spent *listening* increases and the amount of time spent *talking* diminishes. In aggregate, the duty cycle, or the effective time we are able to utilize a specific channel or band diminishes. Mathematically, the construct of exponential decay was used to model this mechanic.

IV. Small Cell Equipment and Leasing Constraints

[redacted]

V. LAA Capable Devices Penetration

Based on supply chain, marketing aspirations, retail presence and various other factors, [redacted]. For the LAA Capacity Gain Model, we based the model's adoption forecast on the previous mentioned forecast but applied a conservative haircut to the adoption rate.

VI. LAA Percentage Threshold of Applicability

This is an on/off trigger component of the capacity gain formula that determines the applicability of LAA as a cost efficient technology to deploy in small cells based on sector size. [redacted]

VII. Transmit Power and Non-cochannel Performance Gains / Sector Area

Effective Performance Gains

T-Mobile's adoption of LAA will be specifically used for supplemental downlink and will require a primary carrier in the licensed spectrum for control signaling. LAA spectrum usage in small cells will not have any cochannel interference from macro towers and will, therefore, have increased performance gains over a larger area when compared with licensed spectrum, albeit, at lower transmit power. Since the *LAA Capacity Gain* model was intended to serve as an input into a more encompassing network capacity model that utilized capacity transfer functions that were derived from licensed spectrum, the model calculated "effective" mid-band spectrum assuming licensed spectrum. Hence, the gains from cochannel interference were modeled as a percentage improvement.

Since the net effects of transmit power, sector size and cochannel interference were a complex subject matter, InCode was commissioned to study specifically the effects of this. The results of their study were reported in "Project Freeboard Final Readout 20161130". [redacted]

LAA Percentage Applicability

With a given sector size, there is a function in the *LAA Capacity Gain* model that estimates the percentage of sectors that are equal to or less than the input sector size. The function is essentially a cumulative function derived by curve fitting from macro tower sector size data. The larger network capacity model (of which the *LAA Capacity Gain* model was integrated into) needs to make decisions about which competing technologies to deploy in small cells. One possible competing technology for small cells is CBRS (3.5 GHz). The capital efficiency of CBRS vs. LAA is very different due transmit power, spectrum propagation and hardware cost differences and is dependent upon the sector coverage area.

Capacity Gain Calculation

Based on the above factors, the overall LAA capacity gain formulation was derived as follows:

[redacted]

[redacted]

A – There are three independent determinations for bandwidth based on technology availability, band availability w/ congestion and space constraints represented by I, II and IV, respectively. The function selects the most constrained option of these three determinations.

B – Device penetration. Given a certain percentage of LAA enabled phones within the population, the effectiveness of LAA to ease traffic congestion is scaled accordingly.

C – We also scale the effectiveness of LAA as a capacity solution based on the notion of a duty cycle factor. This models the effect of diminishing returns as we more spectrum is utilized and more competing users are also adopting its usage.

D – This is an on/off toggle for the capacity calculation to represent LAA as a capacity solution given a certain sector size.

E – This scales the effectiveness of LAA (as it compares to typical licensed mid-band spectrum) due to not having cochannel interference from T-Mobile macro towers.

Attachments:

LAA SC Effective Spectrum Assumption.xlsx – spreadsheet with calculations on LAA gains used in network model

Project Freeboard Final Readout 20161130.pdf – study used for deriving the Transmit Power and Non-cochannel Performance Gains

ATTACHMENT E

NPC CAPACITY GAINS FOR SMALL CELLS AND LAA

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Small cell and LAA gain in NCP

Small Cell and LAA Capacity Gain Assumptions

LAA gain: Ordinary Business Course model does not incorporate capacity gains from LAA. It is looked at as opportunistic spectrum due to:

- Uncertainties around unlicensed spectrum
- Slow and limited LAA deployment
- Limited coverage area
- Handset penetration

- No plans in considering LAA gains for subsequent NCPs
  - Capacity gain is not proven. This feature improves the user experience of LAA capable devices but does not help address the load and congestion.
  - The availability and usage of unlicensed spectrum is not guaranteed, especially at busy hour. In the future, high demand from different carriers will be competing for the same resources which will further reduce the benefits of LAA in busy hour.

[redacted]

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ATTACHMENT F

CAPACITY INVESTMENTS FOR CONGESTION AND AVERAGE SPEED

Capacity Investments for Congestion and Average Speed

Abstract

Congestion and Average Speed are the main targets of T-Mobile's Capacity Management. [redacted] This includes Speed Forecasting to make sure that the best customer experience is provided. The congestion threshold denotes minimum speed and the Average Speed is consistently higher by a large margin. [redacted]

Congestion Mitigation & Management of Average Speed

The Capacity plan at T-Mobile is designed to address congestion and average speed. [redacted] The solution that is identified does not account for only addressing congestion but also increasing Average Speed. The illustrative figure below provides a high-level depiction of the iterative process in the National Capacity Plan cycles and its impact on congestion and average speed:

- [redacted]
- [redacted]
- [redacted]

[redacted]

Effect of Planning Process on Congestion & Average Speeds
(Figure is Illustrative & not built to scale)

In each capacity cycle, the areas with highest growth receive Capacity solutions to maintain and increase speed. [redacted]. This iterative Capacity process has delivered successful results in Congestion and Speed, as depicted in the figure below, which shows the trends [redacted].

[redacted]

Effect of Planning Process on Congestion & Average Speeds

T-Mobile Standalone LTE Speed in 2021

[redacted] TMO standalone must deliver on 5G as one of the biggest targets to stay competitive. To be able to complete the 5G build plan, solutions required to stay above congestion, and coverage expansion plans leaves TMO with no headroom to execute on additional projects that will require sector addition or new site builds. [redacted]

[redacted]

Build Rate Forecast
(Figure is Illustrative & not built to scale)

The New T-Mobile assets enable excellent results for both LTE and 5G during all stages of integration and mature network builds, keeping the same competitive trends that T-Mobile has delivered on LTE. [redacted]

Speed Forecasting & Network Model

As discussed above, congestion mitigation also helps with increasing average speeds. In addition to the congestion forecast, the Capacity team creates Average Speed Forecasts to directly assess its trends. The speed increase is calculated from the Supply addition such as Overlays and Sector Adds.

Model Speeds in 2021: Integration Baseline

The network model Speed forecast extends the practices discussed in the ordinary course of business to multiple years, based on average speed growth. [redacted] Using the typical speed increase, the model keeps an approach consistent with what has been the ordinary course of business in the LTE network.

Deploying capacity for higher average speeds can be confused with deploying excess capacity. As shown in this document, T-Mobile does not plan for the network to operate at the congestion threshold speeds but far above to remain competitive.

ATTACHMENT G

DYNAMIC SPECTRUM SHARING (DSS) OVERVIEW

Dynamic Spectrum Sharing (DSS) Overview

Introduction

- Traditionally spectrum has been allocated to various technology generations in a static manner, typically in blocks of 5 MHz or multiples thereof
- As new technology generations are introduced, historically spectrum has been re-farmed block by block to serve the next generation as device mix changes
- Manual spectrum re-farming creates an **operational burden** as it requires careful planning, coordination and execution of the activity **to avoid degradation** in end user performance
- The [redacted] related to spectrum re-farming, as well as to [redacted] by reducing the effect of having a spectrum block tied up to a technology that is lighty loaded
    - In terms of system performance [redacted], rather increase spectrum utilization
    - This is achieved by enabling real time allocation of radio resources as required by a technology (LTE and 5G)

FIGURE 1

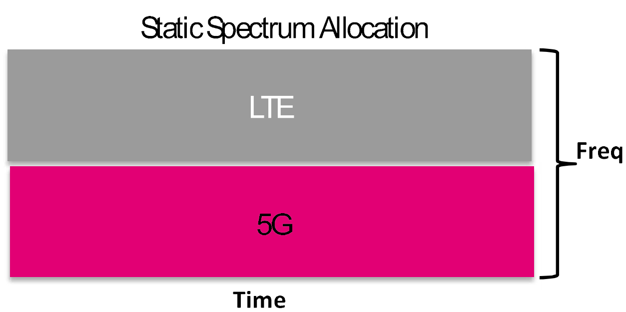

FIGURE 2

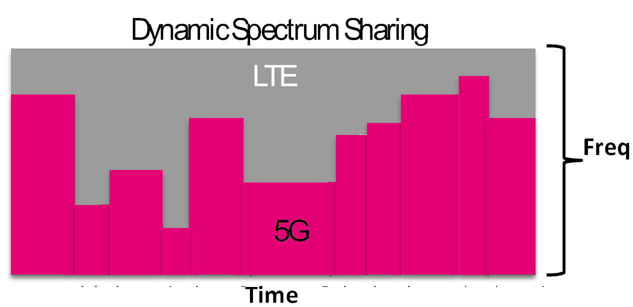

Figure 1 & 2 is an illustrative representation of Static Spectrum Allocation vs Dynamic Spectrum Sharing

Dynamic Spectrum Sharing Overview

- The goal of DSS is to enable radio resources being dynamically allocated to the two technologies on demand, however Dynamic Spectrum Sharing and static allocation of spectrum per technology are not mutually exclusive
- As 5G device penetration increases part of spectrum can be dedicated to 5G proportional to that
    - [redacted]
- The increase in spectrum utilization enabled by DSS is expected to increase operational efficiency and improve user experience. However, that benefit is reduced due to additional overhead required to support the functionality
    - [redacted]
- Majority of the DSS functionality is executed in the Radio Access scheduler making vendor implementations proprietary.
    - 3GPP has defined the needed UE capabilities to support Dynamic Spectrum Sharing in 3GPP R-15
    - The functionality is extremely complicated to develop on the Radio Access Side
- DSS is in early stages of development, and not available for testing or deployment
    - Additionally, initial DSS implementation will have limitations, such as restrictions and/or limitations related to support of existing capabilities, [redacted]

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Limitations of Dynamic Spectrum Sharing (DSS)

- Dynamic Spectrum Sharing will [redacted] based on simulation results
- Dynamic Spectrum Sharing [redacted], possibly creating a capacity constraint.
    - With DSS, [redacted] This will [redacted] we can support.
    - DSS will [redacted] which will [redacted] that we can support.
- Introducing Option2 (Stand Alone Architecture) along with Option 3x (Non-Stand Alone Architecture) using DSS, will further reduce peak throughput due to additional control channels needed for Option2 SA signaling
- Initial implementation will have feature compatibility restrictions, e.g. Nb-IoT, limiting deployment options
- Dynamic Spectrum Sharing is not currently considered for development by our RAN vendors [redacted]

Dynamic Spectrum Sharing Development Status

- Low band spectrum has great propagation characteristics, but is limited in quantity. Hence, Dynamic Spectrum Sharing (DSS) is under development with initial focus on low band to facilitate the migration from LTE to 5G
- Both T-Mobile RAN vendors, Nokia and Ericsson are in the process of developing Dynamic Spectrum Sharing functionality
    - The implementation plans are not the same for both companies, and details on implementation plan are still under development
- Testing and deployment of DSS capability that meets T-Mobile's requirements can earliest start [redacted], however due to complexity of the implementation and uncertainty around performance it is likely that development will continue beyond that
    - Ericsson Dynamic Spectrum Sharing feature, [redacted]
    - Nokia has recently presented new timeline for DSS development [redacted]
        - [redacted] resulting in uncertainty around their plan

Summary

- Dynamic Spectrum Sharing (DSS) is under development to facilitate the migration from LTE to 5G by assigning LTE and 5G simultaneously on the same shared block of spectrum
- If DSS ends up working as advertised by RAN vendors, we view it as an operational tool that will reduce the operational burden related to manual re-farming. Additionally, DSS can improve user experience and spectrum utilization during the technology transition.
- Due to uncertainty in the actual performance, and expected capacity losses that are hard to quantify accurately since the functionality does not yet exist manual allocation of spectrum for forecasting purposes is still the most accurate methodology