**3GPP TSG RAN WG1 Meeting #104-e R1-** **210xxxx**

**January 25th – February 5th, 2021**

**Agenda item: 8.2.6**

**Source: Moderator (Qualcomm Incorporated)**

**Title: Email discussion summary for channel access mechanism for 52.6GHz-71GHz band**

**Document for: Discussion and Decision**

# Introduction

This paper summarizes the channel access related proposals submitted to agenda item 8.2.6, and follow up email discussions below:

[104-e-NR-52-71GHz-07] Email discussion/approval on channel access mechanism with checkpoints for agreements on Jan-28, Feb-02, Feb-05 – Jing (Qualcomm)

# Summary of contributions

The section summarises key proposals and observations from submitted contributions. Discussion points arising from each group of topics are captured separately in subsections.

## Channel bandwidth, nominal bandwidth, and LBT bandwidth

A few papers discussed the definition of channel bandwidth, nominal bandwidth and LBT bandwidth.

### LBT Bandwidth

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| **Company** | **Key Proposals/Observations/Positions** |
| Lenovo, Motorola Mobility | Proposal 2: For NR unlicensed bands between 52.6 GHz and 71 GHz, for LBT based channel access mechanism, there is no need to specify the nominal bandwidth in 3GPP and it is up to devices’ implementation on how to meet the OCB requirements. |
| ZTE, Sanechips | Proposal 1: In order to avoid ambiguity about the understanding of nominal bandwidth and resolve the problem of unclear the conclusion for the OCB requirement, it is necessary to introduce a clear the definition of nominal bandwidth.  Proposal 2: The nominal bandwidth can be defined as follows:  • Nominal bandwidths for the purpose of OCB requirements at the UE are the channel BWs for transmission supported by the UE from the set of channel BWs (carrier BWs) to be defined in 38.101.  • Nominal bandwidths for the purpose of OCB requirements at the gNB are the channel BWs for transmission supported by the gNB from the set of channel BWs (carrier BWs) to be defined in 38.104.  Proposal 3: **Alt 5** that “LBT bandwidth equals with minimum supported channel bandwidth or multiples of the minimum supported channel bandwidth” should be considered to be supported, considering friendly and fair coexistence between the same systems or different systems. |
| OPPO | Proposal 3: Support Alt 5 to define LBT bandwidth. |
| Huawei, HiSilicon | Proposal 1: For operation in NR-U-60, the EDT formula adopted from draft v2.1.20 of EN 302 567 as a baseline should be adjusted to account for an LBT BW other than 2 GHz.  Proposal 5: For operation in the 60 GHz band, the LBT bandwidth should be specified relative to the channel bandwidth defined in RAN4 specifications.  Proposal 6: For operation in the 60 GHz band, the LBT BW can be greater than the carrier BW.  • Support Alt 3 and Alt 5 captured in the TR. |
| Nokia, Nokia Shanghai Bell | Proposal 6: The design of LBT bandwidth in FR1 can be considered as the baseline for operation on 60GHz unlicensed band, e.g., the minimum supported channel bandwidth can be considered as the LBT bandwidth. Also use of channel bandwidth as LBT bandwidth can be considered further. However, before making final decisions, the basic principles of channelization (numerology) should be agreed first. |
| Intel | Proposal 4: When operating in unlicensed 60 GHz band, in order to allow fair coexistence among incumbent systems, the ED threshold calculation shall account not only for the maximum output power, but also at least for the bandwidth used.  Proposal 5: When operating in unlicensed 60 GHz band, the ED threshold calculation shall account for the type of LBT mechanism used.  Proposal 6: For the LBT bandwidth definition, either Alt-4 or Alt-5 are preferred. |
| InterDigital | Proposal 11: Limit the number of supported LBT BWs. FFS number of supported LBT BWs. |
| Samsung | Proposal 2: The scenario for LBT bandwidth discussion should be clarified before down-selecting the alternatives. |
| CATT | Proposal 5: For DL/UL transmission, the transmission bandwidth is used as the LBT bandwidth. |
| CAICT | Proposal 1: Multiple LBT bandwidth could be considered for unlicensed band operation within 52.6-71GHz.  Proposal 2: The relationship between LBT bandwidth and nominal bandwidth should be clarified.  Proposal 3: If interlace design is used for uplink, 50 and 100 PRB based LBT bandwidth should be considered.  Proposal 4: Alt.3 and Alt.5 should be specified for LBT bandwidth selection. |
| vivo | Proposal 1: The LBT bandwidth is variable and can be defined according to the active BWP. |
| Spreadtrum | Proposal 1: At least, Alt 1 and Alt 4 should be supported for LBT bandwidth definition. |
| Ericsson | Observation 4 In EN 302 567, the nominal channel bandwidth and at least one transmission mode with occupied channel BW 70% of NBW is defined for spurious out-of-band emissions and not for LBT purposes.  Observation 5 The relationship between the LBT bandwidth and the channel bandwidth is not specified in EN 302 567 for the sake of technology-neutrality and flexibility.  Proposal 2 Adopt the current definition in 37.213 for LBT BW (“A channel refers to a carrier or a part of a carrier consisting of a contiguous set of resource blocks (RBs) on which a channel access procedure is performed in shared spectrum.”) also for the frequency range 52.6-71 GHz. Thus, no further down-selection among the alternatives for LBT BW is needed. |
| Apple | Proposal 1: LBT bandwidth is channel bandwidth, and ED thread hold is calculated based on channel bandwidth, following EN 302 567 v2.1.21. |
| Qualcomm | Proposal 2: It is not necessary to define a fixed ‘LBT bandwidth’ as a fundamental sensing unit (like the 20MHz LBT bandwidth in FR1). |

### Channelization

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| **Company** | **Key Proposals/Observations/Positions** |
| Lenovo, Motorola Mobility | Proposal 1: For NR unlicensed bands between 52.6 GHz and 71 GHz, for LBT based channel access mechanism, support aligning the channelization between 802.11ad/ay and NR at least where the absence of any other technology sharing the channel cannot be guaranteed on a long-term basis. |
| Sony | Proposal 1: NR devices support 2.16 GHz bandwidth in 60GHz spectrum as one of the nominal channel bandwidths. |
| Convida | Proposal 8: The LBT indication and channel occupation time should be studied when the channel BW for NR-U from 52.6 GHz to 71 GHz is smaller than WiFi 802.11 ad/ay channel BW. |

### Discussion

**LBT Bandwidth: Summary of positions**

* Alt 1: LBT bandwidth equals RAN4 defined channel bandwidth (equivalently RAN1 BWP bandwidth)
  + HW, Nokia, Spreadtrum, Qualcomm, Apple
  + Vivo: Active BWP
* Alt 2: LBT bandwidth equals the minimum of channel bandwidth and the transmission bandwidth (number of RBs for a given transmission), = min(CBW, TBW)
  + CATT, Ericsson
* Alt 3: LBT bandwidth can be wider than channel bandwidth,
* Alt 4: LBT bandwidth can be narrower than the channel bandwidth, with multiple LBT subband within a channel,
  + Intel, Spreadtrum
* Alt 5: LBT bandwidth equals with minimum supported channel bandwidth or multiples of the minimum supported channel bandwidth
  + ZTE, OPPO, Intel
* Multiple LBT Bandwidth: CAICT, InterDigital

Discussion:

Please update your position in about above list, in case it is not correctly captured.

Recommend to separate the discussion into two cases: single carrier transmission, can carrier aggregation

For single carrier case

Alt SC.1. gNB/UE performs LBT over the channel bandwidth (or BWP bandwidth)

Alt SC.2. gNB/UE performs LBT over the transmission bandwidth (from the lowest RB to the highest RB used for the transmission)

Alt SC.3. Define a unit of LBT bandwidth and gNB/UE performs LBT in all the LBT units in the channel bandwidth

For carrier aggregation (intra-band CA) case

Alt CA.1. gNB/UE performs multiple LBT, one for each channel bandwidth separately

Alt CA.2. gNB/UE performs single LBT over all CCs

Alt CA.3. gNB/UE performs multiple LBT, one for each CC over the transmission bandwidth (from the lowest RB in to the highest RB used for the transmission in the CC)

Alt CA.4. gNB/UE performs LBT over the transmission bandwidth over all CCs (from the lowest RB in the lowest CC to the highest RB in the highest CC used for the transmission)

Alt CA.5. Define a unit of LBT bandwidth and gNB/UE performs LBT in all the LBT units in the channel bandwidth in each CC

Please show your support in the list above, or suggest other alternatives

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| **Company** | **View** |
| Apple | For single carrier, Alt SC1: channel BW (or BWP BW) for LBT BW. Even though in EN 302 567, the language used is very generic, however, it is not intended to adapt LBT BW per transmission. Adapting LBT BW can create coexistence issues with other technologies, also create high overhead for regulatory testing.  For multi carrier case, discussion is related to 2.11, multi-channel access. Alt CA.1 is preferred, corresponding to type-A access. |
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**Channelization**

Discussion point:

* For 120KHz, support up to 400MHz channel bandwidth. For 480KHz, support up to 1.6GHz channel bandwidth. For 960KHz, support up to 2.16GHz bandwidth.
* For 960KHz with 2.16GHz channel bandwidth, at least support channelization aligned with 11ad/ay

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| **Company** | **View** |
| Apple | Agree |
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## No-LBT

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| **Company** | **Key Proposals/Observations/Positions** |
| ZTE, Sanechips | Proposal 4: No LBT can be considered to be used in the following cases:  • COT sharing case.  • Specific ares such as ITU region 2 and 3.  • Interference controlled environment.  • The transmission beams of nodes of different operators in the same system(e.g., NR-U ) have little interference with each other.  Proposal 5: Similar restriction as defined in Type 2C channel access procedure in TS 37.213 can also introduced in above 52.6GHz NR-U frequency band but the length of a transmission can be relaxed.  Proposal 6: Conditions for No LBT fallback to LBT should be further studied, e.g., based on the interference level or correctly decoding rate. |
| Huawei, HiSilicon | Proposal 13：For operation in the 60 GHz band, in regions where LBT is not mandated, a gNB/UE can initiate a channel occupancy access using a channel access mechanism without LBT if it is used in conjunction with an interference mitigation scheme.  - Interference mitigation schemes such as ATPC or DFS would be implemented as specified by the region-specific regulations and do not need to be specified by 3GPP.  Proposal 14：For operation in the 60 GHz band, in regions where LBT is not mandated, support switching between channel access with LBT and channel access without LBT in a serving cell by gNB configuration.  Proposal 15：For operation in the 60 GHz band, in regions where LBT is not mandated, the serving cell may enable Rx-side LBT using a higher layer configuration to mitigate high levels of interference experienced from hidden nodes.  Observation 4：When network allows enabling/disabling the LBT mode through cell-specific gNB configuration, coexistence issues would arise as the performance in the cells operating with LBT mode would be adversely impacted by the No-LBT mode operation in the neighboring cells.  Proposal 16：For operation in the 60 GHz band, in regions where LBT is not mandated, MCOT limits should be applied for a channel occupancy initiated without LBT. |
| Nokia, Nokia Shanghai Bell | Observation 8: Channel access mechanism without LBT should fulfil the expected requirements of EN 303 722 but also possibly EN 303 753.  Observation 9: NR for 60 GHz band shall be able to fulfil the EN 303 722 requirements for spectrum sharing based on automatic transmit power control and/or automatic link adaptation. Needed specification changes, if any, are to be considered along with EN 303 722 progress.  Proposal 16: Channel access mechanism (i.e. whether or not LBT is in use) is part of the cell configuration.  Proposal 17: Flexible selection of channel access mechanism (LBT or no-LBT) per gNB beam is considered further. |
| Fujitsu | Proposal 1: If regulation allows, No-LBT channel access mechanism can be applied and switching between LBT and No-LBT channel access mechanisms can be supported. No other condition is needed. |
| AT&T | Proposal 3:  • Receiver assistance in Rel. 17 is limited to measurement enhancements  • Message based schemes similar to RTS/CTS signalling can be addressed in a later release targeting Class B scenarios  • Hand shaking is not supported  • Transmission should be allowed before the receiver assistance is received  • **Receiver assistance can equally be useful, and should be allowed, for the no-LBT mode of transmissions**  • Receiver assistance is a fast, low complexity feedback mechanism to convey to the transmitter the interference environment at the receiver |
| Charter | Proposal 2: When noLBT mode is used where LBT is not required, any further enhancements or restrictions related to channel access are left to gNB implementation. |
| Qualcomm | Proposal 12: For No-LBT deployments, consider specification of optional good neighbor procedures, such as away time, to break persistent beam collisions. |

### No-LBT mode and LBT-NoLBT switching

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| **Company** | **Key Proposals/Observations/Positions** |
| Lenovo, Motorola Mobility | Proposal 18: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, adopt CG retransmission collision avoidance techniques such as retransmission deferral or additional retransmission resources.  Proposal 19: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, switching between LBT and no-LBT based channel access mechanism should be supported for regions where LBT is not mandated.  Proposal 20: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, different implicit and/or explicit methods for switching between LBT and no-LBT mode should be considered. |
| Huawei, HiSilicon | Proposal 15：For operation in the 60 GHz band, in regions where LBT is not mandated, the serving cell may enable Rx-side LBT using a higher layer configuration to mitigate high levels of interference experienced from hidden nodes. |
| Nokia, Nokia Shanghai Bell | Observation 8: Channel access mechanism without LBT should fulfil the expected requirements of EN 303 722 but also possibly EN 303 753.  Observation 9: NR for 60 GHz band shall be able to fulfil the EN 303 722 requirements for spectrum sharing based on automatic transmit power control and/or automatic link adaptation. Needed specification changes, if any, are to be considered along with EN 303 722 progress.  Proposal 16: Channel access mechanism (i.e. whether or not LBT is in use) is part of the cell configuration.  Proposal 17: Flexible selection of channel access mechanism (LBT or no-LBT) per gNB beam is considered further. |
| LG Electronics | Proposal #1: Consider switching mechanism between channel access mechanism with LBT mechanism and that without LBT based on timer operation when the local regulation allows initiating channel occupancy without LBT and the specific conditions such as low interference environment are met. |
| Samsung | Proposal 1: Support LBT mode and no-LBT mode per node in a cell.  • UEs in a cell can operate in same or different mode;  • UE can operate in same or different mode from its serving gNB;  • gNB determines its operation mode up to implementation;  • gNB indicates operation mode to UE in both cell-specific (e.g. system information and RRC parameter) and UE-specific/UE-group-specific (e.g. RRC parameter) manners. |
| CATT | Proposal 1: An explicit LBT mode/No-LBT mode indication is required for UE to obtain current channel access mechanism for up to 71GHz operation. |
| CAICT | Proposal 5: When no-LBT mode is used, when and how to trigger the LBT mechanism and configure the relevant parameters could be left to gNB implementation. |
| vivo | Proposal 7: The channel access mechanism can be selected based on the channel occupancy time, channel access rate, transmission priority, service requirement, or feedback information from the receiver, etc.r |
| Fujitsu | Proposal 1: If regulation allows, No-LBT channel access mechanism can be applied and switching between LBT and No-LBT channel access mechanisms can be supported. No other condition is needed.  Proposal 3: It is unnecessary to have explicit restrictions on direction of transmissions within a channel occupancy initiated by directional LBT. It can be achieved by gNB scheduling if needed. |
| Sony | Observation 1: In EU, no-LBT mode cannot be operated at least under the ‘C1’ for indoor and outdoor deployment.  Observation 2: No-LBT mode works in the uncongested environment.  Observation 3: Congestion could be measured by average RSSI and channel occupancy which have been already introduced in NR-U.  Proposal 2: No-LBT mode is configured by network based on measurement results of RSSI and channel occupancy. |
| Xiaomi | Proposal 1: Whether No-LBT channel access mechanism is allowed can be broadcasted by gNB or be informed by message from core network.  Proposal 2: At least the energy/interference detection threshold of when No-LBT is applicable should be defined in specification.  Proposal 3: Switching between LBT and No-LBT channel access should be studied. The following three alternatives can be considered,  Alt 1, gNB self-determines the applied channel access mechanism for both itself and UEs.  Alt 2, Both gNB and UE self-determines the applied channel access mechanism for itself.  Alt 3, gNB self-determines the applied channel access mechanism for itself, and determines for UEs based on request.  Proposal 4: How to prevent long time continuous channel occupying for Tx using No-LBT should be further studied. |
| Ericsson | Proposal 7 The gNB can choose to use LBT or not based on implementation to optimize the performance and meet regulations. 3GPP only needs to design signaling to communicate the LBT mode to be used by the UE. |
| Convida | Proposal 3: Adaptation between LBT modes and LBT sub-modes to optimize system performance should be considered. |
| DOCOMO | Observation 1:   Channel access without LBT can degrade the system performance when strong interference is frequently observed.  Proposal 1:   Mechanism to identify the actual interference condition should be supported.   RSSI/channel occupancy measurement in Rel-16 can be reused. |

### Long Term Sensing

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| **Company** | **Key Proposals/Observations/Positions** |
| Lenovo, Motorola Mobility | Proposal 23: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, long term sensing should be supported for both LBT based and no-LBT based channel access mechanism to consider potential interference.  Observation 7: Currently, there is no mechanism is support long-term sensing including interference measurements from WiFi or other NR operators at the UE and corresponding reporting.  Proposal 24: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, for long term sensing to measure interference statistics from WiFi systems or other NR operators, a new category of ZP CSI-RS should be supported where the UE is not expected to receive any channel/signal (including NZP CSI-RS for interference measurement) and only measure potential interference from WiFi nodes or other NR operators and report back corresponding measurements. |
| Apple | Proposal 7: Consider using RSSI and channel occupancy for long term sensing. |

### DFS

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| **Company** | **Key Proposals/Observations/Positions** |
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### ATPC

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| **Company** | **Key Proposals/Observations/Positions** |
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### Discussion

For regions where LBT is not required, it has been discussed if additional conditions can be introduced in 3GPP spec to enable no-LBT mode and what are the conditions.

Discussion point:

gNB should indicate to the UE the system is operating in LBT mode or no-LBT mode.

The indication can be

* Alt.1. Cell specific as part of system information
* Alt 2. UE specific as part of UE RRC configuration

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| **Company** | **View** |
| Apple | Alt 2. One metric can be used to decide LBT or no-LBT can be RSSI and channel occupancy feedback from UE. |
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Discussion point:

For regions where LBT is not mandated, shall we introduce additional conditions for no-LBT to be used, or leave it for gNB implementation

* The condition can be based on DFS, long term sensing, etc

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| **Company** | **View** |
| Apple | Up to gNB implementation |
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Discussion point:

For regions where LBT is not mandated when no-LBT is used, what are the good neighbor procedures, if any that can be useful?

* Shall we design ATPC-like mechanism to be used in no-LBT mode
* Shall we design DFS-like mechanism to be used in no-LBT mode
* Shall we design long term sensing type mechanism to be used in no-LBT mode
* Shall we design duty-cycle or away time restriction mechanism to be used in no-LBT mode
* Shall we design transmit power restriction mechanism to be used in no-LBT mode

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| **Company** | **View** |
| Apple | Prefer long term sensing such as RSSI and channel occupancy defined in NR-U can be used. EN 302 567 only specify max backoff should be >=3. With RSSI/CO measurement, gNB can choose large max backoff value for example, for better coex performance with other technology. |
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Discussion point:

For regions where LBT is not mandated, when operating in no-LBT mode, shall we further define mechanism for the system to fall back to LBT mode

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| **Company** | **View** |
| Apple | Long term sensing and feedback, plus UE specific RRC signaling, can be the starting point. |
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## LBT Mode

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| **Company** | **Key Proposals/Observations/Positions** |
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### Sensing Structures

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| **Company** | **Key Proposals/Observations/Positions** |
| Intel | Proposal 1: While the 8us observation period is divided into two slots of 3 and 5us, respectively, the observation window of 5us is composed by a single observation slot of the same length. FFS: the exact value length of the measurement window that should be performed in each observation slots of which the LBT procedure is composed of. |
| Qualcomm | Proposal 4: Study the minimum measurement duration required in the 5 us observation slot.  Proposal 5: Perform two measurements within a 8us deferral period. Study the locations and durations of the two measurements.  Proposal 6: Consider specifying Type 2 LBT sensing structure similar to an observation slot in the baseline LBT procedure. |

### LBT Parameters, COT duration, Gaps

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| **Company** | **Key Proposals/Observations/Positions** |
| Nokia, Nokia Shanghai Bell | Proposal 9: Channel access without channel sensing is supported for a UE responding to a DL transmission within a gNB initiated COT after a time gap of at most X us.  Proposal 10: Time gap of X us is longer that PDSCH processing time and PUSCH preparation time.  Proposal 11: UEs without LBT functionality are also supported.  Proposal 12: Within a COT, gNB does not need to sense the channel after a beam switch when the time gap to previous channel sensing or transmission covering the beam is less than Y us. The value of Y is for further study. |
| Apple | Proposal 6: Regulation is ambiguous on the max gap duration in COT sharing without LBT. Since any gap is counted into 5ms COT, no gap limitation needs to be specified. |
| PANSONIC | Proposal 2: Within gNB initiated COT, if gap between DL transmission and scheduled UL transmission along a given beam direction is larger than a predefined duration, UE should perform LBT before UL transmission; otherwise, no LBT is needed. |

### ED threshold adaptation based on bandwidth

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| **Company** | **Key Proposals/Observations/Positions** |
| Nokia, Nokia Shanghai Bell | Observation 1: Energy detection threshold of EN 302 567 depends on the operating channel bandwidth and on the EIRP incorporating also the beamforming and antenna gain.  Proposal 3: Energy detection threshold is determined by XThresh = -80 dBm + 10 log10 (LBT Bandwidth (in MHz)) + 10 log10 (EIRPmax / EIRPout), where EIRPout is the maximum peak EIRP of intended transmissions. |
| Intel | Proposal 4: When operating in unlicensed 60 GHz band, in order to allow fair coexistence among incumbent systems, the ED threshold calculation shall account not only for the maximum output power, but also at least for the bandwidth used.  Proposal 5: When operating in unlicensed 60 GHz band, the ED threshold calculation shall account for the type of LBT mechanism used.  Proposal 6: For the LBT bandwidth definition, either Alt-4 or Alt-5 are preferred. |
| vivo | Proposal 2: The ED threshold for CCA check should adapt to LBT bandwidth, and take into account the impact of beamforming gain of the directional LBT beams. |
| Spreadtrum | Proposal 4: The formula of ED threshold should consider the LBT bandwidth and beamforming gain. |
| Ericsson | Observation 1 Draft EN 302 567 v2.2.0 contains recent updates that modifies the EDT to include dependency on the LBT bandwidth  Proposal 1 Reuse the energy detection threshold (EDT) from draft EN 302 567 v2.2.0 that already considers EDT scaling with transmit power and LBT bandwidth |
| Qualcomm | Proposal 1: Modify the baseline procedure for the WID LBT mode to include dependency of the energy detection threshold on the operating channel bandwidth. |
| DOCOMO | Proposal 2:  For ED threshold used in LBT, no additional specification is necessary in addition to what ETSI BRAN requires.  Observation 2: |

### Discussion

ED threshold should reflect the updated ETSI regulation

Discussion point:

The baseline ED threshold can be computed as

Where Pout is rated RF output EIRP and Pmax is the output power limit.

* FFS if further adjustment on ED threshold based on sensing beam and transmission beam

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| **Company** | **View** |
| Apple | Agree. Reuse EDT defined in ETSI regulation.  Based on the definition of Pout is specified in 4.2.2, ED threshold should be based on transmission beamforming gain per transmission burst. Therefore, if omni-sensing is used and directional transmission happens within a transmission burst, beam forming gain needs to explicitly added to Pout calculation. “4.2.2.1 Definition The RF output power is the mean equivalent isotropically radiated power (EIRP) for the equipment during a transmission burst. 4.2.2.2 Limit The maximum RF output power is applicable to the system as a whole when operated at the highest stated power level. For a smart antenna system, the limit applies to the configuration that results in the highest EIRP. In case of multiple (adjacent or non-adjacent) channels the total RF output power of all channels shall be less than or equal to the limits in table 3.” |
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Sensing structure for 8us deferral and 5us observation slot

Discussion point:

For channel sensing in the 8us deferral period, two energy measurements are required. For channel sensing in the 5us observation slot, one energy measurement is required.

* FFS the duration and the location of the energy measurements

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| **Company** | **View** |
| Apple | The channel sensing parameters defined in ETSI adopt the parameters defined in 11ad specification. 5us slot is definition of aSlotTime, and 8us is sum of aSIFSTime (3us) + aSlotTime(5us).  In 802.11ad specification (IEEE std 802.11-2016), a SIFSTime and aSlotTime is calculated as    Based on this, there is no need to perform 2 CCA within 8us slot. Only 1 CCA is enough.  For 5us sensing slot, at most 3us should be used for CCA time, based on 802.11ad specification. Remaining time will be used for RxTx turnaround time and propagation time. |
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## COT Sharing Aspects

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| **Company** | **Key Proposals/Observations/Positions** |
| Lenovo, Motorola Mobility | Proposal 11: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, COT sharing between the initiating device and responding device should be supported with at least Cat 2 LBT:  - If the responding device is capable of beam correspondence and it is expected to use only any of the Rx beam(s) as Tx beam(s) for its transmission that have been used to receive at least one of the transmissions from the initiating device within the same COT  - If the responding device determines at least one suitable beam on which it is allowed to transmit within the same COT, where the suitable beam can be determined as follows:  o UE can be configured with a mapping table for determining suitable transmit beams for UL transmissions based on the receive beam(s) which the UE used to receive the prior DL transmissions in the same COT  Proposal 12: For NR unlicensed bands between 52.6 GHz and 71 GHz with directional LBT based channel access mechanism, multiple COT sharing indicators and their corresponding association to different beams can be signaled in a group common DCI and the association of COT sharing indicator to transmission is semi-statically signaled. |
| LG Electronics | Proposal #5: For COT sharing, the Type 2 (e.g., 2A/2B/2C) channel access procedure can be introduced and the maximum gap between the transmissions within the COT can be defined for above 52.6 GHz. |
| CAICT | Proposal 6: Cat 2 LBT could be used to share the COT.  Proposal 7: Cat 2 LBT could also be used for short control signaling. |

### Discussion

ETSI regulation does not explicitly enforce a maximum gap within the COT

Discussion point

On maximum gap within a COT to allow COT sharing without LBT

* Alt 1. No maximum gap defined. A later transmission can share the COT without LBT with any gap within the maximum COT duration
* Alt 2. Define a maximum gap X, such that a later transmission can share the COT without LBT only if the later transmission starts within X from the end of the earlier transmission
  + FFS: Value for X
* Alt 3. Define a maximum gap Y, such that a later transmission can share the COT without LBT only if the later transmission starts within Y from the end of the earlier transmission. If the later transmission starts after Y from the end of the earlier transmission, an one-shot LBT is needed to share the COT
  + FFS: Value for X
  + FFS: How to define the one-shot LBT

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| **Company** | **View** |
| Apple | Alt 1.  Alt 3 follows similar design as 802.11 and eLAA/NR-U. In this case, Y should be 3us SIFS time which is very restrictive. |

## CWS and CAPC

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| **Company** | **Key Proposals/Observations/Positions** |
| Nokia, Nokia Shanghai Bell | Proposal 1: LBT procedure uses fixed contention window size for random back-off. The size of the fixed contention window is FFS.  Proposal 2: Reduced number of CAPCs can be considered for the LBT procedure for 60 GHz band. Support for CAPCs is considered together with the design of short control signalling. |
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| Intel | Proposal 3: The procedure specified in NR-U related to the CWS adjustment should be considered for operation in unlicensed 60 GHz band. RAN1 should further discuss and identify the values Zmin and Zmax. |
| LG Electronics | Proposal #2: Introduce channel access priority class and the contention window adjustment mechanisms when LBT is used in NR above 52.6 GHz, similar to Rel-16 NR-U.  Proposal #8: It would be beneficial for coexistence that channel occupancy acquired by directional LBT is shared only for DL and UL signals/channels having spatial QCL relationship. |
| Samsung | Proposal 3: Support the following types of channel access procedures for 60 GHz unlicensed band:  • Type 1 channel access procedure without CWS adaptation;  • Type 2 channel access procedure with zero and positive fixed sensing duration.  Proposal 4: No need to define CAPC for 60 GHz unlicensed band. |
| CATT | Proposal 3: RAN 1 should further study introduction of CAPC for NR operation up to 71GHz with necessary modifications when LBT is used. |
| PANASONIC | Proposal 2: Within gNB initiated COT, if gap between DL transmission and scheduled UL transmission along a given beam direction is larger than a predefined duration, UE should perform LBT before UL transmission; otherwise, no LBT is needed. |
| Sony | Proposal 3: Contention Window Size should be allowed to be configured. |
| Ericsson | Proposal 11 CAPC, CWS adjustment can be implementation dependent. |
| Charter | Proposal 1: CAPC and contention window adjustment mechanisms are not introduced. Contention window range does not need to be adjusted. |

### Discussion

EN 302 567 only defines the CCA check at the initiating device, which can be consider as a Cat 4 LBT type mechanism. There is no CAPC defined and CWS concept and CWS adjustment procedure. Do we need to introduce them in 3GPP spec.

Discussion point:

* Alt 1. Not introduce CAPC, CWS, and CWS adjustment for 60GHz band
* Alt 2. Introduce CAPS, CWS and CWS adjustment mechanism for 6GHz band, with Rel.16 NR-U as baseline.

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| **Company** | **View** |
| Apple | Alt 1. Priority class is defined in EN 301 893 for 5/6GHz band, but not defined in EN 302 567 for 60GHz.  3GPP design follow regulation, no need to further complicate the design with CAPC, CWS and CWS adjustment. |
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## CET and short control signalling

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| **Company** | **Key Proposals/Observations/Positions** |
| OPPO | Proposal 7: No-LBT mode should be used only for transmission of ACK/NACK, SSB, and PRACH preamble.  Proposal 8: The transmission of SSB and PRACH shall be less than or equal to 10% within an observation period of 100ms. |
| Huawei, HiSilicon | Proposal 17：For operation in the 60 GHz band, in regions where LBT is mandated, support transmission of short control signalling without LBT, and with a duty cycle 10 % within an observation period of 100 ms.  - Short control signaling is defined as a short transmission burst that contains unicast control information without any user plane data |
| Nokia, Nokia Shanghai Bell | Observation 2: EN 302 567, v2.2.0 allows for Short Control Signalling transmissions for up to 10% of time within an observation period of 100 ms.  Proposal 5: NR-U design for 60 GHz bands supports transmission of DL and UL control and management signals as short control signalling without LBT. Details are FFS. |
| Intel | Observation 3:  • For 120 kHz SCS SSB. Transmission of 64 SSB with 20 msec SSB periodicity exceed 10 msec transmission duration within a 100 msec observation period required for short control signal exemption.  • For 480 kHz SCS SSB. Transmission of 64 SSB and 64 Type0-PDCCH with associated PDSCH with 20 msec SSB periodicity exceed 10 msec transmission duration within a 100 msec observation period required for short control signal exemption.  • For 960 kHz SCS SSB. Transmission of 64 SSB and 64 Type0-PDCCH with associated PDSCH with 20 msec SSB periodicity does not exceed 10 msec transmission duration within a 100 msec observation period required for short control signal exemption.  Proposal 14: While SSB may be considered as a candidate for short control signal exemption, RAN1 specification shall support operations of SSB transmission with LBT (at the gNB) at least for 120 kHz SSB.  • For 480 kHz and 960 kHz SSB, also support operations of SSB transmission with LBT (at the gNB) for commonality with 120 kHz SSB.  Observation 4: For 120 kHz, 480kHz, and 960 kHz PRACH transmission, UE does not exceed total transmission duration of 10 msec for PRACH within a 100 msec observation period.  Proposal 15: Consider applying short control signal exemption to PRACH transmission by the UE. |
| Samsung | Proposal 6: For “short control signal”:  • any periodic transmission with high priority can be part of “short control signal”, including discovery burst, non-unicast information, PRACH, PDCCH, PUCCH, and RS.  • support limitation on the transmission duration and duty cycle to use “short control signal”, wherein the transmission duration and duty cycle are defined from the channel occupancy point of view. |
| Ericsson | Observation 6 SCS transmissions have a duty cycle requirement but no limitations on the number of SCS transmissions within the observation period  Proposal 3 Consistent with EN 302 567, a node can access the channel without LBT for control signal/channel transmissions, the total duration of which shall not exceed 10ms within an observation period of 100ms. The following signals/channels shall be classified as short control signaling transmissions:  1 SS/PBCH blocks  2 PRACH  3 FFS: Other control transmissions not multiplexed with user data (subject to gNB configuration) |
| Apple | Proposal 2: For DL, at least SSB should be considered as short control signaling. For UL, at least PRACH should be considered as short control signaling. Other signal can be further discussed or can be configured by network.  Proposal 3: Transmission of SSB/RACH within an acquired COT after LBT success is not counted into 10% limitation within 100ms observation period. |
| Qualcomm | Proposal 3: The short control signaling exemption should be considered for designing LBT procedures. |

### Discussion

Discussion point:

Contention Exempt Short Control Signaling rules apply to the transmission of (combination) of the following channels

DL:

* SSB/PBCH
* PDCCH
* Broadcast PDSCH
* CSI-RS
* PRS

UL:

* PRACH
* PUCCH
* SRS

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| **Company** | **View** |
| Apple | At least SSB/PBCH in DL, at least PRACH in UL. Other signalling can be further discussed. |
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By regulation, short control signalling can be transmitted for no more than 10% of time within any 100ms observation window. Do we need to introduce mechanism to enforce that?

Discussion point:

Alt 1. Usage restriction on short control signalling is enforced by gNB implementation

Alt 2. Introduce additional mechanism to explicitly restrict the short control signalling usage. FFS how.

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| **Company** | **View** |
| Apple | Alt 1 |
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## Cat 2 LBT

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| **Company** | **Key Proposals/Observations/Positions** |
| Lenovo, Motorola Mobility | Proposal 11: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, COT sharing between the initiating device and responding device should be supported with at least Cat 2 LBT:  - If the responding device is capable of beam correspondence and it is expected to use only any of the Rx beam(s) as Tx beam(s) for its transmission that have been used to receive at least one of the transmissions from the initiating device within the same COT  - If the responding device determines at least one suitable beam on which it is allowed to transmit within the same COT, where the suitable beam can be determined as follows:  o |
| OPPO | Proposal 1: The LBT mechanism in EN 302 567 can be defined as Type 1 channel access to initiate a COT for unlicensed band in high frequency range.  Proposal 2: Introduce Type 2 channel access for shared COT operation for unlicensed band in high frequency range. |
| LG Electronics | Proposal #5: For COT sharing, the Type 2 (e.g., 2A/2B/2C) channel access procedure can be introduced and the maximum gap between the transmissions within the COT can be defined for above 52.6 GHz. |
| Samsung | Proposal 3: Support the following types of channel access procedures for 60 GHz unlicensed band:  • Type 1 channel access procedure without CWS adaptation;  • Type 2 channel access procedure with zero and positive fixed sensing duration.  Proposal 7:  • Support channel access mechanism with directional channel sensing.  • Support directional channel sensing in multi-beam operation:  o For multi-beam SDM scenario, both Alt 2 and Alt 3 can be supported.  SDM scenario is only applicable to gNB.  o For multi-beam TDM scenario, select between Alt 2 and Alt 3 depending on whether sensing is required for switching beams within a COT.  If sensing is supported within a COT, Type 2 channel access procedure with fixed sensing duration is sufficient.  TDM scenario can be applicable to both gNB and UE. |
| CAICT | Proposal 6: Cat 2 LBT could be used to share the COT.  Proposal 7: Cat 2 LBT could also be used for short control signaling.  Proposal 9: Multiple LBT beams covering multiple directions could be used for Cat2 LBT. |
| PANASONIC | Proposal 2: Within gNB initiated COT, if gap between DL transmission and scheduled UL transmission along a given beam direction is larger than a predefined duration, UE should perform LBT before UL transmission; otherwise, no LBT is needed. |
| AT&T | Proposal 1: Directional LBT is defined as a complete beam sweep with Cat. 4 LBT followed by Cat. 2 LBT before actually transmitting on any spatial direction deemed idle during the complete beam sweep  Proposal 2: The relationship between sensing and transmitting beams should be specified.  • ED threshold adaptation mechanisms can be considered |
| Ericsson | Proposal 10 Do not support Cat 2 LBT for shared COT |
| Qualcomm | Proposal 6: Consider specifying Type 2 LBT sensing structure similar to an observation slot in the baseline LBT procedure.  Proposal 7: Consider specifying optional/configurable use of Type 2 LBT in channel access procedure. |

### Discussion

Cat 2 LBT is not defined in ETSI regulation. There are proposals to introduce it in 3GPP spec for several use cases.

Discussion point:

Shall we define Cat 2 LBT procedure.

* Alt 1: Do not introduce Cat 2 LBT for 60GHz band
* Alt 2: Design Cat 2 LBT as part of baseline LBT procedures. Use of Cat 2 LBT, where applicable, will not be optional for channel access.
* Alt 3: Design sensing for Cat 2 LBT observation slot requirements and include Cat 2 LBT optional procedure for LBT. Signalling will be designed to enable/disable or configure the parameters for use of Cat 2 LBT.

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| **Company** | **View** |
| Apple | Alt 1 |
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Discussion point:

If Cat 2 LBT is introduced, it can be used in multiple places:

* A: Resume transmission after a large gap: Cat 2 LBT is used to resume transmission by the initiating device within the COT after a large gap
* B: COT sharing: Cat 2 LBT is designed to be optionally used before transmission by a responding node sharing a COT
* C: Multi-Beam LBT: Cat 2 LBT is designed to be optionally used before beam switching in a COT
* D: Rx-Assistance: Cat 2 LBT is designed to be optionally used for sensing to be done at the receiver for Rx-Assistance measurements and associated signalling

For companies supporting introducing Cat 2 LBT, please list your view on which use cases (A/B/C/D) Cat 2 LBT can be used for. Please add other use cases if not listed above.

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| **Company** | **View** |
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## Directional LBT

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| **Company** | **Key Proposals/Observations/Positions** |
| FUTUREWEI | Proposal 1: The 60 GHz unlicensed channel access shall support directional channel sensing that covers the next transmission directions.  Proposal 2: The value of Pout in the CCA Check threshold before initiating a COT should correspond to the maximum EIRP of the transmissions during that COT.  Proposal 3: NR should support solutions to address the asymmetry between the beam (antennas TIS) used for CCA sensing and the beams (EIRP) used for transmissions. |
| Lenovo, Motorola Mobility | Proposal 3: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, beam based (directional) LBT operation should be supported  Proposal 4: For NR unlicensed bands between 52.6 GHz and 71 GHz, with directional LBT based channel access mechanism, configuration and/or indication of multiple LBT beams to UE should be supported for beam-based UL transmission  Proposal 5: For NR unlicensed bands between 52.6 GHz and 71 GHz, with directional LBT based channel access mechanism, explicit mapping between LBT beam(s) and UL transmit beam should be supported, where the LBT beams may or may not be same as the transmit beam  Proposal 6: For NR unlicensed bands between 52.6 GHz and 71 GHz, with directional LBT based channel access mechanism, for UL transmissions on CG resources, time-based autonomous switching of UL Tx beam should be supported, where the switching can be based on a timer within which the UE is expected to receiver HARQ-ACK feedback |
| ZTE, Sanechips | Proposal 7: If directional LBT is supported, similar principle to determine LBT beam in LTE-LAA and below 7GHz NR-U can be reused, i.e. LBT beam is same as the reception beam. |
| OPPO | Proposal 5: The relations between LBT beams and transmission beams can be leaved as implementation. |
| Huawei, HiSilicon | Proposal 7: For operation in the 60 GHz band, specify the spatial relation between the LBT beam and the transmission beam.  Proposal 8: For spatial domain multiplexing of different beams, both one LBT beam covering all transmission beams, and multiple LBT beams covering multiple transmission beams are supported.  Observation 1: (Quasi-)omni-directional simplifies the implementation but could lead to an ‘over protection’ problem and thus reduction of spatial reuse.  Observation 2: Directional LBT potentially improves the channel access probability and enhances the spatial reuse. However, when performed at the transmitter side, the hidden node problem could be more severe due to limited sensing direction. |
| Nokia, Nokia Shanghai Bell | Observation 3: Clarify the feasibility and possible limitations of the omnidirectional ED sensing (true omni LBT) for prospective gNBs operating in 60 GHz unlicensed band.  Proposal 8: Leave the choice of the beam width for the directional LBT operation to the vendor-specific implementations. Vendors can use different beamforming techniques for their LBT procedures, as long as global or region and deployment specific requirements (i.e., ETSI EN 302 567) are fulfilled.  Observation 4: Generic requirements may be considered, e.g., that the beam(s) used in the LBT contain the transmission direction(s) intended to be used during the COT.  Observation 5: CCA check procedure details need to be considered when gNB uses multiple beams for channel sensing during the LBT. |
| Intel | Observation 1: Omni-directional LBT may act in many cases overprotectively and may prevent from fully exploiting spatial reuse under highly directional transmissions. This issue may be mitigated through directional LBT. However, directional sensing exacerbates the well-known hidden node issue, and leads to scenarios where the system could suffer from deafness.  Observation 2: Receiver-aided LBT is able to mitigate the issues introduced by directional LBT and offers a mean to better assess the correct level of interference at the receiver.  Proposal 8: Both omni-directional and directional LBT are supported. When directional LBT is used, a receiver-aided LBT should complement its CCA procedure.  Proposal 9: RAN1 to define some relationship between the received beams used for LBT measurements, and the transmit beam to be used after LBT success. Further details of how the relationship is defined is FFS in RAN1.  Proposal 10: When directional sensing is performed, the COT should be considered to be acquired only in the transmission beams for which the LBT is performed and the LBT measurements have indicated that the channel is idle.  Proposal 11: When directional sensing is performed, and multiple concurrent COT are acquired, these should be independently treated unless LBT measurements have overlapping beams. In this case, RAN1 should define some rules on how to handle these cases.  Proposal 12: RAN1 should further study how to efficiently allow beam-pairing due to LBT success.  Proposal 13: A device should perform directional sensing at the beginning of the COT with sensing beam(s) that covers all transmit beams or the first transmission beam, and additional directional LBT with sensing beam that covers the transmission beam(s) . |
| InterDigital | Observation 1: Omni-directional LBT in unlicensed spectrum from 52.6GHz to 71GHz can under-represent interference in the direction of the associated transmission and over-represent interference in other directions.  Observation 2: Dynamic scenarios with some level of mobility increases the likelihood of transmitter-receiver pairs interfering with each other even when using narrowbeams.  Observation 3: Directional LBT provides benefits over no LBT at least for medium to high loads and especially for tail UEs, while reducing the drawbacks associated with omni-directional LBT.  Proposal 1: Directional LBT is supported.  Proposal 2: The relationship between the LBT beam and the transmission beam should be specified.  Proposal 3: A single directional LBT process can be performed on a beam whose parameters are determined from the parameters of the Tx beam of one or more associated transmissions.  Proposal 4: RAN1 to study when to perform LBT cat 4 within a COT for an LBT beam covering a transmission beam used in a COT. |
| LG Electronics | Proposal #4: If the directional CCA procedure is introduced the followings points can be considered:   How to perform the CCA procedure for multiple-beam sweeping transmission   How to define CWS management (e.g., per-direction or across-direction management)   How to manage the back-off counter value  Proposal #6: It should be discussed how to indicate the direction of LBT (e.g., omni-directional LBT or directional LBT) and the type of LBT (e.g., Type 1 or Type 2A/2B/2C channel access procedure in NR-U) when scheduling a UL transmission inside or outside of a channel occupancy.  Proposal #7: The relationship between the LBT beam with a specific direction to acquire the COT and the transmission beam(s) allowed to transmit in that COT should be defined considering the relationship between the CCA range of the LBT beam and the interference range of the transmission beam(s). |
| Samsung | Proposal 7:  • Support channel access mechanism with directional channel sensing.  • Support directional channel sensing in multi-beam operation:  o For multi-beam SDM scenario, both Alt 2 and Alt 3 can be supported.  SDM scenario is only applicable to gNB.  o For multi-beam TDM scenario, select between Alt 2 and Alt 3 depending on whether sensing is required for switching beams within a COT.  If sensing is supported within a COT, Type 2 channel access procedure with fixed sensing duration is sufficient.  TDM scenario can be applicable to both gNB and UE. |
| TCL | Proposal 1: RAN1 shall study channel access mechanisms based on directional LBT.  Proposal 2: RAN1 shall study directional LBT at UE side to guarantee fair coexistence with 802.11ad.  Proposal 3: RAN1 shall study solutions to mitigate the effect of LBT deafness, beam orthogonality and beam imbalance in order to enable directional LBT at UE side without harming NR-U channel access efficiency.  Proposal 4: RAN1 shall consider the usage of directional LBT at gNB side. |
| AT&T | Proposal 1: Directional LBT is defined as a complete beam sweep with Cat. 4 LBT followed by Cat. 2 LBT before actually transmitting on any spatial direction deemed idle during the complete beam sweep  Proposal 2: The relationship between sensing and transmitting beams should be specified.  • ED threshold adaptation mechanisms can be considered |
| Spreadtrum | Proposal 2: The directional LBT should be supported in 60GHz unlicensed band. |
| Sony | Proposal 4: Directional LBT should be supported on 60 GHz unlicensed operation.  Proposal 5: The following relationship between LBT beam and transmission beam should be specified   One LBT beam covers all transmission beams   Multiple LBT beams cover multiple transmission beams |
| NEC | Proposal 3: For LBT based channel access in mmWave unlicensed band, the relationship between LBT beam and transmission beam should be defined to reduce the complexity of channel access for different nodes. |
| Xiaomi | Observation 1: Omni-directional LBT is more suitable for broadcasted channels and groupcasted channels, and directional LBT is more suitable for unicast channels and receiver assisted LBT. |
| Ericsson | Observation 7 The effectiveness of LBT as medium access mechanism for co-existence in unlicensed spectrum in 60 GHz band is questionable.  Observation 8 Common understanding in ETSI and 802.11ad/ay specs are omni-directional LBT or quasi-omnidirectional LBT  Observation 9 Simulation studies in general indicate no significant gain from using directional LBT.  Observation 10 There is no need to specify anything more stringent than the existing EN 302 567 standard. Directional LBT can be implementation dependent.  Observation 11 It is complex to define a directional sensing beam that covers several transmission beams for every transmission.  Proposal 4 For spatial domain multiplexing when LBT mode is used, the (directional) LBT behaviour can be left for implementation.  Proposal 5 For time domain multiplexing of DL/UL transmissions in multiple beams when LBT mode is used, it should be allowed to perform omni-directional or quasi-omni-directional LBT at the beginning of the COT and no LBT for the following beams in the COT. |
| Apple | Proposal 4: Both omni-directional and directional LBT is supported.  • For omni-directional LBT, Pout is calculated from Tx power + potential beam forming gain. One omni-directional LBT beam coverall all transmission beams.  • For directional LBT, Pout is calculated from the Tx power with Rx/Tx beam correspondence. The LBT beam should be used as the transmission beam. |
| Convida | Proposal 1: Directional LBT and interference mitigation should be considered for frequency range of 52.6GHz to 71GHz.  Proposal 2: Both omni-directional LBT and directional LBT should be supported for frequency range of 52.6GHz to 71GHz. |
| Qualcomm | Proposal 8: Consider the use of antenna gain of sensing beam and transmission beam to determine the suitability of using a given sensing beam in conjunction with a transmission beam.  • The directionality of sensing beam should be accounted for only in the directions of intended transmission i.e., within X dB of the peak EIRP. |
| ITRI | Proposal 1: In order to avoid resource wastage and hidden node problem, the LBT beam should be the same as the transmission beam. |
| DOCOMO | Observation 2:   Directional sensing should be possible in 60 GHz since narrower beam is highly assumed for the exact transmissions.   It would be difficult to support directional sensing with detailed configuration of beam characteristics.  Proposal 3:   Directional LBT should be supported with minimum specification effort.   One possibility is to support directional LBT with the same beam as the one to be used for associated transmission |

### ED threshold adaptation based on Beamforming gain

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| **Company** | **Key Proposals/Observations/Positions** |
| ZTE, Sanechips | Proposal 11: Considering mismatch between LBT beam and transmission beam, the ED threshold provided by the ETSI BRAN 302 567 can be modified to consider mismatching between LBT beam and transmission beam.  Proposal 12: For NR-U and NR-U coexistence scenarios, its ED threshold can be considered to be appropriately relaxed compared with the threshold of coexistence between NR-U and Wi-Fi. |
| Huawei, HiSilicon | Proposal 2: For operation in NR-U-60, the EDT formula adopted from draft v2.1.20 of EN 302 567 as a baseline should be adjusted such that, for a given RF output power (EIRP), EDT proportionally increases with the beamforming gain of the potential following transmission.  Proposal 3: For operation in NR-U-60, when LBT is used, adopt the following generalized formula to capture the potential enhancements to the baseline EDT formulae:  • EDT= X+Y-min(Y, Po + a GTX ) [dBm], wherein 0≤a ≤1 [dBm/dBi],  • X is a reference CCA level further adjustable based on LBT BW, e.g. X=-47+10log10(BW/2GHz),  • Y is the maximum EIRP limit, e.g. Y=40 dBm,  • GTX is the effective transmit antenna gain at the potential transmitter [dBi],  • Po is the output power to the transmit antenna array [dBm] such that Pout (EIRP)= Po+GTX. |
| Nokia, Nokia Shanghai Bell | Proposal 4: Energy detection threshold adjustment can be considered for compensating any difference on the transmission and LBT beamforming gains. |
| InterDigital | Proposal 10: Adapt ED threshold to account for LBT BW and beamforming gain. |
| LG Electronics | Proposal #9: The ED threshold provided by the ETSI 302 567 can be enhanced considering the following points:   The size of LBT bandwidth   Transmit power of beam(s) in the COT   Transmit beam pattern (wide/narrow) |
| Samsung | Proposal 5: ED threshold should depend on:  • Whether other technology sharing the channel is absent or not on a long-term basis;  • LBT bandwidth;  • Beam parameters including beamforming gain and/or beam direction for transmission and/or receiving. |
| CATT | Proposal 4: The energy detection threshold for CCA check in EN 302.567 can be reused for NR operation up to 71GHz |
| vivo | Proposal 2: The ED threshold for CCA check should adapt to LBT bandwidth, and take into account the impact of beamforming gain of the directional LBT beams. |
| Spreadtrum | Proposal 4: The formula of ED threshold should consider the LBT bandwidth and beamforming gain. |
| NEC | Proposal 2: The energy detection threshold adaptation for beam based channel access procedure should take into account the maximum transmission power difference between transmission on a single beam and multiple concurrent beams. |
| Ericsson | Observation 2 EDT defined in draft EN 302 567 v.2.2.0 already depends on the transmit power of the device  Observation 3 Pmax and Pout in the EDT equation include beamforming gain |
| DOCOMO | Proposal 2:   For ED threshold used in LBT, no additional specification is necessary in addition to what ETSI BRAN requires. |

### Discussion

There is strong support to support or study directional LBT. On the other hand, in mmW system, likely there is no true “omni-directional” LBT in the beginning. When we discuss “directionality” of LBT, we should discuss its relationship with transmission beam.

Discussion point:

Should 3GPP spec defines the relationship between the LBT beam and the transmission beam or leave it as implementation. For example, should we define something like the LBT beam should “cover” the transmission beam?

* Alt 1. Leave the relationship between sensing beam and transmission beam as implementation
* Alt 2. Defines the relationship between the sensing beam and the transmission beam, at least sensing beam “covers” the transmission beam
  + FFS: How to define the relationship

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| **Company** | **View** |
| Apple | Alt 2. This is to ensure regulation compliance.  Compare to EN 301 893, the key difference is that in EN 302 567, Pout in EDT equation is explicitly specified with Tx beamforming gain. |
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If we define the relationship between LBT beam and TX beam, another question to answer is if ED threshold should be adjusted by the LBT beam and TX beam choices. For example, given a fixed TX beam, using a pseudo-omni beam or the same TX beam for LBT will produce different LBT ED measurement given the same interference.

Discussion point:

If 3GPP spec defines the relationship between the LBT beam and the transmission beam, shall we also define the impact to ED threshold given a certain LBT beam and transmission beam, or use a fixed ED threshold?

* Alt 1. No impact to ED threshold on sensing beam and transmission beam choices
* Alt 2. ED threshold is a function of the choice of sensing beam and transmission beam
  + FFS: How to adjust the ED threshold by sensing beam and transmission beam

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| **Company** | **View** |
| Apple | Alt 2. Follow EDT equation and Pout definition. |
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## Rx Assistance in LBT process

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| **Company** | **Key Proposals/Observations/Positions** |
| FUTUREWEI | Proposal 4: For UE assisted LBT, the gNB should be able to request UE to measure the interference (received energy) over a specific set of resources and report it back to the gNB prior to LBT procedure at the gNB. |
| Lenovo, Motorola Mobility | Proposal 21: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, receiver assistance should be supported for both LBT and no-LBT based channel access mechanisms to avoid potential interference at the receiver.  Proposal 22: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, only class A receiver assistance should be supported where the assistance information is sent only to the transmitter.  Proposal 25: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, signaling mechanism similar to RTS/CTS should be considered for receiver assistance  - Short transmission using control channels (such as with 1-bit) or reference signals for before the actual transmission could be supported |
| ZTE, Sanechips | Proposal 10: For receiver assisted channel access and interference management,   If existing L1 and L3 measurement mechanism is supported to obtain assistance information, some enhancements may need to be considered for using the measurement results timely and effectively to guide the subsequent transmission.   If LBT is supported to obtain assistance information, assistance information can be considered to be obtained within COT in addition to the beginning of COT. |
| OPPO | Proposal 6: RTS-like signal can be carried in a PDCCH and CTS-like signal can be carried in a PUCCH. |
| Huawei, HiSilicon | Observation 3：Receiver-only directional LBT saves the LBT overhead associated with the transmitter-side LBT of the receiver-assisted LBT mechanism and provides an efficient tradeoff as it aims at increasing the spatial reuse while mitigating the hidden node issue.  Proposal 12：For operation in the 60 GHz band, receiver-side LBT should be supported.  Proposal 15：For operation in the 60 GHz band, in regions where LBT is not mandated, the serving cell may enable Rx-side LBT using a higher layer configuration to mitigate high levels of interference experienced from hidden nodes.  Observation 5: When No-LBT is used in regions where LBT is not mandated by regulations, the hidden node issue would still persist.  Observation 6: Compared to No-LBT, substantial coverage gains are achieved using Receiver-assisted LBT/Receiver-only LBT in the indoor scenario, especially at medium and high traffic load.  - Even higher gains are realized when wider beams are used for directional transmissions  Observation 7: For Receiver-assisted LBT/Receiver-only LBT, if a high EDT\_Rx threshold is used, the DL cell-edge performance degrades if only CTS/idle indication is fed back when interference level is lower than the EDT\_Rx threshold. |
| Nokia, Nokia Shanghai Bell | Observation 6: Considerable benefits from new Rx assistance schemes should be shown in a reasonable range of different situations and with realistic UE feedback delays given the considerable implementation effort involved.  Observation 7: Receiver assistance for channel access is already supported with existing layer 1 and layer 3 measurements and reports.  Proposal 13: Any Rx assistance scheme should be configurable per UE, so that it could be used only with UEs frequently detecting high interference.  Proposal 14: For any new Rx assistance schemes, UE processing time similar to PDSCH processing time (N1) or CSI computation time (N2/Z1Z2) should be considered when providing Rx assistance.  Proposal 15: Rx assistance should not be limited to the beginning of COT only. |
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| InterDigital | Observation 4: In a beam-based environment, LBT (omni-directional or directional) can fail to detect hidden nodes if the interference is only in the direction of the receiving node.  Proposal 5: Receiver based LBT should be considered for both omni-directional and directional LBT.  Proposal 6: Receiver based directional LBT is supported.  Proposal 7: A single receiver based directional LBT process can be performed on a beam whose parameters are determined from the parameters of the Rx beam of one or more associated transmissions.  Proposal 8: The UE receives configuration and indication of the channel access mechanism to use (omni-directional, directional, receiver based, no LBT) from the gNB. FFS if configuration/indication is by RRC or L1 signaling.  Proposal 9: RAN1 to consider if a UE can select a channel access mechanism as a function of measurements or prior LBT success or failure. |
| LG Electronics | Proposal #3: The directional CCA and the receiver assisted LBT can be beneficial to increase cell coverage and spatial reuse, and whether or not the receiver assisted LBT can have an impact on specification except for indicating LBT type to responder should be first investigated. |
| Samsung | Proposal 9: Support dynamic RX-assistant channel access mechanism with handshake between transmitter and receiver, e.g. wherein the channel access request is based on DCI and channel access response is based on UCI in a downlink scenario.  Proposal 10: Support RSSI measurement outside the active BWP and in non-serving cell. |
| CATT | Proposal 2: The receiver assistance information can be designed base on the A-CSI feedback framework. |
| vivo | Proposal 4: When gNB operates as an initiating device, the transmitter request can be sent in a PDCCH like channel, and receiver feedback can be sent in a PUCCH like channel.  Proposal 5: Each transmitter request monitoring occasion corresponds to a receiver feedback transmission opportunity.  Proposal 6: When UE operates as an initiating device, the transmitter request can be a UL reference signal or sent in a PUCCH like channel with UE identity information. The receiver feedback can be sent in a PDCCH like channel.  Proposal 7: The channel access mechanism can be selected based on the channel occupancy time, channel access rate, transmission priority, service requirement, or feedback information from the receiver, etc. |
| AT&T | Proposal 3:  • Receiver assistance in Rel. 17 is limited to measurement enhancements  • Message based schemes similar to RTS/CTS signalling can be addressed in a later release targeting Class B scenarios  • Hand shaking is not supported  • Transmission should be allowed before the receiver assistance is received  • Receiver assistance can equally be useful, and should be allowed, for the no-LBT mode of transmissions  • Receiver assistance is a fast, low complexity feedback mechanism to convey to the transmitter the interference environment at the receiver |
| Spreadtrum | Proposal 3: The receiver assisted LBT should be supported in 60GHz unlicensed band. |
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| Sony | Proposal 6: Receiver assisted LBT should be supported on 60 GHz unlicensed operation. |
| Xiaomi | Proposal 5: Conditions about whether to enable/disable receiver assisted LBT can be studied.  Proposal 6: How to design a receiver assisted LBT with a simpler flow and little spec impact should be considered. |
| Ericsson | Observation 12 Ideal receiver assisted LBT does not show performance improvement as compared to no LBT.  Observation 13 Good link adaptation algorithm is enough to cope with occasional interference in 60 GHz band  Observation 14 CSI-Reporting mechanism in the current specification is a suitable tool to communicate receiver assistance information to the transmitter, i.e., the gNB. Enhancement may be needed to enable aperiodic CSI reporting to be triggered by DL DCIs and to be transmitted on PUCCH as being discussed in the URLLC WI.  Observation 15 Current processing delays for CSI reports in NR are rather long, which diminishes any potential benefit of receiver assisted channel access.\  Observation 16 If any gains of RAL are to be expected at all, then it requires fast feedback  Proposal 6 If any enhancements to better support receiver assisted channel access are to be specified at all, it should be based on CSI reporting enhancement as currently being discussed in the URLLC WI, with potential enhancements to the CSI report type and the CSI processing timeline. |
| Convida | Proposal 4: Receiver assisted LBT and channel access scheme should be supported in 52.6 GHz to 71 GHz. |
| Qualcomm | Proposal 11: Consider Rx-side CCA for receiver assistance. |
| DOCOMO | Proposal 4:   RSSI/channel occupancy measurement supported in Rel-16 NR-U can be reused in 52.6 – 71 GHz unlicensed band   Whether/how to apply directivity for RSSI/CO measurement and reporting can be further discussed |

### Discussion

Rx Assistance to be considered has been narrowed down to exchange between the serving and the served nodes.

Following aspects of the Rx-Assistance can further be discussed.

Discussion point

For receiver to provide assistance, channel sensing needs to be performed. The following set of tools can be considered

* Alt 1. Legacy RSSI measurement
* Alt 2. AP-CSI report
* Alt 3. LBT at receiver
  + Alt 3.1 eCCA
  + Alt 3.2 Cat2 LBT

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| **Company** | **View** |
| Apple | All alternatives can be considered. |
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## Multibeam operation

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| **Company** | **Key Proposals/Observations/Positions** |
| Lenovo, Motorola Mobility | Proposal 7: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, when multiple UL transmissions are scheduled on multiple beams in TDM or SDM manner, then a mapping table should be configured to UE to allow different mapping combinations between LBT beams(s) and transmit beam(s) including  - One LBT beam to one transmit beam mapping  - One LBT beam to many transmit beams mapping (including omni-directional LBT as well)  Proposal 8: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, when multiple DL/UL transmissions are scheduled on multiple beams in TDM in same COT, then LBT can be performed at the beginning of the transmissions and also in the middle of same COT, if needed, which is depending upon following gaps:  - Maximum allowed gap between the first symbol of the following scheduled transmission on a given beam and the last symbol of the transmitted (same) beam  - Or if there is no previous transmission on the same beam within a COT, then the maximum allowed gap between the between the first symbol of the following scheduled transmission on a given beam and the time instance when Cat 4 LBT was successful on a beam covering the transmit beam  Proposal 9: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, when multiple DL/UL transmissions are scheduled on multiple beams in TDM in same COT, then either of Cat 1 LBT or Cat2 LBT can be applied in the middle of the COT depending upon the gaps between the two transmissions on the same beam or the gap between the transmission on a beam and first LBT at the beginning that covered the transmit beam  Proposal 10: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, when multiple DL/UL transmissions are scheduled on multiple beams in TDM and if directional LBT is performed on multiple beams with Cat 4 LBT, then multiple COTs should be initiated corresponding to each of the LBT beam |
| ZTE, Sanechips | Proposal 8: Considering transmission opportunity and utilization of resource, multiple LBT beams that cover multiple transmission beams can be considered for the transmission with multiple beams in spatial domain multiplexing, if directional LBT is supported.  Proposal 9: Considering transmission opportunity and unnecessary interference to other device that is going to transmit transmission, Scheme-3 that “directional LBT for at the beginning of COT with sensing beam(s) that covers the first transmission beam, and additional directional LBT with sensing beam that covers the next transmission beam for each beam switching within COT” can be considered for the transmission with multiple beams in time domain multiplexing, if directional LBT is supported. |
| Huawei, HiSilicon | Proposal 9: For time domain multiplexing of transmissions in different beams in the same COT, support LBT at the beginning of COT by the initiating device with sensing beam(s) that covers all TDM transmission beams from the initiating device.  Proposal 10: LBT before subsequent transmissions by the initiating device within the same COT is not supported. |
| Samsung | Proposal 7:  • Support channel access mechanism with directional channel sensing.  • Support directional channel sensing in multi-beam operation:  o For multi-beam SDM scenario, both Alt 2 and Alt 3 can be supported.  SDM scenario is only applicable to gNB.  o For multi-beam TDM scenario, select between Alt 2 and Alt 3 depending on whether sensing is required for switching beams within a COT.  If sensing is supported within a COT, Type 2 channel access procedure with fixed sensing duration is sufficient.  TDM scenario can be applicable to both gNB and UE. |
| CATT | Proposal 6: When directional or omni-directional LBT with sensing beam(s) that covers all TDM beams has been performed at the beginning of COT, there is no need to support additional LBT in the middle of COT. |
| CAICT | Proposal 9: Multiple LBT beams covering multiple directions could be used for Cat2 LBT.  Proposal 10: Additional directional LBT with sensing beam that covers the next transmission beam for each beam switching in the middle of COT could be supported. |
| vivo | Proposal 3: Perform directional or omni-directional LBT at the beginning of COT with sensing beam(s) that covers all TDM beams or the first transmission beam, and additional directional LBT with sensing beam that covers the next transmission beam for each beam switching in the middle of COT. |
| TCL | Observation 5: Beam switching within an active COT may lead to collisions in case the new beam has at least partially non-overlapping coverage compared to the formerly active beam.  As this issue can degrade the quality of transmission, we propose to investigate further the mechanisms either preventing the channel access by neighboring devices, or some form of short LBT by the gNB prior to beam switching to ensure that no other device has taken over the channel.  Proposal 5: It is proposed to investigate the mechanisms which can avoid collisions due to double ownership of the shared carrier at beam transition events. |
| PANASONIC | Proposal 1: gNB performs directional LBT at the beginning of COT with a sensing beam or multiple sensing beams that covers all intended beams and additional directional LBT with sensing beam that covers the next transmission beam for each beam switching in the middle of COT. |
| Sony | Proposal 5: The following relationship between LBT beam and transmission beam should be specified   One LBT beam covers all transmission beams   Multiple LBT beams cover multiple transmission beams |
| NEC | Proposal 1: For the sensing/LBT beams on the same carrier with different directions, beam based channel access procedures could be performed independently in LBT mode operation. |
| Xiaomi | Proposal 7: Multi-beam transmission should be studied to fully take advantage of spatial diversity. |
| Apple | Proposal 5: Perform directional or omni-directional LBT at the beginning of COT with sensing beam(s) that covers all TDM beams and with no LBT before each beam switching in the middle of COT |
| Qualcomm | Proposal 9: For multi-beam COT, the sensing beam used at the start of the COT should represent the union of directions covered by the intended transmission beams.  Proposal 10: Consider the use of additional per-beam sensing before switching transmission beams for a COT |
| ITRI | Proposal 2: Multiple LBT beams cover multiple transmission beams should be supported for 60 GHz NR-U. |

### Discussion

Discussion point:

Within a COT, what is the LBT requirement for MU-MIMO (SDM)?

Alt 1: Single LBT sensing with wide beam ‘cover’ all beams to be used in the COT with appropriate ED threshold

Alt 2: Independent per-beam LBT sensing at the start of COT is performed for beams used in the COT

Please provide your view below

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| **Company** | **View** |
| Apple | Alt 1 |
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Discussion point:

Within a COT, what is the LBT requirement for TDM of beams with beam switching?

Alt 1: Single LBT sensing with wide beam ‘cover’ all beams to be used in the COT with appropriate ED threshold

Alt 2: Independent per-beam LBT sensing at the start of COT is performed for beams used in the COT

Alt 3: Alt 2 with additional requirement on Cat 2 LBT before beam switch

Please provide your view below:

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| **Company** | **View** |
| Apple | Alt 2 |
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## Multi-Channel Access

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| **Company** | **View** |
| Ericsson | Proposal 8 Support Type A multi-channel access from 37.213 wherein, LBT is performed per-carrier for the multi-channel case  Proposal 9 Do not support Type B multi-channel access from 37.213 |
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Discussion point:

For multi-channel LBT,

* Alt 1 (Type A). Each channel performs independent eCCA
* Alt 2 (Type B). Identify a primary channel and perform eCCA on the primary channel, while perform Cat 2 LBT for other channels in the last observation slot

Please indicate company position on LBT for multi-channel access, Alt 1, Alt 2, or both, or others

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| **Company** | **View** |
| Apple | Both. |
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## SSB related

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| **Company** | **Key Proposals/Observations/Positions** |
| Huawei, HiSilicon | Proposal 11: For operation in the 60GHz unlicensed band, support LBT before SSB burst transmission. |
| Intel | Observation 3:  • For 120 kHz SCS SSB. Transmission of 64 SSB with 20 msec SSB periodicity exceed 10 msec transmission duration within a 100 msec observation period required for short control signal exemption.  • For 480 kHz SCS SSB. Transmission of 64 SSB and 64 Type0-PDCCH with associated PDSCH with 20 msec SSB periodicity exceed 10 msec transmission duration within a 100 msec observation period required for short control signal exemption.  • For 960 kHz SCS SSB. Transmission of 64 SSB and 64 Type0-PDCCH with associated PDSCH with 20 msec SSB periodicity does not exceed 10 msec transmission duration within a 100 msec observation period required for short control signal exemption.  Proposal 14: While SSB may be considered as a candidate for short control signal exemption, RAN1 specification shall support operations of SSB transmission with LBT (at the gNB) at least for 120 kHz SSB.  • For 480 kHz and 960 kHz SSB, also support operations of SSB transmission with LBT (at the gNB) for commonality with 120 kHz SSB.  Observation 4: For 120 kHz, 480kHz, and 960 kHz PRACH transmission, UE does not exceed total transmission duration of 10 msec for PRACH within a 100 msec observation period. |
| Convida | Proposal 7: Increasing the number of SSB candidate positions to above 64 to increase transmission opportunities to cope with LBT failure should be considered. |

### Discussion

Discussion point:

SSB transmission with no-LBT supported under short control signalling framework

FFS: Restrictions to SSB transmission with no LBT

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| **Company** | **View** |
| Apple | Agree with the proposal. SSB transmission with no-LBT supported under short control signalling framework. This can simplify UE implementation and all measurement design and requirement.  For 480KHz SCS and 960KHz SCS, |
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Discussion point:

SSB transmission with LBT supported

FFS: How to perform LBT for SSB transmissions, such as

* Single eCCA covers all SSB beams before the SSB burst transmission
* Multi-beam eCCA before SSB burst transmission
* Cat 2 LBT before each beam

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| **Company** | **View** |
| Apple | Do not see the need to specify SSB transmission with LBT. SSB transmission within short control signalling framework enable efficient design for access, beam management and RRM/RLF measurement.  480KHz and 960KHz SCS has no issue to meet 10% limitation of short control signalling. For 120KHz SCS, with max 64 SSB, total SSB transmission is over 10%. However, SSB transmission within an already acquired COT should not be counted as short control signalling. Configuration of 64 SSB with 120KHz SCS can be up to gNB implementation to ensure 10% requirement is met. |
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## Misc Issues

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| **Company** | **Key Proposals/Observations/Positions** |
| ZTE, Sanechips | Proposal 13: Study and evaluate the impact of LBT and the limitation of COT length on the procedure of beam failure detection. |
| Samsung | Proposal 8: Support indicating COT, available RB set, and search space group switching in a beam-specific manner for 60 GHz licensed band.  Proposal 10: Support RSSI measurement outside the active BWP and in non-serving cell. |
| ITRI | Proposal 3: PDCCH monitoring enhancement for M-TRP operation should be supported for 60 GHz NR-U. |
| Fujitsu | Proposal 2: RAN1 shall study directional LBT at UE side to guarantee fair coexistence with 802.11ad. |
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