Qualcomm Incorporated

1730 Pennsylvania Ave., NW ■ Suite 850 ■ Washington, DC 20006 ■ 202.263.0022 office ■ www.qualcomm.com

April 27, 2021

***Ex Parte* Notice**

Marlene Dortch
Secretary
Federal Communications Commission
45 L Street NE
Washington, DC 20554

Re: Use of Spectrum Bands Above 24 GHz For Mobile Radio Services - GN Docket No. 14-177
Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95, and 101 To Establish Uniform License Renewal, Discontinuance of Operation, & Geographic Partitioning and Spectrum Disaggregation Rules & Policies for Certain Wireless Services - WT Docket No. 10-112

Dear Ms. Dortch:

On April 23, 2021, Dean Brenner, Aleksandar Damnjanovic, Sumant Iyer, Arumugam Kannan, Tao Luo, Juan Montojo, Marco Papaleo, Xiaoxia Zhang, and the undersigned, representing Qualcomm, met via teleconference to discuss the Lower 37 GHz shared licensed band with the following members of the Commission's Wireless Bureau and its Office of Engineering and Technology: Bahman Badipour, Kenneth Baker, Nicholas Oros, Barbara Pavon, John Schauble, Blaise Scinto, Jennifer Tomchin, Janet Young, and Nancy Zaczek.

Qualcomm presented the attached slide deck that includes simulations with multiple overlapping licensees and a technology-neutral regulatory proposal to enable licensed sharing in the entire 600 MHz-wide Lower 37 GHz band. The simulations, which follow the established 3GPP scenario for multiple operators in a uniform random deployment, demonstrate that fully overlapping licenses in both frequency and location can perform very well in an extremely high-density node deployment scenario. This unsurprising result is due to the highly directional nature of millimeter wave communications.

Qualcomm's regulatory proposal takes advantage of this inherent quality of millimeter wave communications and ensures guaranteed access to spectrum. To support a defined Quality of Service ("QoS") and enable sharing at the same time, Qualcomm proposes assigning priority users a license to a 100 or 200 MHz channel in the Lower 37 GHz band in a given area on which they have primary rights, and each priority licensee would have secondary rights to the other channels in the Lower 37 GHz band. If the priority user, be it commercial or federal, needs to access the band, any secondary user whose operations would interfere with the primary user must vacate the channel. If secondary operations can occur — on the same channel and in the same area as the primary user — without interfering with an active primary receiver, the secondary licensee can continue operating. Based on the extensive simulations Qualcomm has

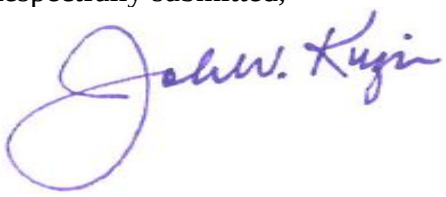
conducted, we believe the Lower 37 GHz band can support successful secondary communications almost all of the time.

In other words, Qualcomm's proposal opens the entire band for sharing, and by assigning each priority licensee a baseline amount of spectrum (e.g., 100 or 200 MHz) on which it has priority, each licensee will always have an available channel to enable a baseline QoS. The highly directive nature of communications in the Lower 37 GHz band enables spatial sharing and intense levels of frequency reuse by all licensees. To have successful sharing, a means of protecting each active receiver is needed. The "Look Before Talk" technology neutral regulatory approach Qualcomm proposes in the attached slide deck relies on synchronized listening periods to protect active receivers from harmful interference and opens the full band to intensive sharing by multiple licensees — one primary licensee and multiple secondary licensees.

In addition, Qualcomm proposes to allow indoor use of the entire 600 MHz, subject to protection of outdoor users and possibly using lower transmit power levels. Given the high levels of building entry and exit losses ("BEL") coupled with the highly directional nature of millimeter wave communications, indoor operations can use the entire 600 MHz without impacting outdoor operations. This band can support smart machines and industrial IoT, and these indoor operations can be managed by the property owner or by a mobile operator on behalf of the property owner.

Qualcomm encourages the Commission to propose the technology-neutral shared licensing approach set out in the attached deck to open the Lower 37 GHz band for 5G and other advanced communications applications and services.

Respectfully submitted,



John W. Kuzin
Vice President and Regulatory Counsel

Att.

cc: Bahman Badipour
Kenneth Baker
Nicholas Oros
Barbara Pavon
John Schauble
Blaise Scinto
Jennifer Tomchin
Janet Young
Nancy Zaczek

April 23, 2021

The Lower 37 GHz Band

Qualcomm Incorporated

Table of Contents

Uniform Random Deployment Scenarios with Increasing Operators

- We consider two dimensions:
  - Increase number of operators (with fixed number of nodes)
  - Increase number of nodes (with fixed number of operators)

Nodes per Operator	1 operator	2 operators	4 operators
6	✓	✓	✓
12	✓	✓	☑
24	✓	☑	✗
48	☑	✗	✗

✓ Studied

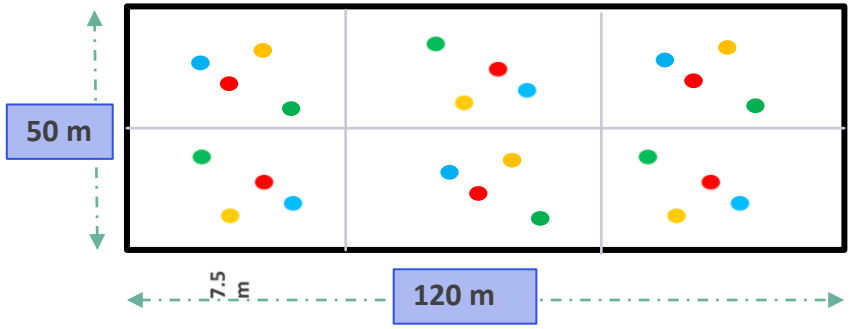
☑ Presented here

✗ Not studied

Parameters	
Carrier freq.	37 GHz
gNB ant array	128 ant elements per pol, single panel
UE ant array	4 ant elements per pol per panel
Traffic	DL only, UL only, Full buffer traffic
gNB EIRP	49 dBm
UE EIRP	25 dBm (Typical implementations)
Bandwidth	Clarified in the plot legends (W = 600 MHz)

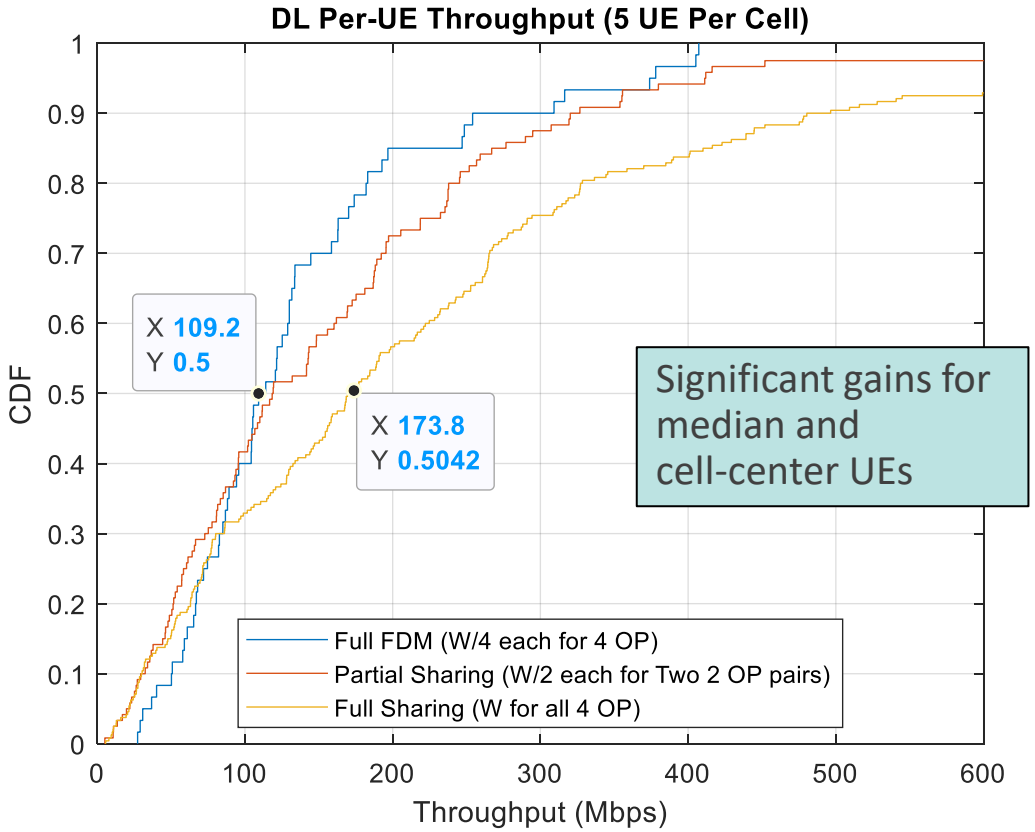
All simulations follow established 3GPP Deployment Scenario for Multiple Operators In Uniform Random Deployment

- Node placement
  - To mimic randomized placement of gNBs across and within operators, we divide deployment floor plan into 6 tiles as shown
  - Total number of gNBs is divided into 6 equal parts → corresponding to 6 tiles
  - gNBs allocated to a tile are dropped randomly within the tile
- UE placement: Uniformly random throughout the deployment



Downlink: Unplanned Deployments & Multiple Operators

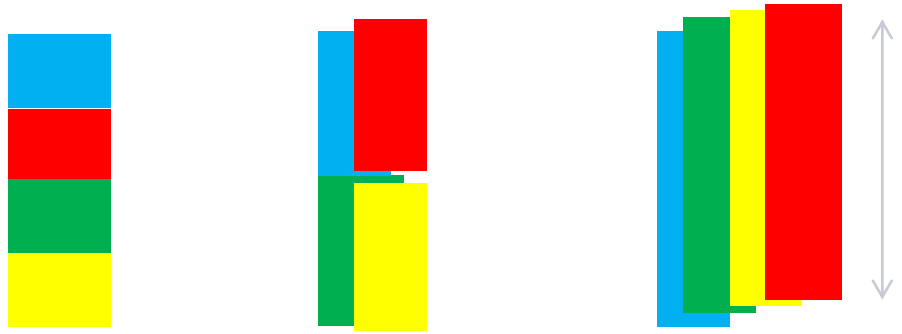
Spectrum Sharing vs FDM: 48 Nodes Total, 4 Operators



Significant gains for median and cell-center UEs

Tail losses demonstrate need for a mechanism to "guarantee" edge performance

Each color represents one operator



Full FDM
- Least BW
- Least interference

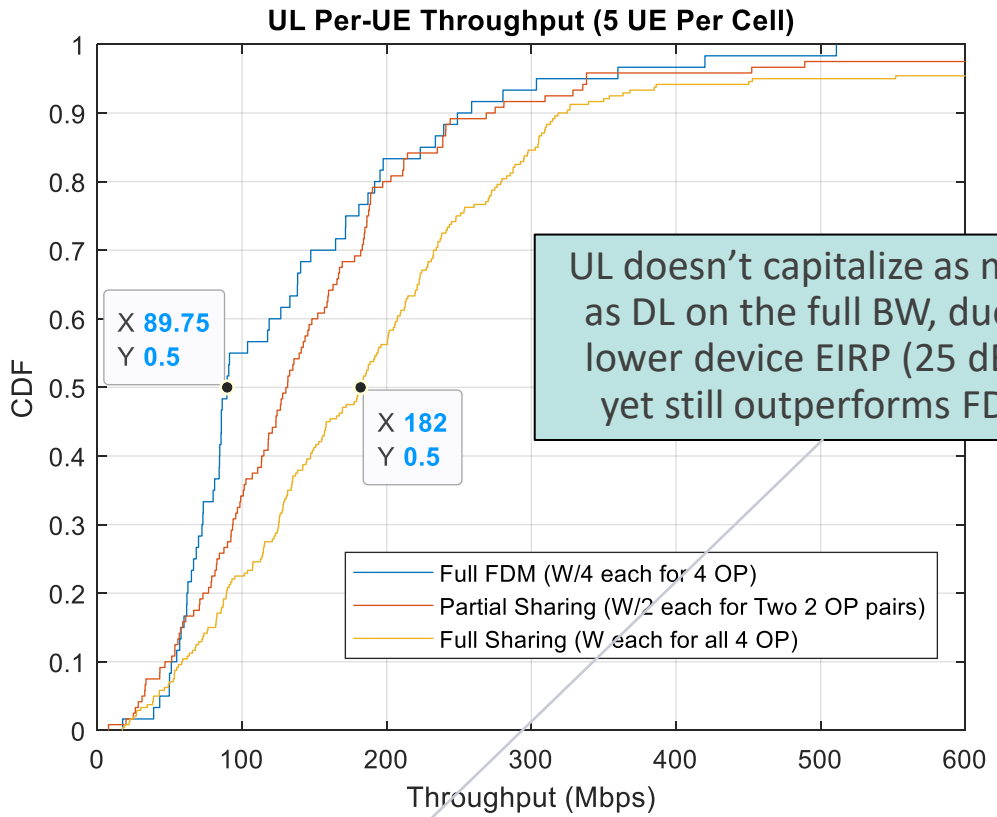
Partial Sharing

Full Sharing
- Most BW
- Most interference

- Key takeaway 1: In the interference v. BW tradeoff, BW largely prevails due to beamforming-based operation
- Key takeaway 2: While significant gains are seen for median and cell-center UEs, tail UEs exhibit some degradation (beam collisions) so an appropriate mechanism for "QoS guarantee" – as presented in upcoming slides – is desirable

Uplink: Unplanned Deployments & Multiple Operators

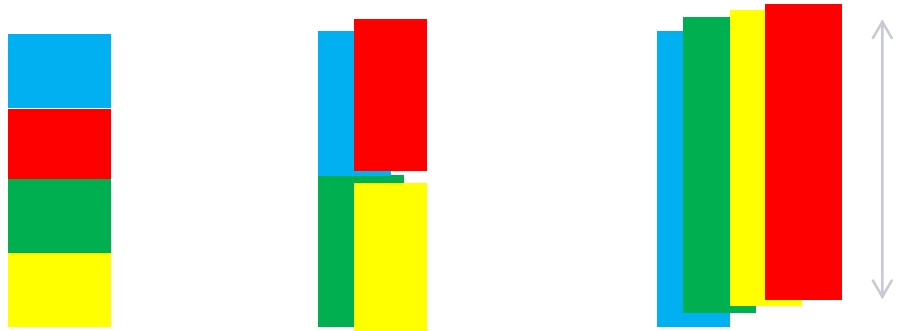
Spectrum Sharing vs FDM



UL doesn't capitalize as much as DL on the full BW, due to lower device EIRP (25 dBm) yet still outperforms FDM

For the same reason (i.e., lower UL EIRP), the tail losses on UL are lower

Each color represents one operator



Frequency domain

Full FDM
- Least BW
- Least interference

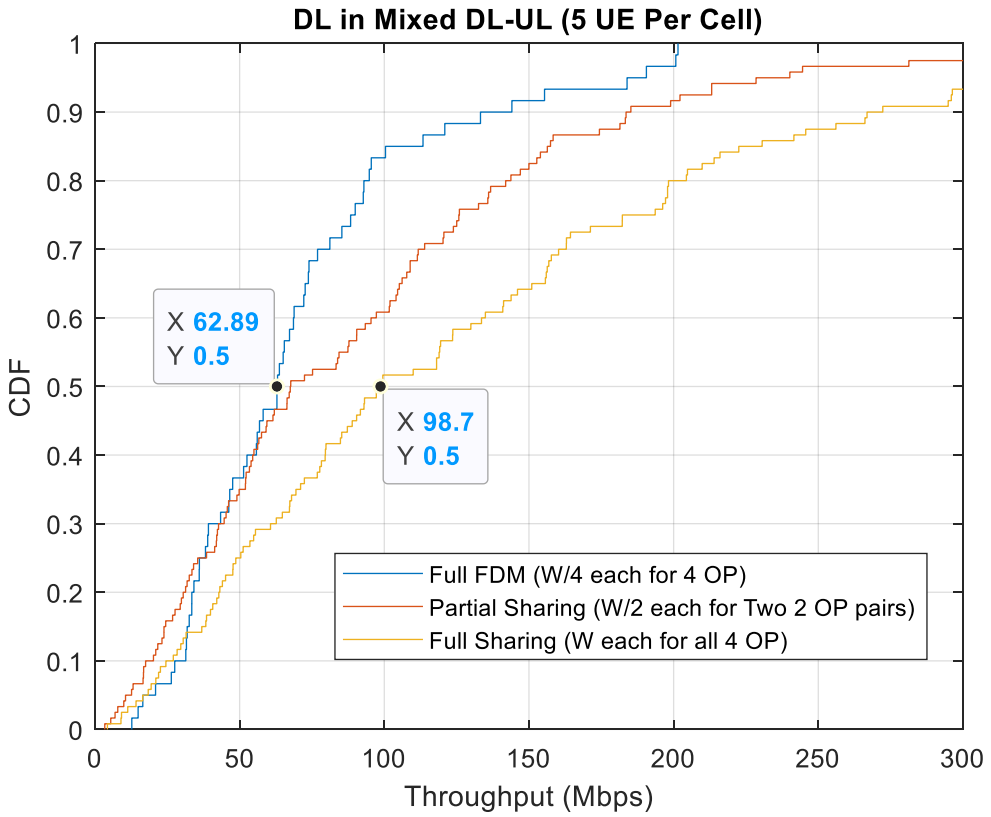
Partial Sharing

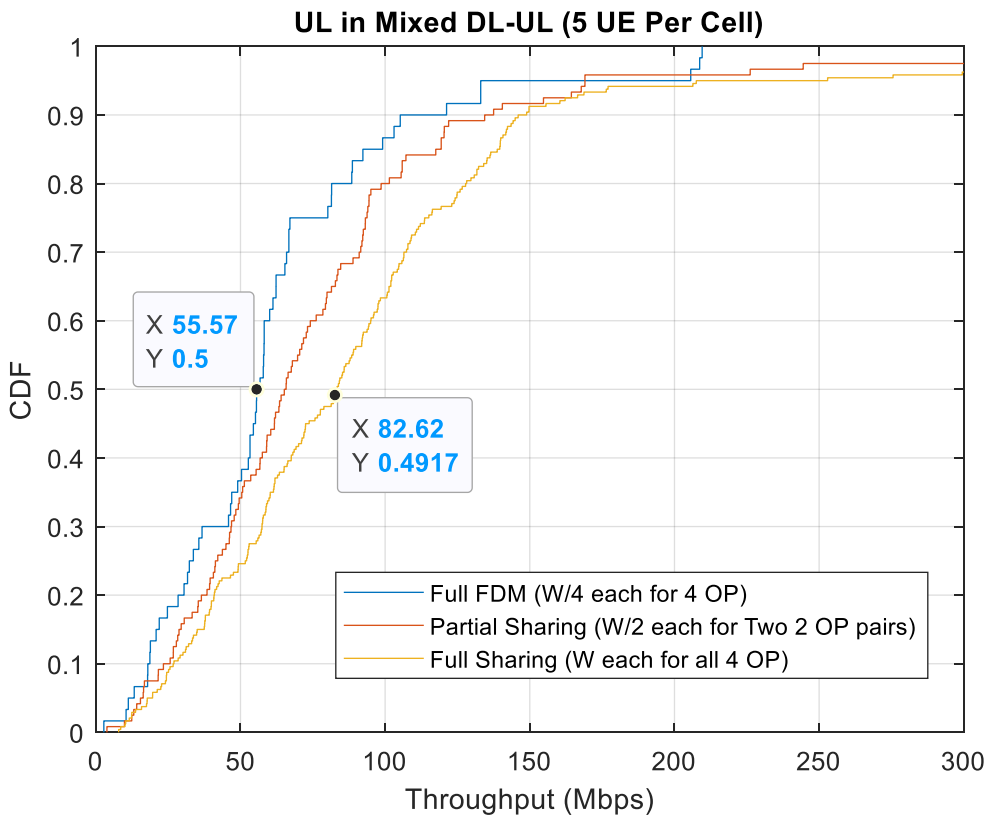
Full Sharing
- Most BW
- Most interference

- Key takeaway 1: Overall the UL operation is lower in EIRP but the concept of sharing outperforming FDM remains the same
- Key takeaway 2: The gains of sharing on upper tail are less pronounced compared to DL due to device EIRP limitation but for the same reason, full sharing fares better at median and lower tail

Mixed DL - UL: Unplanned Deployments & Multiple Operators

Spectrum Sharing vs FDM





- Key takeaway 1: Interference impact of UL on DL is slightly lower compared to DL on DL (Full sharing v full FDM crossover point is lower for the mixed case)
- Key takeaway 2: Interference impact of DL on UL is slightly higher compared UL on UL (Overall reduced gains for UL sharing vs UL FDM)

Licensed Sharing Recommendation and Regulatory Proposal for the Lower 37 GHz Band

Access to shared spectrum

Current approach and proposed new path forward

- Today, coexistence mechanisms in shared spectrum bands typically rely exclusively on non-synchronized energy sensing
  - ETSI BRAN adopted a single Listen Before Talk (“LBT”) energy sensing threshold for multi-technology coexistence in the 6 GHz and 60 GHz bands
- However, LBT-enabled spectrum sharing in millimeter wave (“mmW”) bands faces challenges due to poor correlation between detection of the transmitter activity through energy sensing, and the need to protect the receiver
  - Narrow beamwidth communications often lead to a scenario where energy from the ongoing transmission is not detected and medium access causes interference to a nearby receiver; QoS often expected with licensed services cannot be guaranteed in many cases
- Qualcomm offers a regulatory solution to provide licensed spectrum service level quality for multiple operators each using a portion of the spectrum, while enabling wider bandwidth operation through spectrum sharing, and thus more intensive use of the spectrum than would otherwise be possible

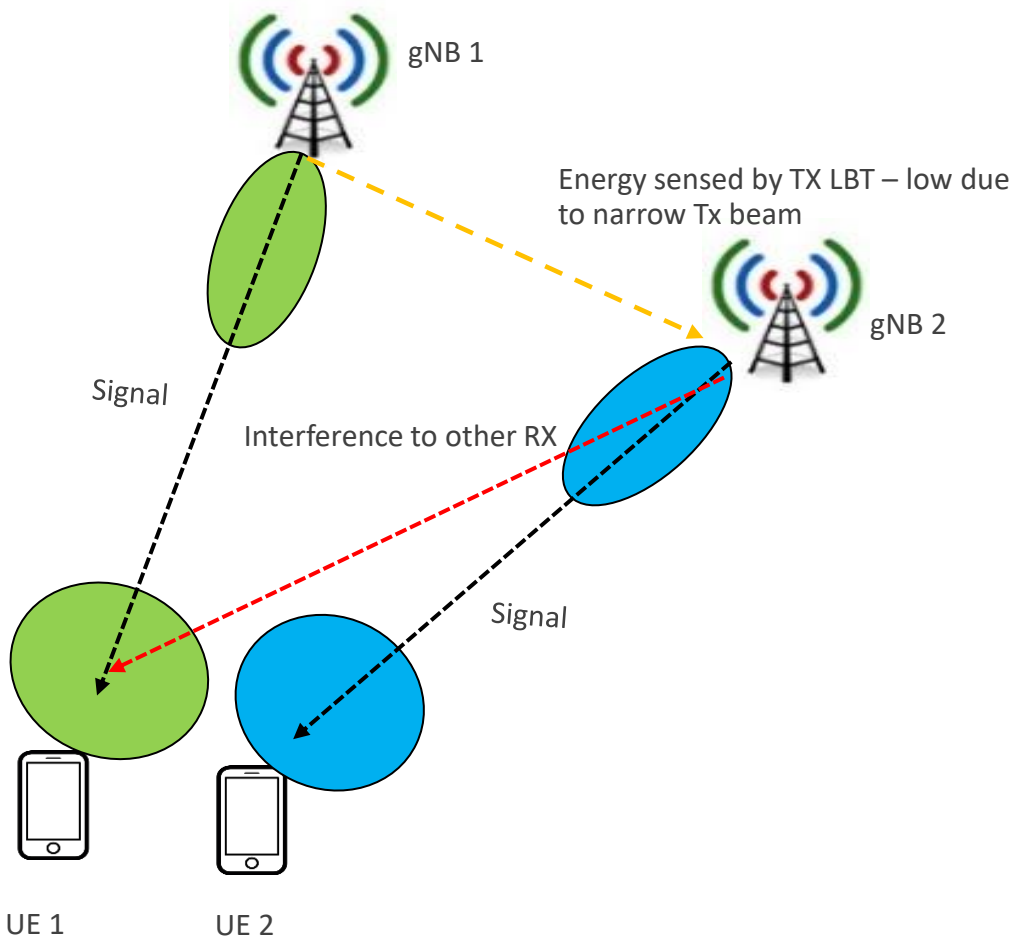
Proposed Regulatory Framework for Lower 37 GHz Band

Local licensing with "Look Before Talk" receiver protection mechanism

- Each local licensee receives prioritized access to a portion of the spectrum
  - Enables minimum QoS "guarantee" due to each licensee's prioritized access
- **Priority License**: Lower 37 GHz band can support 3 or 6 priority licensees, with each allocated primary licensed access to 200 or 100 MHz
  - Local licensees have full and unconditional use of their primary channel
- **Sharing Component**: Each licensee may conditionally use full 600 MHz by ensuring that it will not cause interference to primary licensees
  - Sharing mechanism enables much more efficient use of the spectrum
- **Technology-neutral** "receiver detect and avoid" transmission procedure (*i.e.*, "Look Before Talk") prevents harmful interference to primary licensees

mmW Medium Access Challenges

Non-synchronized LBT and the lack of receiver protection – illustration

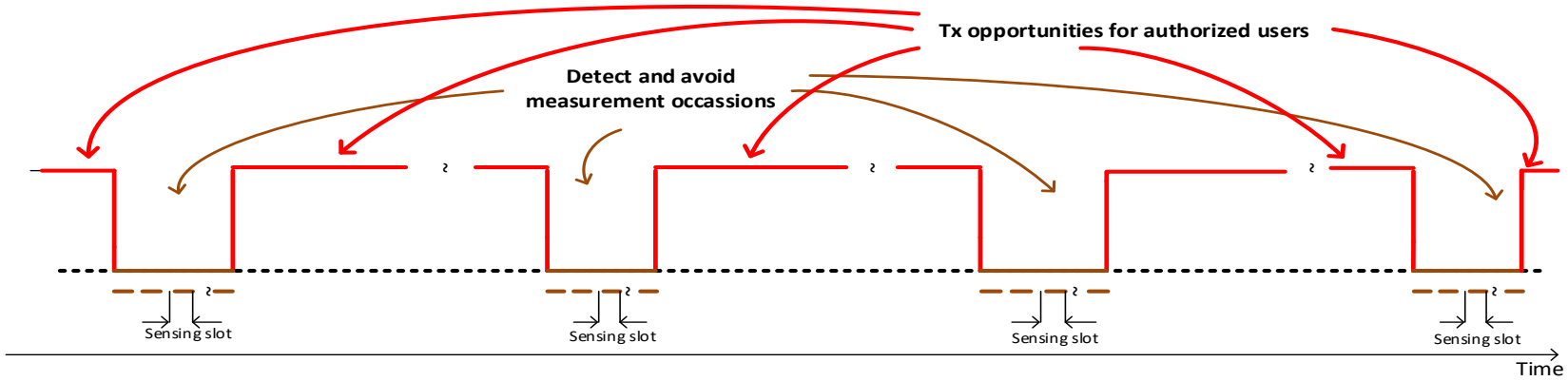


- gNB 2 (blue network) cannot detect energy from gNB 1 (green network) due to narrow Tx/Rx beams, yet gNB 2 can interfere with the gNB 1 to UE 1 communications link
- If UE 1 would transmit a feedback signal that gNB 2 would interpret as an identifying signal from a receiver that requires protection, gNB 2 would not access the medium utilizing the interfering beam
  - Receiver feedback signal typically consists of a frequently repeated short signal that conveys control messages, such as ACK, channel feedback
  - Not possible to reliably identify and protect mmW band receivers with non-synchronized LBT

Reliably detect receiver and avoid transmission

Using Coordinated Silencing

- Coordinated silencing of users of one network can enable robust detect and avoid scheme to mitigate interference to another network without high false alarm rates
  - Coordinated silencing improves detection and identification of the sparse feedback signals transmitted by the receivers of another network
  - Measurements should be frequent enough to support desired mobility



Coordinated silencing for detect and aviod

- Synchronized detect receiver and avoid transmission (aka “Look Before Talk”) scheme can facilitate prioritized use of resources and receiver protection since only non-prioritized users are required to perform measurements and avoid the channel if other users are detected

Proposed Lower 37 GHz Band Spectrum Sharing Rule

Priority based access

- A) Licensees shall coordinate the start of the measurement occasions for each segment of the band based on Coordinated Universal Time (UTC)
- B) Except for the priority users of the licensed channel, all other users shall not transmit on that channel for at least first n1=[100] us from the start of the measurement occasions
- C) Except for the priority users of the licensed channel, all other users shall stop transmission on that channel in the direction where for the matching receiver beam, the detected energy level exceeded the energy detection threshold (EDT) within the last T1 [s] for at least n2 us, and shall not resume transmission for the next T2 [s]

Proposed Lower 37 GHz Band Spectrum Sharing Rule

Transmit Power

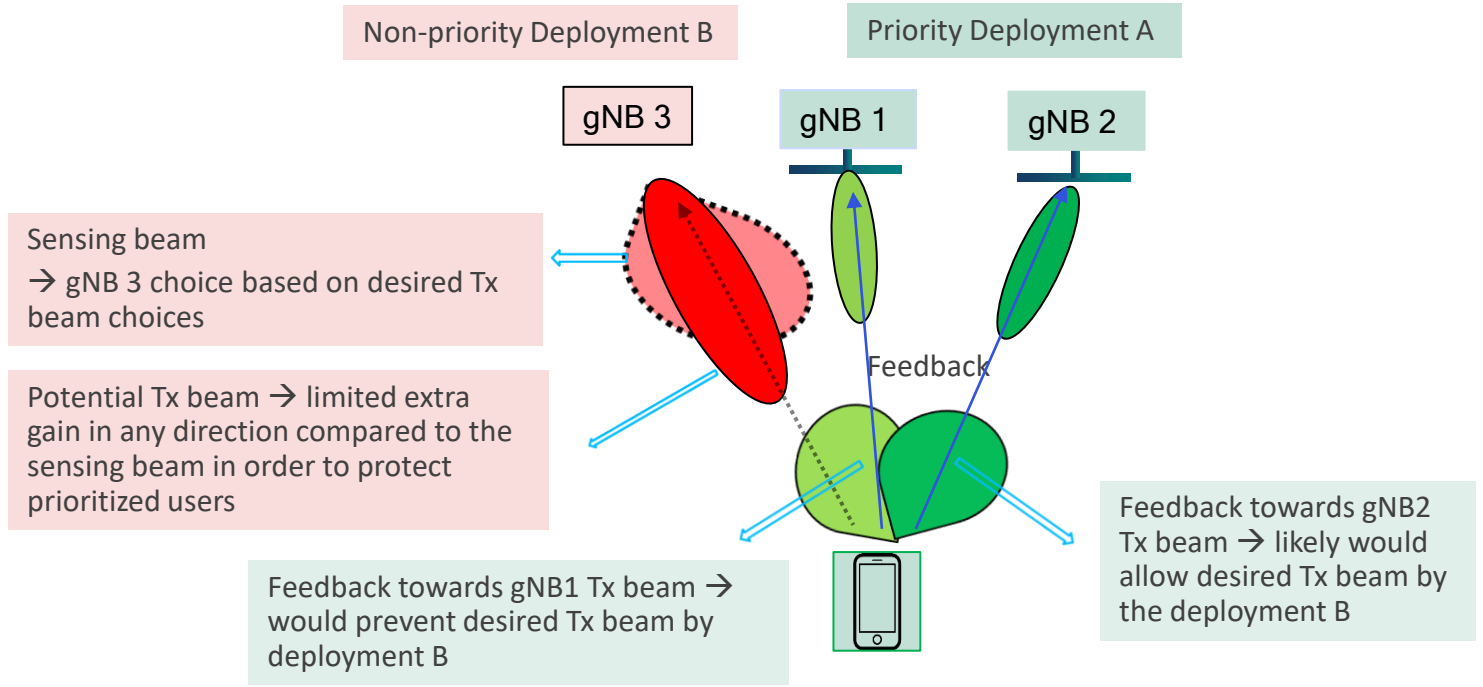
- Operation across entire band after detect receiver and avoid transmission procedure may be allowed with lower PSD level than for the prioritized licensee over a band segment – to further protect primary licensee's operations
- Indoor deployments may be allowed to use the entire 600 MHz band with a lower PSD limit, subject to protecting outdoor operations; indoor operations may be managed by the property owner or by an operator on behalf of the property owner

This shared licensing approach makes the band attractive for outdoor mobile network operator deployments, and for new, diverse indoor applications (e.g., smart manufacturing, industrial IoT).

Detect receiver and avoid transmission – continued

Measurements

- Narrowbeam measurements support improved spatial multiplexing among deployments
- The receive antenna beam used for measurements should match the antenna gain of the intended transmitter beam

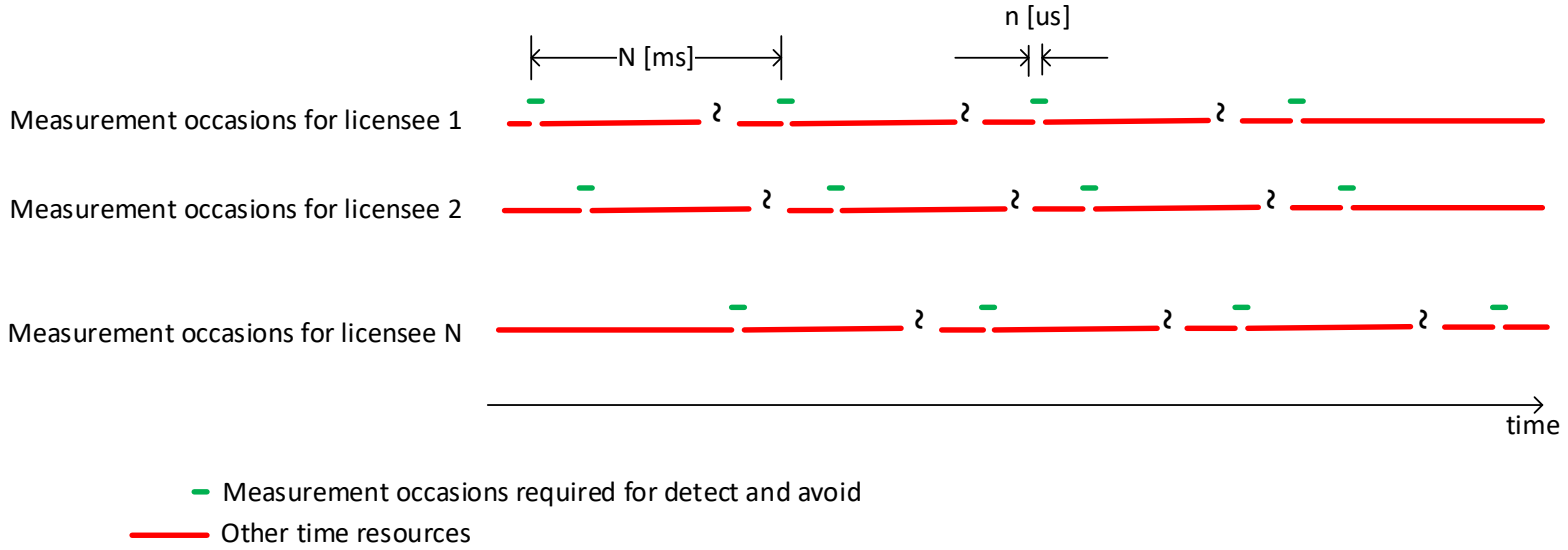


Detection of other deployments

Detect receiver and avoid transmission – continued

Measurements

- Each primary licensee may be assigned intervals where other non-primary licensees will have an opportunity for sensing for the purposes of detection and avoidance



- Supervising device can perform energy measurements over [n] us (corresponds to n_s consecutive sensing slots) at least every N ms (corresponds to N_s sensing slots)
- Value of N should be determined based on the desired mobility and traffic activity

Detect receiver and avoid transmission – continued

Measurements

- Sensing beam remains unchanged during measurement occasion
  - Example 1
    - B=64 beams
    - Measurement occasions every N=20 ms
    - Per beam, measurements repeats every L=B*N=1280 ms
  - Example 2
    - B=16 beams
    - Measurement occasions every N=80 ms
    - Per beam, measurements repeats every L=B*N=1280 ms

Detect receiver and avoid transmission – continued

Measurements

Overhead per licensee

Duration/Period	20 ms	40 ms	80 ms	160 ms	320 ms
50 us	0.25%	0.125%	0.0625%	0.0312%	0.0156%
100 us	0.5%	0.25%	0.125%	0.0625%	0.0312%
200 us	1%	0.5%	0.25%	0.125%	0.0625%

Time to cycle over all beams

Beams/Period	20 ms	40 ms	80 ms	160 ms	320 ms
4	80 ms	160 ms	320 ms	640 ms	1.28 s
16	320 ms	640 ms	1280 ms	2.56 s	5.12 s
64	1.28 ms	2.56 ms	5.12 ms	10.24 ms	20.48 ms

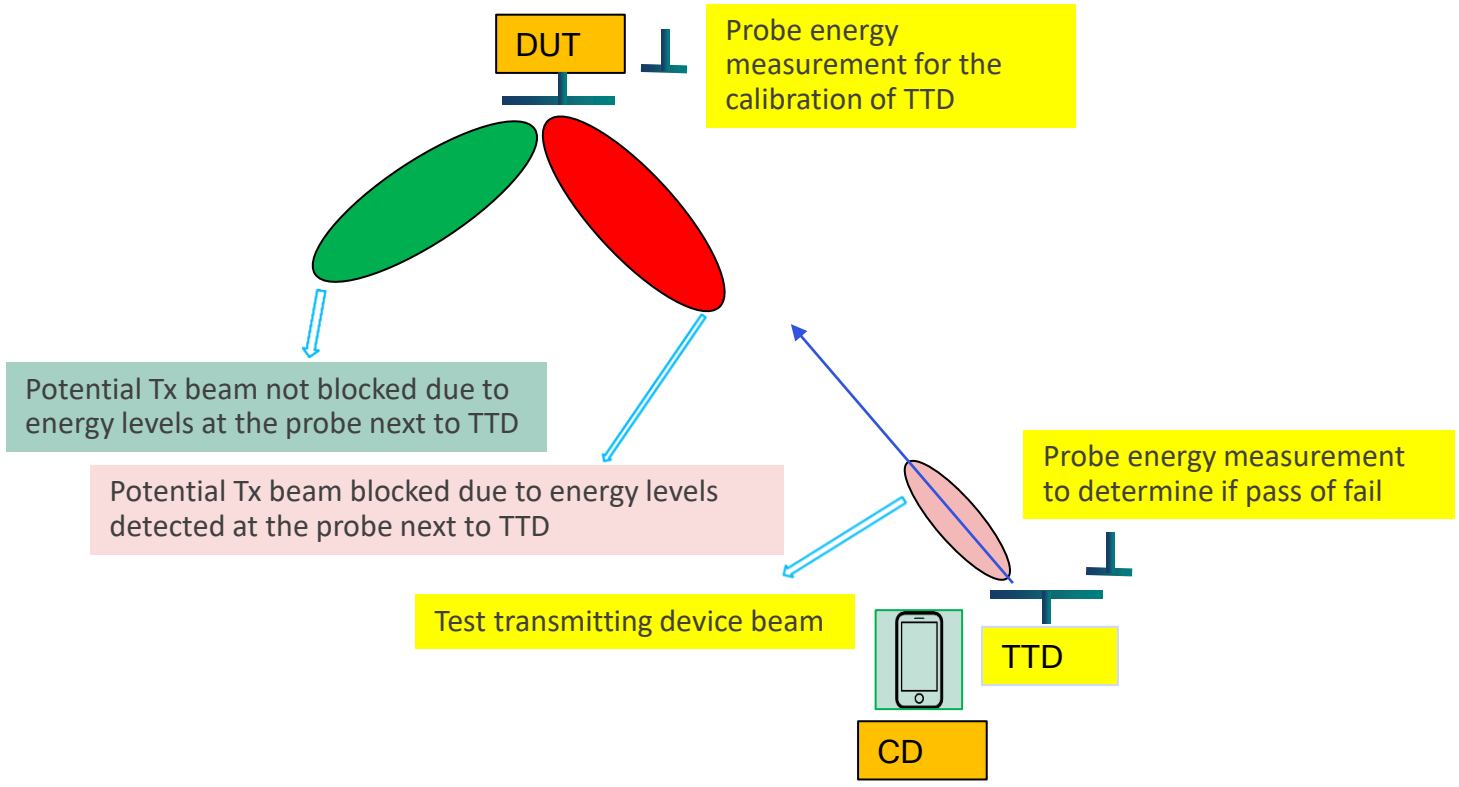
Test Procedure

To assess detection of priority deployments – similar to OET Lab's 6 GHz KDB

- Place one test sensing device (TSD) next to the device under test (DUT) antennas and another TSD next to test transmitting device (TTD)
- Set up test transmitting device (TTD) Tx power so that TSD energy detection (ED) level is above ED threshold (EDT) at the sensing antenna next to the DUT
  - TTD utilizes time domain pattern that represent receiver feedback
- Generate full traffic load for DUT transmitting to the companion device (CD)
- After [T1] s of the start of the test, TTD stops transmitting and DUT is required to ensure that ED at TSD next to the TTD is below EDT(2) and remains below EDT during the remainder of the test of [T2] s
  - DUT is required to pass the test k-m out of k test attempts

Test Procedure - continued

To assess detection of priority deployments



Qualcomm

Thank you

Follow us on:

For more information, visit us at:

www.qualcomm.com & www.qualcomm.com/blog