**3GPP TSG RAN WG1 Meeting #104bis-e** **R1-2105986**

**May 10th – May 27th, 2021**

**Agenda item: 8.2.6**

**Source: Moderator (Qualcomm Incorporated)**

**Title: Contribution summary of channel access mechanism for 52.6GHz-71GHz band, ver01**

**Document for: Discussion and Decision**

# Introduction

This paper summarizes the channel access related proposals submitted to agenda item 8.2.6 in RAN1-105e.

# 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.

## ED Threshold computation FFS Items

Agreement:

The baseline ED threshold can be computed as

$$EDT=-80 dBm+10\*log10\left(\frac{Pmax}{Pout}\right)+10\*log10(Operating Channel BW in MHz)$$

 Where Pout is RF output power (EIRP) and Pmax is the RF output power limit, Pout≤Pmax.

* FFS: Further adjustment on ED threshold based on the sensing beam and the transmission beam (further adjustment should not violate EDT requirements as per regulations)
* FFS: If Pout is max output EIRP of the device or instantaneous output EIRP
* FFS definition of Operating Channel BW
* FFS: Whether ED threshold for NR-U and NR-U coexistence scenarios (eg, at regulation level) can be appropriately relaxed compared with the threshold of coexistence between NR-U and Wi-Fi.
* FFS: EDT when the COT has time varying transmission beams and varying EIRP

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| **Company** | **Key Proposals/Observations/Positions** |
| AT&T | Proposal 2: • The ED threshold can be adjusted based on the sensing beam and the transmission beam within any requirements per regulationso FFS: ED threshold when the COT has time varying transmission beams and varying EIRP |
| CATT | Proposal 9: Adjustment value should be considered for the baseline ED threshold.Proposal 10: For adjustment value on baseline EDT, at least beamforming gain difference between the transmission beam and sensing beam should be considered. |
| Ericsson | Observation 1 ED threshold defined in EN 302 567 v2.2.0 is a function of the transmission’s EIRP Pout, which includes the transmission beamforming gain. It does not include the sensing beamforming gain.Proposal 2 Further adjustment on ED threshold based on the transmission and sensing beamforming gains could be up to implementation while not violating EDT requirements as per regulations. |
| FUTUREWEI | Proposal 4: Consider the use of composite transmit angular power profile (APP) of an intended set of transmit beams to design sensing beam that “covers” that intended set.• Prominent directions of intended transmission, i.e., those for which composite transmit APP is with a fraction of the peak APP, should have relatively large sensing gain. **• For EDT determination, define Pout as the maximum EIRP over that intended set of transmit beams.• Appropriate EDT incorporates shortfall (if any) in the sensing gain over prominent directions.** • Enable augmented sensing to avoid blind spots without excessive exposed nodes. |
| Huawei HiSilicon | Proposal 3: For operation in NR-U-60, the agreed baseline EDT formula should be adjusted such that, for a given RF output power (EIRP), the EDT proportionally increases with the effective beamforming gain of the potential following transmission(s) by the device. Proposal 4: For operation in NR-U-60, when LBT is used, adopt the following formula to capture the potential adjustment to the baseline EDT formula based on the transmit beamforming gain:EDT=-80 dBm+10\*〖log〗\_10⁡(Pmax/Pout)+10\*〖log〗\_10⁡(BW [MHz])+(1-a)(G\_TX -G\_(TX,max))GTX is the effective transmit antenna gain at the potential transmitter [dBi]GTX,max is the maximum effective transmit antenna gain considered for the deployment [dBi]a is a scaling factor such that 0≤ a≤ 1Proposal 5: For operation in NR-U-60, when LBT is used, the sensing beamforming gain of the LBT beam is deducted from the detected energy level before comparing it to the EDT. |
| Intel Corporation | Proposal 4: When operating in unlicensed 60 GHz band, the ED threshold calculation shall account for the sensing beam used to perform the LBT procedure.Proposal 5: In case the network is able to assess the absence of any other incumbent technology, the ED threshold value that a device may use during the LBT procedure is up to the gNB and may be configured via higher layer signaling.  |
| InterDigital Inc. | Proposal 11: Adapt EDT to account for beamforming gain of the sensing beam. |
| LG Electronics | Proposal #14: The ED threshold provided by the ETSI 302 567 can be enhanced considering the following points:l The size of LBT bandwidthl Transmit power of beam(s) in the COTl The beam correspondence capability/requirement of UE. |
| NEC | Proposal 1: The energy detection threshold adaptation for beam based channel access procedure should take into account the antenna gain and mapping between transmission beam(s) and sensing beam(s). |
| Nokia Nokia Shanghai Bell | Proposal 8: Further adjustment of EDT based on the sensing and transmission beams is not specified. |
| OPPO | Proposal 6: the EDT value should be adjusted: smaller value is applied when sensing beam is narrower. |
| Qualcomm Incorporated | Proposal 2: The ED based comparison rule for medium busy should reflect the directionality of sensing beam and transmission beam. |
| Spreadtrum Communications | Proposal 5: The formula of ED threshold should consider the LBT bandwidth and beamforming gain. |
| vivo | Proposal 8: The ED threshold for CCA check should take into account the impact of beamforming gain of the directional sensing beams. |
| ZTE Sanechips | Proposal 18: Considering mismatch between LBT sensing beam and transmission beam, the ED threshold provided by the ETSI BRAN 302 567 can be modified to consider mismatching between LBT sensing beam and transmission beam.Proposal 19: 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. |

Working assumption:

* For Pout in EDT determination, define Pout as the maximum EIRP of the node determining EDT during a COT.

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| **Company** | **Key Proposals/Observations/Positions** |
| Charter Communications | Proposal 1: Confirm the working assumption for the EDT definition: Pout is defined as the maximum EIRP of the node determining EDT during a COT. |
| Ericsson | Proposal 1 Confirm the working assumption that Pout corresponds to the maximum of the mean output power EIRPs of the transmissions or transmission bursts in a COT that may contain varying transmission beams and EIRPs. |
| FUTUREWEI | Observation 1. The working assumption is only well justified when a single LBT sensing is carried out by a node using one sensing beam for all transmit beams intended to be used in the COT.For EDT determination, define Pout as the maximum EIRP over that intended set of transmit beams. |
| Huawei HiSilicon | Proposal 1: For operation in NR-U-60, confirm the working assumptions on the definition of Pout in the previously agreed baseline EDT formula. |
| Nokia Nokia Shanghai Bell | Proposal 7: For Pout in EDT determination, define Pout as at least the maximum of beam-specific mean EIRPs of the node determining EDT during a COT.Proposal 10: CG PUSCH configuration and operation is investigated in light of EDT dependency on Pout. |
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| vivo | Proposal 6: The maximum output EIRP of the beams or transmission bursts within a COT is used to calculate the EDT. |

### First Round Discussion

12 Companies (AT&T, CATT, Huawei, Intel, Interdigital, LG, NEC, Qualcomm, OPPO, Spreadtrum, Vivo, ZTE) are proposing to modify Energy Detection based computation to include transmit beamforming and sensing beam. 2 companies (Nokia and Ericsson) are against this.

Discussion 2.1.1-1

On further adjustment on ED threshold based on the sensing beam and the transmission beam (further adjustment should not violate EDT requirements as per regulations), please provide your view for the following

* Alt A: Support additional adjustment to Energy Detection computation to include transmit beamforming and sensing beam relationship
	+ FFS how to adjust
* Alt B: No additional adjustment to Energy Detection computation introduced (Energy measurement directly compared with baseline EDT agreed no matter which transmit beamform(s) and sensing beam(s) are used

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| Company | View |
| Nokia, NSB | Alt B. We do not see a benefit is defining more strict EDT definitions than what the ETSI harmonized standard requires.Directivity of transmissions is considered in ETSI EN 303 722, and the new work item EN 303 753. In these cases, LBT is not required at all, provided that certain conditions for e.g. antenna gain are fulfilled.On the contrary ETSI EN 302 567 does not acknowledge any relationship between the beamwidth and the EDT. Since EDT cannot be increased above the value given by the formula 4.2.5.3 in 302567, consideration of the beamwidth in EDT calculation could only result in reduced EDT for wider beams. Therefore, for a device operation according to EN 302 567, EDT should not be impacted by antenna gain. |
| Charter Communications | Alt B.We do not see a need to penalize device EDT settings based on antenna array capabilities. |
| Lenovo, Motorola Mobility | We suggest postponing this discussion until we make some progress on defining relationship between sensing and transmission beams (section 2.9) |
| ZTE, Sanechips | We support Alt A, especially for the case that the sensing beam is inconsistent with the transmission beam. In order to accurately evaluate the actual interference in the transmission beam, it is recommended to consider introduction an additional factor in current ED threshold formula to reflect the difference of transmission beam and reception beam. |
| Intel | We support Alt. A. As it has been highlighted during the SI, when a low ED threshold is used, LBT performed with more directional beams may overperform LBT performed using a wider beam given that the level of protection offered by the later gets increased, which may help sufficiently mitigate the hidden node issue bringing this in par with that of LBT performed with more directional beams while still offering better spatial reuse than that. In this matter, it may be beneficial within the ED threshold calculation to also account more specifically for the measurement beam used so that to exploit the advantage described above. |
| vivo | Support Alt A with the following wording update as below. Alt A: Support additional adjustment to Energy Detection computation to include transmit beamforming and sensing beam ~~relationship~~Since Pout is RF output power (EIRP), the beamforming gain of the transmission beam has already been included in the EDT equation. For additional adjustment, only the impact of the beamforming gain of the directional sensing beams should be considered. |
| Apple | Support Alt A. Transmission beamforming gain is already included in the EDT calculation. Sensing beamforming gain and transmission beamforming gain should be compensated based on regulation requirement.  |

Multiple companies have proposed to clarify the working assumption of Pout as the maximum EIRP of the node determining EDT during a COT.

Proposal 2.1.1-2

Confirm the working assumption that “For Pout in EDT determination, define Pout as the maximum EIRP of the node determining EDT during a COT”.

* FFS: For COT sharing case, if the maximum EIRP of the responding device needs to be considered for EDT determination

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| Company | View |
| Nokia, NSB | While we acknowledge that calculation the mean EIRP may be more complex than max EIRP, we want to stress that EN 302 567 allows for use of mean EIRP. We do not see a need to define more stringent EDT definition than what ETSI allows for, and therefor propose the following modification.* For Pout in EDT determination, define Pout as at least the maximum of beam-specific mean EIRPs of the node determining EDT during a COT.

Note that this definition still allows a device to calculate the Pout according to max EIPR as in the working assumption (i.e. more conservatively), but does not unnecessarily penalize other devices that can calculate the mean EIRP as well. |
| Charter Communications | Open to Nokia’s definition |
| Lenovo, Motorola Mobility | We support to confirm the working assumption |
| ZTE, Sanechips | The definition of Pout in EN 302 567 is the mean Equivalent Isotropically Radiated Power(EIRP) for the equipment during a transmission burst. While we reached WA that “For Pout in EDT determination, define Pout as the maximum EIRP of the node determining EDT during a COT”. In order to better match the definition of Pout in EN 302 567 and WA as reached in 3GPP, we think WA should be modified as below:For Pout in EDT determination, define Pout as the maximum of mean EIRP of transmission bursts for the node determining EDT during a COT.Further, considered beam feature, we also agree the modification from Nokia.However, for the responding device, the same rule should be also applied.  |
| Intel | We are OK with the proposal and to confirm the previous working assumption. As for the FFS, we do not see the technical reason to include the EIRP of the responding device within the calculation.  |
| vivo | We support to confirm the WA. For COT sharing case, it is not necessary to take into account the maximum EIRP of the responding device. |
| Apple  | Support to confirm the WA.  |

## LBT Bandwidth FFS Items

Agreement:

For LBT for single carrier transmission, consider the following alternatives

* 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 (to be transmitted in) in the channel bandwidth

For LBT for multi-carrier transmission in intra-band CA, consider the following alternatives

* 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 (to be transmitted in) in the channel bandwidth in each CC

Note: supporting more than one alternative for at least multi-carrier transmission in intra-band CA is not precluded.

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| **Company** | **Key Proposals/Observations/Positions** |
| Apple | Proposal 1: LBT bandwidth is channel bandwidth for single carrier.Proposal 2: For multi-carrier, gNB/UE perform multiple LBT, one for each channel bandwidth separately.  |
| CAICT | Proposal 1: For LBT for single carrier transmission, Alt SC.1 should be supported.Proposal 2: For LBT for multi-carrier transmission, Alt CA.1 and Alt CA.2 should be supported. |
| CATT | Proposal 8: For LBT bandwidth, Alt SC.1 and Alt CA.1 should be supported. |
| Charter Communications | Proposal 2: For single-carrier LBT, support Alt SC.3 with a pre-defined unit of LBT bandwidth. FFS if the unit is dependent on SCS, for e.g., 100 MHz for 120 kHz and 400 MHz for 480/960 kHz.Proposal 3: For multi-carrier LBT, support Alt CA.5. Define a unit of LBT bandwidth and gNB/UE performs LBT in all the LBT units (to be transmitted in) in the channel bandwidth in each CC. |
| Convida Wireless | Proposal 14: To down-select the options of LBT BW with single carrier and multi-carrier operation for supporting NR form 52.6 GHz to 71 GHz, co-existence of single carrier and multi-carrier operation within a same channel BW should be studied. |
| Ericsson | Observation 2 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 3 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.Observation 4 Operating channel BW defined in EN 302 567 is the LBT BW in RAN1 which is already defined in 37.213 as a “channel”Observation 5 Alt SC3/CA5 poses an artificial restriction to insert guard bands at the end of the LBT unitsObservation 6 For SC3, LBT failure for a node within a LBT unit is complex and not discussed.Observation 7 Definitions in EN 302 567 and TS 37.213 at least covers Alt SC1.Proposal 3 Support Alt SC1/Alt CA1 for LBT in single carrier and multi-carrier operation. Other options are not precluded by implementation.Proposal 4 Support Alt1 in the agreement that allows only Type A multi-channel access from 37.213. |
| FUTUREWEI | Proposal 1: In LBT for single carrier transmission gNB/UE performs LBT over the channel bandwidth (or BWP bandwidth)*Proposal 2: In LBT for multi carrier transmission gNB/UE support:• gNB/UE performs multiple LBT, one for each channel bandwidth separately,• gNB/UE performs single LBT over all CCs.* |
| Huawei HiSilicon | Proposal 2: For operation in NR-U-60, the term ‘Operating Channel Bandwidth’ in the agreed baseline EDT formula is defined as the ‘LBT Bandwidth’ or the ‘bandwidth on which a channel access procedure is performed in shared spectrum’. Proposal 9: For a single-carrier transmission in NR-U-60, support performing a single LBT over the channel/BWP bandwidth, i.e. Alt SC.1.Proposal 10: For a multi-carrier transmission in intra-band CA in NR-U-60, support both performing a single LBT over all CCs, and performing multiple LBTs, one for each channel bandwidth separately, i.e., Alt CA.2 and Alt CA.1, respectively.  |
| Intel Corporation | Proposal 6: In single carrier transmission, a gNB/UE performs LBT over the channel bandwidth.Proposal 7: For carrier aggregation, a gNB/UE performs multiple LBTs and one over each channel bandwidth. |
| InterDigital Inc. | Proposal 12: The Operating Channel BW used in the EDT formula is equivalent to the LBT BW.Proposal 13: For single-carrier transmission, support Alt SC.3.Proposal 14: For multi-carrier transmission, support Alt CA.5.Proposal 15: Support a set of LBT BWs and LBT is performed in each CC on one or more adjacent LBT BWs that covers at least the transmission BW. |
| Lenovo Motorola Mobility | Proposal 1: 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.Proposal 2: For NR unlicensed bands between 52.6 GHz and 71 GHz, for LBT based channel access mechanism:- For single carrier transmission defining a unit of LBT bandwidth where gNB/UE performs LBT in all the LBT units (to be transmitted in) in the channel bandwidth- For multi-carrier transmission in intra-band CA, support defining a unit of LBT bandwidth where gNB/UE performs LBT in all the LBT units (to be transmitted in) in the channel bandwidth in each CC - Defined LBT bandwidth value is fixed for both cases |
| LG Electronics | Proposal #3: Define a unit of LBT bandwidth and gNB/UE performs LBT in all the LBT units (to be transmitted in) in the channel bandwidth. |
| Nokia Nokia Shanghai Bell | Proposal 9: The operating channel bandwidth in EDT determination equals to the LBT bandwidth.Proposal 11: All the LBT bandwidth options in the agreements from RAN1#104bis-e shall be supported without further down-selection for both single and multiple carrier transmission.Proposal 12: How to perform LBT is left to implementation as long as the LBT bandwidth used covers the transmission bandwidth for NR-U on 60GHz band. |
| NTT DOCOMO INC. | Proposal 1:l For LBT for single carrier transmission and multi-carrier transmission in intra-band CA, support either of the following:Ø Alt.A: Adopt Alt SC.1 (gNB/UE performs LBT over the channel bandwidth (or BWP bandwidth)) for single carrier transmission and Alt CA.1 (gNB/UE performs multiple LBT, one for each channel bandwidth separately) for multi-carrier transmission in intra-band CAØ Alt.B: Adopt Alt SC.3 (Define a unit of LBT bandwidth and gNB/UE performs LBT in all the LBT units (to be transmitted in) in the channel bandwidth) for single carrier transmission and Alt CA.5 (Define a unit of LBT bandwidth and gNB/UE performs LBT in all the LBT units (to be transmitted in) in the channel bandwidth in each CC) for multi-carrier transmission in intra-band CA² Minimum CBW can be considered as the unit of LBT bandwidth |
| OPPO | Proposal 1: support both Alt SC.1 and Alt SC. 3.Proposal 2: support both Alt CA.1 and Alt CA.5. |
| Qualcomm Incorporated | Proposal 8: Support enhanced RSSI reporting for Rx-Assistance, enhancements include at least L1-RSSI measurement, and AP-CSI based L1-RSSI reportingProposal 9: For single carrier LBT, support both Alt SC.1 and Alt SC.3 as implementation choices, as long as the aggregated LBT bandwidth covers the transmission bandwidth. FFS how to indicate the aggregated LBT bandwidth from the COT initiating node to the COT sharing node.Proposal 10: For multi-carrier transmission in intra-band CA, support Alt-CA.1, Alt-CA-2, and Alt CA.5 as implementation choices, as long as the aggregated LBT bandwidth covers the transmission bandwidth.Proposal 11: Consider specifying the maximum number of LBT-Bandwidth units a UE can sense as a UE capability. |
| Samsung | Proposal 2: For LBT bandwidth, support Alt SC.1 + CA.1 + CA.2 as the first preference, and SC.3 + CA.5 as the second preference.Proposal 6: ED threshold should depend on:• Whether other technology sharing the channel is absent or not on a long-term basis;• LBT bandwidth (which is operation channel bandwidth in regulation);• Beam parameters including beamforming gain and/or beam direction for transmission and/or receiving.  |
| Spreadtrum Communications | Proposal 1: Regarding LBT bandwidth, at least Alt SC.1 and Alt CA.1 should be supported.• For single carrier transmission, at least gNB/UE should perform LBT over the channel bandwidth (or BWP bandwidth)• For multi-carrier transmission, at least gNB/UE should perform multiple LBT, one for each channel bandwidth separately |
| vivo | Proposal 1: Both Alt SC.1 and Alt SC. 3 are supported for single carrier transmission, gNB performs multi-channel LBT in all the LBT units to be transmitted in, and the UE performs wideband LBT over the active BWP or over all the LBT units to be transmitted in.Proposal 2: Both Alt CA.1 and Alt CA. 5 are supported for multi-carrier transmission, gNB performs multi-channel LBT in all the LBT units to be transmitted in, and the UE performs wideband LBT over the active BWP or over all the LBT units to be transmitted in in each carrier.Proposal 7: The LBT bandwidth should be used as the operating channel bandwidth for EDT evaluation. |
| WILUS Inc. | Proposal 1: We support o Alt SC.3 for LBT on single carrier transmission.o At least Alt CA.1 or Alt CA.5 for LBT on multi-carrier transmission in intra-band CA. |
| Xiaomi | Proposal 1: Support Alt SC.3 for LBT for single carrier transmission, and Alt CA.5 for multi-carrier transmission in intra-band CA. |
| ZTE Sanechips | Proposal 1: Support Alt SC.3 that “Define a unit of LBT bandwidth and gNB/UE performs LBT in all the LBT units (to be transmitted in) in the channel bandwidth” and Alt CA.5 that “Define a unit of LBT bandwidth and gNB/UE performs LBT in all the LBT units (to be transmitted in) in the channel bandwidth in each CC”, considering channel access probability and spectrum utilization and friendly and fair coexistence between the same systems or different systems.Proposal 2: If Alt SC.3 and Alt CA.5 are supported, it is recommended that the unit of LBT bandwidth is defined as the minimum channel bandwidth.Proposal 3: If Alt SC.3 and Alt CA.5 are supported, it is not necessary to separately define LBT bandwidth for single carrier and multi-carrier cases, just a LBT bandwidth unit needs to be defined.Proposal 4: Considering Alt SC.1 and Alt CA.1 are the special cases of Alt SC.3 and CA.5 respectively, Alt SC.1 and Alt CA.1 can be also supported only if the channel bandwidth is configured as the minimum channel bandwidth that is regarded as the unit of LBT bandwidth.Observation 1: It is worth emphasizing that the OCB should be satisfied for each transmitter such as gNB or UE.Proposal 5: 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 6: 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. |

### First Round Discussion

For LBT for single carrier transmission, the following positions have been reached.

* Alt SC.1. gNB/UE performs LBT over the channel bandwidth (or BWP bandwidth)
	+ Apple, CAICT, CATT, Ericsson, FUTUREWEI, Huawei, Intel, Nokia, DOCOMO, OPPO, Qualcomm, Samsung (1st Preference), Spreadtrum, vivo
* Alt SC.3. Define a unit of LBT bandwidth and gNB/UE performs LBT in all the LBT units (to be transmitted in) in the channel bandwidth
	+ Charter, InterDigital, Lenovo, LG, DOCOMO, OPPO, Qualcomm (unit sizes left to implementation), Samsung (2nd Preference), vivo, WILUS, Xiaomi, ZTE

For LBT for multi-carrier transmission in intra-band CA, the following positions have been reached.

* Alt CA.1. gNB/UE performs multiple LBT, one for each channel bandwidth separately
	+ Apple, CAICT , CATT, Ericsson, FUTUREWEI, Huawei, Intel, OPPO, Samsung (1st Preference) , Spreadtrum, vivo, WILUS
* Alt CA.2. gNB/UE performs single LBT over all CCs
	+ CAICT, FUTUREWEI, Huawei, Samsung (1st Preference)
* Alt CA.5. Define a unit of LBT bandwidth and gNB/UE performs LBT in all the LBT units (to be transmitted in) in the channel bandwidth in each CC
	+ Charter, InterDigital, Lenovo, DOCOMO, OPPO , Qualcomm (unit sizes left to implementation), Samsung (2nd Preference) , vivo, WILUS, Xiaomi, ZTE

Proposal 2.2.1-1

For LBT for single carrier transmissions, support both Alt SC.1 and Alt SC.3, and leave the choice to gNB/UE implementation.

* FFS if and how gNB indicates the LBT bandwidth adopted to UE
* FFS if and how UE indicates the LBT bandwidth adopted to gNB

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| Company | View |
| Nokia, NSB | We support at least Alt SC.1. Alt SC.3 is also ok in principle, but we would like to first see what options for LBT bandwidth are considered.For the choice of LBT bandwidth, we are not yet sure if leaving the choice of the LBT BW for UE is a reasonable approach. As the baseline, the network should have means for controlling UE’s LBT BW. |
| Charter Communications | OK with the compromise proposal, but hesitant to leave the LBT bandwidth open to implementation. Also a question for Alt SC. 1, if there is interference that is non-contiguous in frequency domain, what is the chunk granularity that gNB/UE assumes is available for transmission? |
| Lenovo, Motorola Mobility | Although we support Alt SC. 1 but are ok with proposal to support both. However, the choice should be only up to the network, and not UE |
| ZTE, Sanechips | Although we prefer to support Alt SC.3, but considering Alt SC.1 can be considered as a special case of Alt SC.3 only if the channel bandwidth is configured as the minimum channel bandwidth that is regarded as the unit of LBT bandwidth, we can also accept Alt SC.1. specifically, how to support one of these two methods for gNB/UE, we can discuss it further.  |
| Intel | We are not OK to leave up to gNB/UE’s implementation to decide which definition of the LBT BW to use, and we would rather prefer to down-select one of the alternatives. While the group has introduced a factor within the ED threshold to account for the BW, the resulting values that could be calculated may differ based on the LBT BW definition that is used even when the channel/transmission BW may be the same. This would induce co-existence issues, that the group was trying to mitigate by introducing the dependency from the BW. Also, we do not see the need to introduce additional signalling and overhead to indicate the definition of the LBT BW used.Among the two options, while both are technically valid, our preference is for Alt. SC.1, which is the simplest solution. As for Alt. SC.3, we lack to understand why we may need to overcomplicate the design, and what is the technical motivation to introduce a specific LBT BW unit. This was well motivated for sub-6 GHz band, since the ETSI BRAN imposes a 20 MHZ LBT BW, but for above 52.6 GHz no restrictions are mandated.  |
| vivo | Support to have both Alt SC.1 and Alt SC.3. For Alt SC.3, the LBT unit can be configured via RRC signalling. For UE, Alt SC.1 or wideband LBT over all the LBT units (to be transmitted in) should be applied since multi-channel LBT over multiple LBT units will not bring benefit. UEs are only allowed to transmit when all the LBT units are idle. For gNB, the LBT bandwidth is up to implementation and there is no need to indicate to UE. |
| Apple | Do not support the proposal. It is not clear how alt SC3 works when LBT unit size is left for UE and gNB implementation. In NR-U, the size is 20MHz defined by regulation.  |

Proposal 2.2.1-2

For LBT for multi-carrier transmissions in intra-band CA, support Alt CA.1, Alt CA.2, and Alt CA.5, and leave the choice to gNB/UE implementation.

* FFS if and how gNB indicates the LBT bandwidth adopted to UE
* FFS if and how UE indicates the LBT bandwidth adopted to gNB

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| Company | View |
| Nokia, NSB | We are in principle ok with supporting all alternatives, but for Alt 5, more discussion on the possible BW options would be needed before agreeing.Similarly as in the single carrier case, as a starting point the network should be able control the LBT BW that the UE uses. |
| Charter Communications | OK with the compromise proposal with the same caveat as the single carrier case. |
| Lenovo, Motorola Mobility | Although we support Alt CA. 5 but are ok with proposal to support all three. However, the choice should be only up to the network, and not UE |
| ZTE, Sanechips | If proposal 2.2.1-1 is agreed, then it is a nature way that proposal 2.2.1-2 should be also supported. But eventually it depends on the result of proposal 2.2.1-1 discussion.  |
| Intel | Please see comments above. |
| vivo | We only support Alt CA.1 and Alt CA.5. The application of Alt CA.2 should be FFS since the over protection will reduce the performance of CA. For example, is it feasible/desirable to perform a single LBT covering say 5 CC each with around 2 GHz channel bandwidth? |
| Apple | Do not support this proposal. It is not clear how alt CA5 works when LBT unit size is left for UE and gNB implementation. In NR-U, the size is 20MHz defined by regulation.  |

## Sensing Structures FFS Items

Agreement:

For energy measurement in 8us deferral period, down-select from the following:

* Alt 1. Two energy measurements are required
* Alt 2. One measurement is required
* Alt 3. Extend the 8us to 10us and perform two measurements, one in each 5us segment

For energy measurement in 5us observation slot, perform single measurement

* FFS minimum duration of the measurement
* FFS location of the measurement

Working assumption:

* For energy measurement in 5us observation slot, when performing single measurement, the location of the measurement within the 5us is left for implementation, i.e., anywhere within the 5us.FFS location of the measurement

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| **Company** | **Key Proposals/Observations/Positions** |
| Apple | Proposal 10: Only one sensing is required in 8us initial sensing period. It is up to implementation to perform two sensing, or longer sensing time for better accuracy.  |
| CAICT | Proposal 3: One measurement for energy measurement in 8us deferral period is proposed.Proposal 4: the minimum duration of one measurement in 5us observation slot equals the length of one symbol length for 480kHz. |
| CATT | Proposal 3: The minimum duration of deferral period is 8us.Proposal 4: One energy measurement is required for 8us deferral period. |
| Ericsson | Observation 27 IEEE 802.11ad and IEEE 802.11ay do not perform two energy measurements in the 8 µs deferral periodObservation 28 ETSI HS does not require two energy measurements in 8 µs deferral period.Observation 29 No simulation studies to suggest that two energy measurements are needed in an 8us deferral period for good coexistence.Proposal 18 For energy measurement in 8 µs deferral period, Alt2 is preferred.Proposal 19 The minimum duration of energy measurement within 5 µs can be left for implementation.Proposal 20 Confirm the working assumption that for the location of the energy measurement in 5us,it can be left for implementation. |
| Huawei HiSilicon | Proposal 6: Confirm the following WA reached in RAN1 #104bis-e:“For energy measurement in 5us observation slot, when performing single measurement, the location of the measurement within the 5us is left for implementation, i.e., anywhere within the 5us.”Proposal 7: For operation in NR-U-60, when LBT is used, the measurement duration X us within the 5us observation is implementation specific.Proposal 8: For operation in NR-U-60, when LBT is used, support one energy measurement in the 8us deferral period.Td consists of a Tf duration immediately followed by a 5us slot duration, and Tf=3us does not include any measurement duration.  |
| Intel Corporation | Proposal 1: Alt-1 is supported and the 8us observation period is divided into two slots of 3 and 5us, respectively. For the energy measurement in the 3us observation slot, the location of the measurement is left up to implementation. |
| OPPO | Proposal 3: two energy measurements are required during a 8us deferral period.Proposal 4: a minimum measurement duration of 2us can be considered. Proposal 5: confirm the following working assumption Working assumption:For energy measurement in 5us observation slot, when performing single measurement, the location of the measurement within the 5us is left for implementation, i.e., anywhere within the 5us. |
| Samsung | Proposal 3: For sensing structure, confirm the working assumption from RAN1#104b-e, and support single energy measurement within the 8 us deferral period. |
| Spreadtrum Communications | Proposal 6: Two energy measurements are required for 8us deferral period.Proposal 7: The duration of the measurement should be 3us for 5us observation slot. |
| WILUS Inc. | Proposal 2: We propose to support Alt-2 that one measurement is required for energy measurement in 8us deferral period. Option 1: For the sensing structure within 8us deferral period, the regulation does not specify anything which is left to the implementation at the device. Regardless of one or two energy measurements are required, it seems reasonable to be left to the implementation aspects.  Option 2: Similar to define performing one energy measurement for 16us Cat-2 LBT in Rel-16 NR-U considering to actually miss the channel busy within a 16us, the 8us deferral period includes an observation slot that occurs within the last 5us of 8us deferral period. The channel is considered to be idle within the duration of the 8us deferral period if the channel is sensed to be idle for a total of at least (5us or 4us) with at least 3us of sensing occurring in the sensing slot.Option 3: Similar to define performing one energy measurement for 16us Cat-2 LBT in Rel-16 NR-U considering to actually miss the channel busy within a 16us, the channel is considered to be idle within the duration of the 8us deferral period if the channel is sensed to be idle for a total of at least 5us with at least 3us of sensing occurring in the deferral period. |
| ZTE Sanechips | Observation 12: Deferral period can be composed of 3us observation slot and one or more consecutive 5us observation slot.Observation 13: Energy measurement is performed in 3us observation slot and one or more consecutive 5us observation slot(s), respectively.Observation 14: For deferral period and 5us observation slot, the length of energy measurement can be further discussed.Observation 11: Consider the minimum value of deferral period as 8us in CCA check procedure of EN 302 567 and specific deferral period value is related to the channel access priority class (p). |

### First Round Discussion

Summary: Current support for sensing structure discussion items appears as follows.

For energy measurement in (minimum) 8us deferral period, continue down-selection between the following alternatives:

* Alt 1. Two energy measurements are required
	+ Intel, OPPO, spreadtrum,
* Alt 2. One measurement is required
	+ Apple, CAICT, CATT, Ericsson, Huawei, Samsung,
* Alt 3. Extend the 8us to 10us and perform two measurements, one in each 5us segment
	+ ZTE
* Implementation
	+ WILUS

For energy measurement in 8us observation slot, with minimum duration of the measurement

* + 2us (OPPO), 3us (ZTE)

Proposal 2.3.1-1:

For energy measurement in 8us deferral period, continue down-selection between the following alternatives

* Alt 1. Two energy measurements are required, with one measurement in the first 3us and one measurement in the last 5us
* Alt 2. One measurement is required
	+ FFS where the measurement is located

Note: By implementation, it is possible to support longer than 8us deferral period (Intend to cover Alt 3 as implementation choice for either Alt 1 or Alt 2)

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| Company | View |
| Nokia, NSB | We are ok with Alt 2. |
| Charter Communications | Fine with Alt 2.  |
| Lenovo, Motorola Mobility | We prefer Alt 1 to have two energy measurements |
| ZTE, Sanechips | We support Alt 1 considering such sensing structure is also used in LTE-LAA and NR-U and it is different with that of Wi-Fi, so I am not sure why we have to keep sensing structure in 52.6GHz the same as in 802.11ad/ay. |
| Intel | We are OK with the proposal 2.3.1-1, and we prefer Alt. 1. Also as for the duration of the measurement, we could impose a minimum of 2 us (to resemble IEEE), and leave up to implementation the actual duration.  |
| Apple  | Alt 2. This is what required by regulation and implemented by 802.11ad. For devices want to improve accuracy with longer sensing time, device can always perform longer sensing.  |

## COT Sharing

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| Agreement:On maximum gap within a COT to allow COT sharing without LBT, down-select from* 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 Y
	+ FFS:  How to define the one-shot LBT
* FFS location of the measurement
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| **Company** | **Key Proposals/Observations/Positions** |
| Apple | Proposal 11: Regulation does not define max gap duration in COT sharing without LBT. Since any gap is counted into 5ms COT, no gap limitation needs to be specified.  |
| CAICT | Proposal 5: Alt.3 should be supported for COT sharing.Proposal 6：When the later transmission starts after the defined maximum gap from the end of the earlier transmission, whether a one-short LBT needs to be performed can be decided by gNB. |
| Ericsson | Observation 26 ETSI BRAN regulations do not specify a minimum or maximum gap in the 60 GHz HS.Proposal 16 Support Alt 1 for gaps in COT sharing. |
| FUTUREWEI | Proposal 6: 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, a one-shot LBT is needed to share the COT:• Where Y (for all SCS) may be the time duration of 3 symbols (@120 kHz SCS • Where One-shot LBT duration (for all SCS): the time duration of 1 symbol @ 120kHz SCS |
| Huawei HiSilicon | Proposal 18: For COT sharing without LBT in NR-U-60, no maximum gap is defined and a later transmission from a responding device can share the COT without LBT irrespective to the gap duration within the MCOT.Any gap duration should be counted in the COT duration |
| InterDigital Inc. | Proposal 16: When COT sharing, a UE determines what LBT to use based on the gap duration between the upcoming transmission and a previous transmission on the same beam. |
| Lenovo Motorola Mobility | Proposal 16: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, 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, one-shot LBT is needed to share the COTProposal 17: 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 COTProposal 18: 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. |
| Nokia Nokia Shanghai Bell | Proposal 26: On maximum gap within a COT to allow COT sharing without LBT, we support Alt. 1. Proposal 27: In case of Alt.2 or Alt.3 for COT sharing without LBT, the maximum time gap X is at least longer that PDSCH processing time and PUSCH preparation time. |
| OPPO | Proposal 11: 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. The value of Y is 8us or 13us. |
| Spreadtrum Communications | Proposal 8: Regarding COT sharing, NO maximum gap is needed. |
| vivo | Proposal 3: No maximum gap is defined for COT sharing. A later transmission can share the COT without LBT with any gap within the maximum COT duration. |
| WILUS Inc. | Proposal 3: We support Alt-1 since it seems no need to define a maximum gap for COT sharing within the maximum COT duration from the ETSI regulation perspectives. |

### First Round Discussion

On maximum gap within a COT to allow COT sharing without LBT, the following positions are collected.

* Alt 1. No maximum gap defined. A later transmission can share the COT without LBT with any gap within the maximum COT duration
	+ Apple, Ericsson, Huawei, Nokia, Spreadtrum, vivo, WILUS
* 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
* 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, a one-shot LBT is needed to share the COT
	+ CAICT, FUTUREWEI, Lenovo, OPPO, InterDigital?

Discussion 2.4.1-1:

On maximum gap within a COT to allow COT sharing without LBT, please provide your view on the following alternatives

* Alt 1. No maximum gap defined. A later transmission can share the COT without LBT with any gap within the maximum COT duration
	+ Support: Apple, Ericsson, Huawei, Nokia, Spreadtrum, vivo, WILUS
* 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
* 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
	+ Support: CAICT, FUTUREWEI, Lenovo, OPPO, InterDigital?

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| Company | View |
| Nokia, NSB | We are ok with either Alt 1 or Alt 2.  |
| Charter Communications | Support Alt 1 |
| Lenovo, Motorola Mobility | We support Alt 3. If no maximum gap is defined, and channel can be accessed without LBT within the maximum COT duration, there is a possibility that channel can become occupied. |
| ZTE, Sanechips | We support Alt 3 and think one-shot LBT is necessary before the later transmission to prevent the bursty interference, which is not only conducive to prevent interference to the equipment that is already transmitting, but also to avoid interference and influence from other equipment. |
| Intel | Our view is that both Alt.1 and Alt.3 can be supported. One-shot LBT, if introduced, should be used in a configurable manner up to gNB. When the one-shot LBT is not used, Alt.1 is used, which is consistent with the minimum requirements mandated by the ETSI BRAN. However, when one-shot LBT is configured, Alt-3 is used, and the concept of maximum gap could be used to discern the case when no-LBT or one-shot LBT is used. |
| vivo | Alt-1 is supported. According to the ETSI BRAN regulation, no maximum gap is specified. Therefore, we prefer not to impose additional constrains. |
| Apple  | We support alternative 1 per regulation requirement. We do not see how Y can be determined. If we use 802.11ad as reference for Y value, the same way as LAA/NR-Uusing 802.11a, Y is 3us which is way to small.  |

## Cat 2 LBT

Agreement:

For Cat 2 LBT, down-select from the following alternatives

* Alt 1: Do not introduce Cat 2 LBT for 60GHz unlicensed band operation
* Alt 2: Introduce Cat 2 LBT for 60GHz unlicensed band operation

Agreement:

If Cat 2 LBT is introduced, the following use cases can be further studied:

* Resume transmission after a gap Y:  Cat 2 LBT may be used to resume transmission by the initiating device within the COT after a gap Y (FFS the value of Y)
* COT sharing: Cat 2 LBT may be used before transmission by a responding node sharing a COT
* Multi-Beam LBT:  Cat 2 LBT may be used before switching to a new transmission beam (not used in earlier part of the COT) in a COT with TDM beams, or resume a previously used transmission beam after a gap Z (FFS the value of Z)
* Rx-Assistance:  Cat 2 LBT may be used for sensing at the receiver as a responding device for Rx-Assistance measurements and associated signalling

Other use cases not precluded.

FFS if Cat 2 LBT is mandated for each use case or not.

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| **Company** | **Key Proposals/Observations/Positions** |
| Apple | Proposal 12: No CAT-2 LBT needs to be defined for COT sharing.  |
| AT&T | Within a COT with TDM of beams with beam switching, independent per-beam LBT sensing at the start of COT is performed for beams used in the COT with additional requirement on Cat 2 LBT before beam switchThe per-beam LBT for different beams is performed one after another in time domain. The node completes one eCCA on one beam, and directly move on to the eCCA on the other beam, with no transmission in the middle |
| CAICT | Proposal 6: Cat2 LBT should be supported.Proposal 5: Cat 2 LBT should be introduced for 60GHz NR-U.Proposal 14: Performing Cat 2 LBT before beam switching within the COT could be supported, and it can be decided by gNB. |
| Charter Communications | Proposal 6: Do not introduce Cat 2 LBT for 60GHz unlicensed band operation. |
| Ericsson | Observation 23 CAT2 LBT is not specified in HS EN 302 567Observation 24 Simulations study show that there is no consistent gain using CAT2 LBT compared to no LBT for COT sharing.Observation 25 It is not precluded to do CAT2 LBT in addition to the CAT3 LBT requirements. There is no motivation to specify it in the 3GPP RAN1 standard.Proposal 15 Do not support CAT2 LBT for NR operation in 52.6 GHz to 71 GHz. |
| FUTUREWEI | Proposal 5: Introduce Cat 2 LBT for 60GHz unlicensed band operation.Proposal 7: When independent per-beam LBT sensing at the start of COT is performed for beams used in the COT, an additional requirement on Cat 2 LBT before beam switch during the COT should be specified. |
| Huawei HiSilicon | Proposal 19: Support introducing CAT2 LBT for 60GHz unlicensed band operation (Alt 2 in the agreement made in RAN1#104-e). Support only use cases related to COT initiation, i.e., starting transmission on a secondary channel in Type B multi-channel access, and energy measurement and reporting of Rx-assistance information by the receiver in Rx-assisted LBT.  |
| Intel Corporation | Proposal 10: Cat-2 LBT is introduced for 60 GHz unlicensed band operation. |
| LG Electronics | Proposal #8: Type 2 (e.g., 2A/2B/2C) channel access procedure can be introduced for the use cases such as COT sharing, multi-beam LBT, and Rx-Assistance and the maximum gap Y between the transmissions within the COT can be defined for above 52.6 GHz. |
| NEC | Proposal 3: A maximum gap Y should be defined, 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.Proposal 4: Cat 2 LBT for 60GHz unlicensed band operation should be introduced. |
| Nokia Nokia Shanghai Bell | Proposal 3: Decide on Cat-2 LBT support separately for gNB and UE.Proposal 4: Decide on Cat-2 LBT support together with the specific Cat-2 LBT use case.Proposal 5: Do not support Cat-2 LBT at the UE side.Proposal 6: Do not support Cat-2 LBT at the gNB side unless required for SSB transmission.Proposal 16: One-shot LBT within COT is not required before gNB beam switch between SSBsObservation 4: Use of LBT provides mostly loss of median throughput compared to no-LBT modeObservation 5: Use of LBT reduces throughput for cell edge UesObservation 6: Simulation results do not show any gain from introduction of additional Cat-2 LBT at gNB beam switch during COT.  |
| NTT DOCOMO INC. | Proposal 2: Cat 2 LBT, i.e., LBT with fixed sensing duration, should be introduced for 60 GHz unlicensed band operation, at least to support COT sharing.l Other use cases can be studied further |
| OPPO | Proposal 12: introduce Cat-2 LBT with a sensing duration of 13us, which further consists of an 8us duration followed by a 5us sensing slot. |
| Panasonic | Proposal 4: For a COT with TDM of beams, support both Alt-1 and Alt-2 in the previous agreement at the start of COT. Whether or not additional Cat 2 LBT is required before beam switching within the COT depends on the gap of no transmission of the next beam direction.  |
| Qualcomm Incorporated | Proposal 7: Consider defining Cat 2 LBT as a sensing/measurement. Consider the use of such Cat 2 LBT sensing as an optional/configured and triggered component of LBT proceduresProposal 14: Support Alt 2 for Multi-Channel LBT. For Type B multi-channel access, introduce Cat 2 LBT for non-primary channels. |
| Samsung | Proposal 4: 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. |
| Sony | Proposal 7: Directional LBT should be supported in 60 GHz unlicensed operation. |
| Spreadtrum Communications | Proposal 9: Cat 2 LBT should be supported for 60GHz unlicensed band operation.Proposal 10: Cat 2 LBT may be used in case of Receiver-Assistance. |
| vivo | Proposal 4: The Cat 2 LBT can be used before switching to a new beam in a COT with TDM beams, before response with assistant information at the receiver, and in the Type B multi-channel access scheme. |
| WILUS Inc. | Proposal 5: We support Alt-2 to introduce Cat 2 LBT for 60GHz unlicensed band operation. |
| ZTE Sanechips | Observation 10: Current CCA check procedure in EN 302 567 can be regarded as “Cat 4” rather than “Cat3”.Proposal 17: Cat 2/one-shot LBT should be considered to be introduced in above 52.6GHz for the following cases:• COT sharing• FBE mode• Multi-channel access procedure• Rx-assisted LBT• Resume transmission/beam switching |

### First Round Discussion

Summary: Current support for CAT 2 LBT FFS item appears as follows.

For Cat 2 LBT,

* Alt 1: Do not introduce Cat 2 LBT for 60GHz unlicensed band operation
	+ Apple, Charter, Ericsson, Nokia, MTK
* Alt 2: Introduce Cat 2 LBT for 60GHz unlicensed band operation
	+ AT&T, CAICT, FUTUREWEI, Huawei, Intel, LGE, NEC, NEC, NTT, OPPO, Qualcomm, Samsung, Spreadtrum, vivo, WILUS, ZTE,

Seems that there is relative majority on introducing Cat 2 LBT, though there is strong objections from multiple companies as well. I would like to see if we can reach some compromise.

Discussion 2.5.1-1

Do you agree with the following statement: For the use case of Cat 2 LBT identified, a Cat 4 LBT can serve the purpose as well, at the cost of longer LBT time, and uncertainty of LBT time.

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| Company | View |
| Nokia, NSB | Alt 1. Since EN 302 567 does now recognize Cat 2 LBT, we do not see a reason to introduce it. We have not seen evidence that use of Cat 2 LBT would provide benefit in operation at 60 GHz.Furthermore, before making a blanket decision on introduction of Cat2 LBT, one should consider the use cases where it would be applied, as well as which devices (gNB or UE) is concerned. It seems different proponents of Alt 2 have very different ideas of when exactly Cat 2 LBT should be used.For discussion 2.5.1-1: the LBT scheme described in 302 567 is rather Cat3 than Cat4 , as there is no CWS adjustment. The comparison between Cat3 and Ca2 depends on the specific use case. |
| Charter Communications | Alt 1. The principles of sub-7 GHz NR-U do not apply here. |
| Lenovo, Motorola Mobility | We do not see what this statement is supposed to achieve. Generally, a successful long CCA implies that the channel would have sensed as idle even for a shorter period. But it doesn't serve the purpose of having to sense the channel for only a reasonably small period.Support Alt 2 and it is applicable to use cases of COT sharing, in case of receiver assistance, beam switching within COT with TDM |
| ZTE, Sanechips | Support Alt 2 and we agree Cat4 LBT can also achieve the function of Cat2 LBT but the effect may be different since Cat4 LBT may need to cost more times to complete LBT procedure, but Cat2 LBT does not need. So we don’t think Cat 4 LBT can directly replace Cat2 LBT. |
| Intel | We are OK with the statement made by the feature lead. The issue in using Cat-4 LBT is that the overall overhead would be greatly increased, which if used for instance for COT sharing may impact quite negatively the average system performance. However, the use of CAT-2 LBT may have a smaller impact, while helping to boost the QoS of the edge users. |
| vivo | We support Alt 2. On the argument to against introducing Cat.2 LBT, we really don’t understand the logic. A fundamental reason that we had multiple categories of LBT in unlicensed band operation (LAA/NR-U) is to serve different purpose/scenario where one category LBT may be better than another. Multiple scenarios have been identified for Cat.2 LBT in 60 GHz operation where there’s benefit to use Cat.2 LBT. Let me ask this question, what would the harm by having Cat.2 LBT? Will the system performance degrade?  |
| Apple | Alt 1When a CAT4 LBT is performed, a new COT is acquired, therefore does not fit into the concept for three use cases, resume transmission after gap, COT sharing and multi-beam COT. For Rx assisted, UE can always measure channel is busy or not and feedback assisted information. We do not see CAT-2 LBT is needed either.  |

Discussion 2.5.1-2

Do you agree with the following compromise:

* Alt 3: Instead of introducing Cat 2 LBT, a Cat 4 LBT with fixed counter (instead of randomly from 0 to 3) can be used for proposed use cases for Cat 2 LBT
	+ The fixed counter can be 0

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| Company | View |
| Nokia, NSB | According to EN 302 567, size of the contention window shall be at least 3. Hence Alt 3 is not in line with the harmonized standard. |
| Lenovo, Motorola Mobility | No, we do not agree |
| ZTE, Sanechips | Disagree Alt 3 and reason has been mentioned in discussion 2.5.1-2. Besides, at least for COT sharing or Rx-assistance case, we think that Cat 3 LBT with fixed counter cannot replace Cat2 LBT. |
| Intel | As long as the introduced LBT procedure has a short and fixed length, we would be OK with Alt.3, and to fix the counter to 0, so a minimum of 8us observation period would be performed. However, this new LBT procedure should not be used to initiate a COT, so that the rules mandates in the ETSI BRAN are not violated. |
| Vivo | As we commented, we categorize LBT types for a reason. We still prefer Cat.2 LBT. |
| Apple | Do not support Alt 3.  |

## Rx Assistance

Agreement:

For receiver to provide assistance, channel sensing and reporting need to be performed. The following set of tools can be considered for further discussion

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

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| --- | --- |
| **Company** | **Key Proposals/Observations/Positions** |
| 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 |
| CATT | Proposal 15：The receiver assistance channel access mechanism can be designed based on the A-CSI feedback framework. |
| Convida Wireless | Proposal 9: Receiver assisted LBT and channel access should be supported in 52.6 GHz to 71 GHz.Proposal 10: Enhancement of resource utilization and interference mitigation in 52.6 GHz to 71 GHz should be considered.Proposal 11: For receiver to provide assistance, the following can be further discussed: legacy RSSI measurement and reporting with possible enhancements, AP-CSI report with possible enhancements and LBT at receiver using eCCA or Cat2 LBT. |
| Ericsson | Observation 17 Receiver assisted LBT does not show consistent performance improvement as compared to no LBT operation.Observation 18 Receiver assistance LBT involves RTS/CTS-like handshaking in every data transfer procedure, which significantly increases data transfer latency, reduces spectrum efficiency and system capacity.Observation 19 The standardization and implementation technical complexity and cost for receiver assistance LBT should not be under-estimated.Observation 20 A new L1 report quantity of L1-RSSI can be introduced for UE to report interference level to gNB.Observation 21 Enhancement to enable aperiodic CSI reporting to be triggered by DL DCIs and to be transmitted on PUCCH as being discussed in the URLLC WI can be reused to communicate receiver assistance information to gNB.Observation 22 Current processing delay requirement for CSI reporting in NR can be reduced for L1-RSSI reporting, to make the receiver assistance mechanisms more efficient.Proposal 12 Do not support receiver assisted LBT (Alt-3) in Rel-17.Proposal 13 Support Alt-1 and Alt-2 for receiver assistance mechanisms that are based on the existing RSSI or CSI reporting and decoupled from data transmission procedure.Proposal 14 The following enhancements on the current AP-CSI reporting can be considered to better support receiver assistance information reporting: |
| Fujitsu | Proposal 2: To support that gNB determines whether to transmit a PDSCH based on UE’s assistance information, LBT at receiver (Alt 3) is preferred. |
| FUTUREWEI | Proposal 8: For receiver assisted LBT, support NR CSI-IM based reporting for the clear channel assessment at the receiver.Proposal 9: For receiver assisted LBT, the receiver shall report the resource availability prior to the transmission. The RSSI measurement definition may be extended to assess the resource availability, where the resources, type of measurement (for instance Cat2 LBT) shall be provided by the transmitter. |
|  |
| Huawei HiSilicon | Observation 4：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 20：For operation in the 60 GHz band, receiver-side LBT should be supported (Alt 3 in the agreement made in the RAN1#104-e).Observation 7: 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 8: 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. |
| Intel Corporation | 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. |
| InterDigital Inc. | Proposal 5: Receiver based directional LBT is supported.Proposal 6: 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 7: Enhance legacy RSSI measurements and AP-CSI reporting to enable beam-based receiver assisted channel sensing and reporting. |
| Lenovo Motorola Mobility | Proposal 21: 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 24: 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 25: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, enhancement to the transmitter side LBT mechanism based on failure to receive HARQ feedback scheme or timer-based scheme should be supported for LBT based channel access mechanisms to consider potential interference at the receiver.Proposal 26: 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 28: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, for receiver to provide assistance, channel sensing and reporting need to be performed and following enhancements to legacy RSSI measurements should be supported:- 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. Proposal 29: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, for receiver to provide assistance, channel sensing and reporting need to be performed and eCCA should be supported as follows:- Signaling mechanism similar to RTS/CTS should be considered for receiver assistanceo Short transmission using control channels (such as with 1-bit) or reference signals for before the actual transmission could be supported |
| LG Electronics | Proposal #6: For the receiver to provide assistance, support Alt 1 (i.e., legacy RSSI measurement and reporting with possible enhancements), and the introduction of directional RSSI and L1 RSSI reporting can be considered as the potential enhancements. |
| MediaTek Inc. | Proposal 3: Among candidate mechanisms to obtain assistant information from receiver in receiver-assisted LBT, at least RSSI should not be considered. |
| Nokia Nokia Shanghai Bell | Proposal 29: Employ RSSI measurements and CSI reporting as a part of the receiver assistance.Proposal 30: Wait for the URLLC discussion to conclude on aperiodic CSI on PUCCH feature.Proposal 31: Any Rx assistance scheme should be configurable per UE, so that it could be used only with UEs frequently detecting high interference.Proposal 32: 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 33: Rx assistance should not be limited to the beginning of COT only. |
| NTT DOCOMO INC. | Proposal 3: For Rx assistance, support Alt 1 (Legacy RSSI measurement and reporting with possible enhancements) and/or Alt 2 (AP-CSI report with possible enhancements):l Alt 1 with enhancements to consider beam-related aspects should be a starting point at least for the support of long-term Rx-assistancel Alt 2 should also be considered if the need of short-term Rx-assistance is observed |
| OPPO | Proposal 15: RTS-like signal can be carried in a PDCCH and CTS-like signal can be carried in a PUCCH.  |
| Qualcomm Incorporated | Observation 5: The results for 2-operator deployment indicate that beam collisions can be severe with a significant fraction of users experiencing interference level higher than the carrier level.Observation 6: The worst-case beams collisions, if persistent, can lead to stuck situations, that is, an extended duration of severe interference.Observation 7: The worst-case collisions, if sporadic and unpredictable, can lead to intense bursty interference and consequent penalties. Proposal 6: Support LBT sensing at the receiver with a conditional response from the receiver for Rx-Assistance. |
| Samsung | Proposal 11: 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 12: Support RSSI measurement outside the active BWP and in non-serving cell. |
| SonySony | Proposal 11: Receiver assisted LBT should be supported in 60 GHz unlicensed operation.Observation 5: For RSSI measurement and reporting with possible enhancements, L1-RSSI carried in CSI needs to be considered.Observation 6: For AP-CSI report with possible enhancements, fast and low complexity measurement/reporting may be required.Observation 7: For LBT at receiver, PDCCH transmission corresponds to RTS-like signal and PUCCH corresponds to CTS-like signal.Proposal 12: For reporting receiver assistance information, CSI reporting mechanism should be a baseline. |
| Spreadtrum Communications | Proposal 4: Regarding receiver assisted LBT, at least the method of Legacy RSSI measurement and reporting with possible enhancements (Alt 1) and the method of AP-CSI report with possible enhancements (Alt 2) should be supported for further study. |
| vivo | Proposal 13: LBT at receiver is supported and Cat 2 LBT can be applied.Proposal 14: The assistant information can include the channel state information at the receiver, such as the LBT results, AP-CSI report.Proposal 15: The transmitter request triggering UE to send assistant information should be studied.Proposal 16: Each transmitter request monitoring occasion corresponds to a receiver feedback transmission opportunity. |
| Xiaomi | Proposal 4: Conditions about whether to enable/disable receiver assisted LBT can be studied.Proposal 5: How to design a receiver assisted LBT with a simpler flow and little spec impact should be considered.Proposal 6: For receiver to provide assistance, the Rx side can report its detected interference level periodically to Tx. And Tx can determine whether to occupy the channel based on the interference level values previously received from Rx side. |
| ZTE Sanechips | Proposal 16: For receiver assisted channel access and interference management,l 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.l 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.n If Cat2 LBT is used for receiver, then Cat4 LBT should be used for transmitter to initiate a COT. |

### First Round Discussion

For receiver to provide assistance, the following positions are collected

* Alt 1. Legacy RSSI measurement and reporting with possible enhancements
	+ AT&T, Ericsson, FUTUREWEI, Lenovo, LG, Mediatek (at least), Nokia, DOCOMO, Samsung, Sony, Spreadtrum, ~~vivo,~~ ZTE
* Alt 2. AP-CSI report with possible enhancements
	+ CATT, Convida, Ericsson, Nokia, Sony, Spreadtrum, ~~vivo~~
* Alt 3. LBT at receiver (Convida, Fujitsu, Huawei, Intel, AT&T, InterDigital, OPPO, Sony, vivo, Xiaomi(study), ZTE )
	+ Alt 3.1 eCCA
	+ Alt 3.2 Cat2 LBT

Proposal 2.6.1-1

As a receiver assistance technique, introduce L1-RSSI measurement to be sent as part of AP-CSI report

* FFS: Timeline of measurement, reporting and trigger
* FFS: Measurement configuration/resource of L1-RSSI
* FFS: ZP-CSI-RS based measurement
* FFS: Beam specific RSSI measurement and reporting
* FFS: What is included in the L1-RSSI report, such as the value of RSSI measurement, comparison outcome with Energy Detection threshold, etc

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| Company | View |
| Nokia, NSB | We support specification of L1-RSSI measurement and reporting. |
| Charter Communications | OK with the proposal. |
| Lenovo, Motorola Mobility | We are fine with the proposal, but would additionally suggest including a proposal on further consideration for Alt 3 that doesn’t seem to be covered by the proposal, although there is quite good support for Alt 3 as well |
| ZTE, Sanechips | Agree with the proposal 2.6.1-1. further, we would like to confirm whether this proposal also include the triggering of AP-L1-RSSI. |
| Intel | We are generally OK with the proposal. |
| vivo | First of all, we corrected our position in the summary as we don’t support Alt 1 and Alt 2. We have concerns about the proposal. Is the intention to confirm Alt 1 and Alt 2? If that’s the understanding, then we don’t support this proposal. We think Alt 3 should be part of Rx Assistance data as that has been evaluated and demonstrated effective gain during SI. |
| Apple  | Need clarification on Alt 1 and this proposal. Is Alt-1 limit to L3-RSSI and its enhancement? As AP-CSI enhancement, the improvement of L1-RSSI versus L1-SINR is not clear.  |

## Multi-Beam COT

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| Agreement:For a COT with MU-MIMO (SDM) transmission, further consider the follow alternatives (down-select or support both)* Alt 1: Single LBT sensing at the start of the COT 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

Agreement:Within a COT with TDM of beams with beam switching, down-select one or more of the following LBT operations * Alt 1: Single LBT sensing with wide beam ‘cover’ all beams to be used in the COT with appropriate ED threshold
	+ FFS: Details on the definition of "cover"
* Alt 2: Independent per-beam LBT sensing at the start of COT is performed for beams used in the COT
* Alt 3: Independent per-beam LBT sensing at the start of COT is performed for beams used in the COT with additional requirement on Cat 2 LBT before beam switch

Agreement:* SSB transmission with LBT is supported, at least when the conditions for contention exempt short control signalling based SSB transmission is not met
	+ Note the channel access for SSB with LBT may not be different from a normal COT with multiple beams
	+ FFS: If any difference from a multi-beam COT LBT needs to be introduced

Agreement:For a COT with MU-MIMO (SDM) transmission, when independent per-beam LBT sensing at the start of COT is performed for beams used in the COT (Alt 2 in earlier agreement) is considered, the following alternatives are further considered* Alt A: The per-beam LBT for different beams is performed in TDM fashion
	+ Alt A-1: The node completes one eCCA on one beam, and directly move on to the eCCA on the other beam, with no transmission in the middle
	+ Alt A-2: The node completes one eCCA on one beam, start transmission with the beam to occupy the COT, then move on to the eCCA on the other beam
	+ Alt A-3: The node performs eCCA of the different beams simultaneous, round robin between different beams
* Alt B: The per-beam LBT for different beams is performed simultaneously in parallel, assuming the node has the capability to simultaneously sense in different beams

Agreement:Within a COT with TDM of beams with beam switching, when independent per-beam LBT sensing at the start of COT is performed for beams used in the COT (Alt 2 or Alt 3 in earlier agreement) is considered, the following alternatives are further considered* Alt A: The per-beam LBT for different beams is performed one after another in time domain
	+ Alt A-1: The node completes one eCCA on one beam, and directly move on to the eCCA on the other beam, with no transmission in the middle
	+ Alt A-2: The node completes one eCCA on one beam, start transmission with the beam to occupy the COT, then move on to the eCCA on the other beam
	+ Alt A-3: The node performs eCCA of the different beams simultaneous, round robin between different beams
* Alt B: The per-beam LBT for different beams is performed simultaneously in parallel, assuming the node has the capability to simultaneously sense in different beams
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| **Company** | **Key Proposals/Observations/Positions** |
| Apple | Proposal 6: Alt A-3 and Alt B can be used for multi-beam COT sensing. |
| AT&T | Proposal 1: • Within a COT with TDM of beams with beam switching, independent per-beam LBT sensing at the start of COT is performed for beams used in the COT with additional requirement on Cat 2 LBT before beam switch• The per-beam LBT for different beams is performed one after another in time domain. The node completes one eCCA on one beam, and directly move on to the eCCA on the other beam, with no transmission in the middle |
| CAICT | Proposal 7: For a COT with MU-MIMO(SDM) transmission, Alt B and Alt A-3 is proposed.Proposal 8: For COT with TDM transmission with beam switching, Alt B and Alt A-3 is proposed. |
| CATT | Proposal 11：Consider supporting both of single LBT sensing with wide beam and independent per-beam LBT sensing for all beams to be used within the COT at the start of the COT.Proposal 12: If supporting Alt A-1 or Alt A-2, the ‘blocking issue’ (failure of forward beam LBT cause subsequent beams unable to perform LBT) should be addressed.Proposal 13: Alt A-3 of which node performs eCCA round robin between different beams should be supported to increase the multi-beam LBT efficiency. |
| Convida Wireless | Proposal 5: For a COT with MU-MIMO (SDM) transmission, support both single LBT sensing at the start of the COT with wide beam ‘cover’ all beams to be used in the COT with appropriate ED threshold and independent per-beam LBT sensing at the start of COT performed for beams used in the COT.Proposal 6: Within a COT with TDM of beams with beam switching, support both single LBT sensing with wide beam ‘cover’ all beams and independent per-beam LBT sensing at the start of COT performed for beams used in the COT. Further discuss independent per-beam LBT sensing at the start of COT for beams used in the COT with additional requirement on Cat 2 LBT before beam switch.Proposal 7: For a COT with MU-MIMO (SDM) transmission, consider both per-beam LBT for different beams performed in TDM fashion and per-beam LBT for different beams performed simultaneously in parallel, assuming the node has the capability to simultaneously sense in different beams.Proposal 8: Within a COT with TDM of beams with beam switching, consider both per-beam LBT for different beams performed in TDM fashion and per-beam LBT for different beams performed simultaneously in parallel, assuming the node has the capability to simultaneously sense in different beams. |
| Ericsson | Observation 16 All alternatives agreed to be considered for a COT with TDM and SDM of beams, depends solely on how directional LBT for a single beam would be specified.Proposal 10 If any enhancements to better enable multiple beam transmissions within a COT when LBT mode is used can be agreed now, it is to support Alt 1 in principle for TDM and SDM case where a single LBT at the beginning of the COT is performed with the definition of “cover” meaning omni-directional or quasi-omni-directional. |
| FUTUREWEI | Proposal 7: When independent per-beam LBT sensing at the start of COT is performed for beams used in the COT, an additional requirement on Cat 2 LBT before beam switch during the COT should be specified. |
| Huawei HiSilicon | Proposal 14: For initiating a COT with SDM or TDM of different beams, support multiple per-beam LBTs, i.e. Alt 2.Proposal 15: For initiating a COT with SDM or TDM of different beams, support one LBT beam covering all transmission beams (Alt 1) as a fallback mechanism when the one-to-one correspondence between the LBT beams and transmission beams cannot be established.Observation 1: specifying the spatial relationship between a wide LBT beam and multiple subsequent transmission beams is feasible if spatial properties similar to those defined in TS 38.104 for a transmission beam are defined for the LBT beam, including beam peak direction, beam center direction and beamwidth.Proposal 16: For initiating a COT with SDM or TDM of different beams using a single LBT, gNB selects a spatial sensing filter that minimizes the resulting XdB sensing beamwidth which at least contains all beam peak directions of the subsequent DL transmission beams within the COT.Proposal 17: For initiating a COT with SDM or TDM of different beams, when independent per-beam LBT sensing at the start of COT is performed for beams used in the COT, support performing the per-beam LBTs simultaneously in parallel (Alt B).If the node is incapable of sensing simultaneously in different beams, a single LBT beam should be used as in Alt-1.FFS: How to coordinate these parallel LBTs to align the start times of the SDMed transmissions, and how to determine the COT start time in the TDM case. |
| Intel Corporation | Proposal 11: It is up to the gNB on whether to mandate or not the use of LBT before attempting any transmission from any device within an initiating device’s acquired COT. Proposal 12: For a COT with MU-MIMO, both Alt-1 and Alt-2 are supported. As for Alt-2 both Alt-A-2 and Alt-B could be considered.Proposal 13: For a COT with beam switching, both single LBT sensing with wide beam and independent per-beam LBT sensing at the start of the COT are supported.  |
| InterDigital Inc. | Proposal 17: For a COT with MU-MIMO (SDM) transmission, support Alt-3.Proposal 18: For a COT with TDM of beams with beam switching, support Alt A-2 or A-3.Proposal 19: Support of Alt B for SDM or TDM of beams can be considered for some UEs. |
| ITRI | Proposal 2: For a COT with MU-MIMO (SDM) transmission, the per-beam LBT for different beams is performed simultaneously in parallel.Proposal 3: For a COT with TDM transmission, the per-beam LBT for different beams is performed one after another in time domain. |
| Lenovo Motorola Mobility | Proposal 7: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, for a COT with MU-MIMO (SDM) transmission, all of the following should be supported:- Single LBT sensing at the start of the COT with wide beam ‘cover’ all beams to be used in the COT with appropriate ED threshold- Independent per-beam LBT sensing at the start of COT is performed for beams used in the COTProposal 8: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, within a COT with TDM of beams with beam switching, all of the following should be supported:- Single LBT sensing with wide beam covering all beams to be used in the COT with appropriate ED threshold, where covering implies that the coverage region of wide beam contains the coverage region of all the beams- Independent per-beam LBT sensing at the start of COT is performed for beams used in the COT- Independent per-beam LBT sensing at the start of COT is performed for beams used in the COT with additional requirement on Cat 2 LBT before beam switchProposal 9: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, for a COT with MU-MIMO (SDM) transmission, the per-beam LBT for different beams is performed simultaneously in parallel, assuming the node has the capability to simultaneously sense in different beamsProposal 10: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, for a COT with TDM transmission, the per-beam LBT for different beams can be supported with both alternatives below:• Alt A: The per-beam LBT for different beams is performed one after another in time domaino Alt A-1: The node completes one eCCA on one beam, and directly move on to the eCCA on the other beam, with no transmission in the middleo Alt A-2: The node completes one eCCA on one beam, start transmission with the beam to occupy the COT, then move on to the eCCA on the other beamo Alt A-3: The node performs eCCA of the different beams simultaneous, round robin between different beams• Alt B: The per-beam LBT for different beams is performed simultaneously in parallel, assuming the node has the capability to simultaneously sense in different beamsProposal 11: 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 beamProposal 12: 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 sensing beam |
| LG Electronics | Proposal #13: For a COT with MU-MIMO (SDM) and TDM of beams transmission, adopt Alt A-1 (the node completes one eCCA on one beam, and directly move on to the eCCA on the other beam, with no transmission in the middle) when independent per-beam LBT sensing at the start of COT. |
| MediaTek Inc. | Proposal 2: Alt A-1 and Alt A-3 should be precluded, and both Alt A-2 and Alt B can be considered. |
| NEC | Proposal 5: For a COT with SDM transmission, when independent per-beam LBT sensing at the start of COT is performed, the following LBT operations should be supported:Ÿ If the node has the capability to simultaneously sense in different beams, the node performs per-beam LBT for different beams simultaneously in parallel.Ÿ Otherwise, the node performs eCCA of the different beams simultaneous, round robin between different beams.Proposal 6: Within a COT with TDM of beams with beam switching, when independent per-beam LBT sensing at the start of COT is performed for beams used in the COT, the following LBT operations should be supported:• The node completes one eCCA on one beam, start transmission with the beam to occupy the COT, then move on to the eCCA on the other beam.• The node performs eCCA of the different beams simultaneous, round robin between different beams. |
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| Nokia Nokia Shanghai Bell | Proposal 20: For a COT with MU-MIMO (SDM) transmission, support both Alt 1 and Alt 2Proposal 21: Within a COT with TDM of beams with beam switching, support both Alt 1and Alt 2 for LBT operations.Proposal 22: For a COT with MU-MIMO (SDM) transmission, support Alt B.Proposal 23: Alt A-1 is modified as: The node completes one eCCA on one beam, and directly move on to the eCCA on the other beam, with no transmission in the middle. After completing eCCA on all beams, a further round robin CCA check is carried out in all beams (except the last beam).Proposal 24: Alt A-3 is modified as: The node performs eCCA of the different beams simultaneous, round robin between different beams. • single contention window is shared by beams or each beam has a separate contention window.• the last CCAs shall indicate vacant channel on all beams that are part of the COTObservation 7: It is important to maintain flexibility of gNB implementation for multi-beam COTProposal 25: For a COT with TDM transmission, support the modified Alt A-1 and Alt A-3. |
| NTT DOCOMO INC. | Proposal 4: l For LBT initiating a COT with SDMed multiple transmissions, support a single LBT at the start of COT, covering all the SDMed beams. l For LBT initiating a COT with TDMed multiple transmissions, support independent per-beam LBT at the start of COT (Alt A-1) or at the start of transmission with changed beam within a COT (Alt A-2).  |
| OPPO | Proposal 13: For COT containing multiple beams, including MU-MIMO (SDM) and TDM of beams, Alt A-2 is not supported. Alt A-1 and Alt A-3 can be left for implementation. |
| Panasonic | Proposal 1: Support Alt A-1, A-3 and B for a COT with MU-MIMO (SDM) transmission, when independent per-beam LBT sensing at the start of COT is performed for all beams used in the COT. Proposal 2: Support both Alt 1 (single wide beam LBT sensing) and Alt 2 (independent per-beam LBT sensing) at the start of COT with SDM of beams.Proposal 3: Support Alt A-1, A-3 and B for a COT with TDM beam transmission, when independent per-beam LBT sensing at the start of COT is performed for all beams used in the COT.Proposal 4: For a COT with TDM of beams, support both Alt-1 and Alt-2 in the previous agreement at the start of COT. Whether or not additional Cat 2 LBT is required before beam switching within the COT depends on the gap of no transmission of the next beam direction.  |
| Qualcomm Incorporated | Observation 1: To enable any form of per beam channel access on more than one beam, e.g. for a multi-beam COT, more than one separate sensing operations need to be supported.Proposal 4: Support Alt-B where applicable for simultaneous sensing. Support Alt-A-2 for SDM and TDM COT where applicable. Proposal 5: Any LBT based Rx-Assistance procedure should be made optional/configurable on a per UE link basis. |
| Samsung | Proposal 9: Support directional channel sensing in multi-beam operation:• For multi-beam SDM scenario, both Alt 1 and Alt 2 can be supported.• For multi-beam TDM scenario, Alt 1 can be supported as baseline, and selection between Alt 2 and Alt 3 depends on whether sensing is required for switching beams within a COT.Proposal 10: For per-beam LBT for different beams,• Support both Alt A and Alt B, and up to implementation to choose between Alt A and Alt B.• Within Alt A, support Alt A-1 as the baseline. |
| Sony | Proposal 10: Within a COT with TDM of beams with beam switching, both Alt 1 (single LBT sensing with wide beam ‘cover’ all beams to be used in the COT with appropriate ED threshold) and Alt 2 (independent per-beam LBT sensing at the start of COT is performed for beams used in the COT) should be supported.Observation 4: If per-beam LBT sensing is introduced, per beam COT indication may be needed. |
| Spreadtrum Communications | Proposal 11: For a COT with MU-MIMO (SDM) transmission, single LBT sensing at the start of the COT with wide beam ‘cover’ all beams to be used in the COT with appropriate ED threshold should be supported.Proposal 12: For a COT with MU-MIMO (SDM) transmission, independent per-beam LBT sensing at the start of COT is performed for beams used in the COT should be supported, and the per-beam LBT for different beams is performed simultaneously in parallel, assuming the node has the capability to simultaneously sense in different beams.Proposal 13: Within a COT with TDM of beams with beam switching, single LBT sensing at the start of the COT with wide beam ‘cover’ all beams to be used in the COT with appropriate ED threshold should be supported.Proposal 14: Within a COT with TDM of beams with beam switching, when independent per-beam LBT sensing at the start of COT is performed for beams used in the COT:- If the transmitter has the capability to simultaneously sense in different beams, the per-beam LBT for different beams is performed simultaneously in parallel- If the transmitter does not have the capability to simultaneously sense in different beams, Alt A-1 should be supported. |
| vivo | Proposal 9: For a COT with MU-MIMO (SDM) transmission, the per-beam LBT for different beams is performed simultaneously in parallel, assuming the node has the capability to simultaneously sense in different beams.Proposal 10: Alt A-1 and Alt-B are supported for the transmission within a COT with TDM of beams with beam switching. |
| Xiaomi | Proposal 7: Multi-beam transmission should be studied to fully take advantage of spatial diversity.Proposal 8: Support independent per-beam LBT sensing at the start of COT for a COT with TDM of beams with beam switching. |
| ZTE Sanechips | Proposal 14: Considering LBT overhead and transmission delay, Alt B that“The per-beam LBT for different beams is performed simultaneously in parallel, assuming the node has the capability to simultaneously sense in different beams” should be considered if Alt 2 is supported.Proposal 15: Considering transmission opportunity and unnecessary interference to other device that is going to transmit transmission, Alt-3 that “Independent per-beam LBT sensing at the start of COT is performed for beams used in the COT with additional requirement on Cat 2 LBT before beam switch” can be considered for the transmission with multiple beams in time domain multiplexing, if directional LBT is supported.l Considering LBT overhead and transmission delay, Alt B that“The per-beam LBT for different beams is performed simultaneously in parallel, assuming the node has the capability to simultaneously sense in different beams” should be considered if Alt 2 or Alt 3 is supported |

### First round discussion

A large number of companies argue for support of both Alt 1 and Alt 2 for SDM Multi-Beam COT from the following agreement:

For a COT with MU-MIMO (SDM) transmission, further consider the follow alternatives (down-select or support both)

* Alt 1: Single LBT sensing at the start of the COT 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

Proposal 2.7.1-1

For a COT with MU-MIMO (SDM) transmission, support both Alt 1 and Alt 2 below:

* Alt 1: Single LBT sensing at the start of the COT 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

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| Company | View |
| Nokia, NSB | We support the proposal |
| Charter Communications | Support the proposal  |
| Lenovo, Motorola Mobility | We support the proposal |
| ZTE, Sanechips | Agree with the proposal 2.7.1-1 |
| Intel | We are OK to support both Alt-1 and Alt-2 and leave up to the device capability which alternative to use. However, for Alt-2, we should leave for FFS how the procedure is done given that in prior meeting we have identified multiple alternatives or multiple views on how this could be performed (i.e., Alt A-1/2/3) |
| vivo | Support the proposal. |
| Apple | Support the proposal  |

Proposal 2.7.1-2

For a COT with MU-MIMO (SDM) transmission if Alt 2 is supported (independent per beam LBT), and if the node has the capability to perform simultaneous sensing in different beams, simultaneous per-beam LBT for different beams is supported.

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| Company | View |
| Nokia, NSB | We support the proposal |
| Charter Communications | Proposal is OK but this does not need to be specified in the specs |
| Lenovo, Motorola Mobility | We support the proposal, though we are not certain if the simultaneous per-beam LBT will have any specification impact. It may be sufficient to specify the support of independent per-beam sensing. |
| ZTE, Sanechips | Agree with the proposal 2.7.1-2 |
| Intel | We are also OK with this proposal. |
| vivo | Support the proposal. |
| Apple | Support the proposal  |

Proposal 2.7.1-3

Within a COT with TDM of beams with beam switching, down-select to one of the following LBT operations

* Alt A: Support both Alt-1 and Alt 2
* Alt B: Support both Alt-1 and Alt 3

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| Company | View |
| Nokia, NSB | We support Alt A |
| Lenovo, Motorola Mobility | We support Alt B i.e. support Alt-1 and Alt-3* Alt 1: Single LBT sensing with wide beam ‘cover’ all beams to be used in the COT with appropriate ED threshold
	+ FFS: Details on the definition of "cover"
* Alt 3: Independent per-beam LBT sensing at the start of COT is performed for beams used in the COT with additional requirement on Cat 2 LBT before beam switch
 |
| ZTE, Sanechips | Support Alt B. |
| Intel | Our preference is for Alt. A. However, for Alt-2, we should leave for FFS how the procedure is done given that in prior meeting we have identified multiple alternatives or multiple views on how this could be performed (i.e., Alt A-1/2/3) |
| vivo | Alt B |
| Apple | Alt A |

Proposal 2.7.1-4

Within a COT with TDM of beams with beam switching, if Alt 2 or Alt 3 is supported (independent per beam LBT), and if the node has the capability to perform simultaneous sensing in different beams, simultaneous per-beam LBT for different beams is supported.

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| Company | View |
| Nokia, NSB | We support the proposal |
| Charter Communications | Support the proposal |
| Lenovo, Motorola Mobility | We support the proposal, though we are not certain if the simultaneous per-beam LBT will have any specification impact. It may be sufficient to specify the support of independent per-beam sensing. |
| ZTE, Sanechips | Agree with the proposal 2.7.1-4 |
| Intel | We also support this proposal. |
| vivo | Support the proposal. |
| Apple | Support the proposal  |

Discussion 2.7.1-5

For a gNB/UE to initiate a COT with SDM or TDM multiple beams with separate LBT per beam and the gNB/UE does not have the capability to simultaneously sense in different beams, the following alternatives have been identified:

* Alt A-1: The node completes one eCCA on one beam, and directly move on to the eCCA on the other beam, with no transmission in the middle
* Alt A-2: The node completes one eCCA on one beam, start transmission with the beam to occupy the COT, then move on to the eCCA on the other beam
* Alt A-3: The node performs eCCA of the different beams simultaneous, round robin between different beams

Please provide your view below

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| Company | View |
| Nokia, NSB | We support Alt A-1 and Alt A-3. Alt A-2 seems more like there are separate COTs initiated for each beam. It is not clear if this case needs to be considered separately. |
| Lenovo, Motorola Mobility | We prefer supporting Alt A-1 and Alt A-2. We don’t think Alt A-3 is useful considering proposal 2.7.1-4 already considers simultaneous sensing in different beamsAlso, which alternative to apply when and how can be further discussed. |
| ZTE, Sanechips | Support Alt A-2 or Alt A-3. |
| Intel | Our preference is Alt A-2.  |
| vivo | Alt A-1 |
| Apple | Alt A-3. Alt A-1 perform much longer eCCA than needed. Alt A-2 is equivalent to multiple single beam COT. |

## Multi-Channel channel access

Agreement:

Define Type A and Type B multi-channel channel access as:

* Type A: Perform independent eCCA for each channel
* 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

Down-selection between

* Alt1: Support Type A multi-channel channel access only
* Alt2: Support both Type A and Type B multi-channel channel access.

Note: How eCCA is performed on each channel, and the BW of the channels over which eCCAs are performed are separately discussed

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| **Company** | **Key Proposals/Observations/Positions** |
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| CAICT | Proposal 9: Support both Type A and Type B multi-channel channel access. |
| EricssonEricsson | Observation 8 ETSI regulation for 60 GHz bands do not support Type B multi-channel access.Proposal 5 Do not support Type B multi-channel access for NR operation in 52.6 GHz to 71 GHz. |
| Huawei HiSilicon | Proposal 11: For multi-channel access in NR-U-60, support both Type A and Type B procedures, i.e., Alt2 in the agreement made in RAN1#104-e. |
| Nokia Nokia Shanghai Bell | Proposal 13: Only Type A multi-channel access procedure (i.e. Alt.1) shall be supported in NR-U on 60GHz band. |
| vivo | Proposal 5: Both Type A and Type B multi-channel channel access can be supported. |
| WILUS Inc. | Proposal 6: At least Type A multi-channel access which performs independent clear channel assessment (CCA) for each channel should be supported. For support of the Type B multi-channel access, it should be further discussed after the decision by depending on support of Cat-2 LBT including definition of Cat-2 LBT. |
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### First Round Discussion

There are differing views on whether to support Type B multi-channel access. The discussion seems to focus on if Cat 2 LBT is introduced or not.

Proposal 2.8.1-1

* Type A multi-channel channel access is supported
* If Cat 2 LBT is introduced, type B multi-channel channel access is supported

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| Company | View |
| Nokia, NSB | We see no need to Type B multi-channel LBT. Type B multi-channel channel access is not allowed by ETSI EN 302 567. Furthermore, Type B channel access assumes a specific type of channelization (channel bonding), which seems very impractical at 60 GHz unlicensed spectrum where different channel and LBT bandwidths are applied.  |
| Charter Communications | Prefer to agree to Type A multi-channel access first  |
| Lenovo, Motorola Mobility | We support the proposal |
| ZTE, Sanechips | We do not see that EN302 567 explicitly states that cat2 LBT is not supported. In addition, combined with Cat2 LBT required in many used cases, then, we understand that Type B multi-channel channel access should not be precluded in above 52.6GHz. |
| Intel | We are OK with the first bullet, but are not OK with the second bullet. While we support the introduction of Cat-2 LBT, we do not support type B since this violates ETSI BRAN rules, and we would prefer to keep this second bullet as an FFS.  |
| vivo | Support the proposal. |
| Apple | Agree with type A is supported. Type B is FFS.  |

## Directional LBT

Proposal for convergence: Directional Sensing

3GPP specification defines the relative relationship between all applicable sensing beams and the transmission beam(s), at least sensing beam “covers” the transmission beam(s). Choose one of the following alternatives:

* Alt 1. To define “cover”, the angle included in the [3]dB beamwidth of the transmission beam(s) is included in the [3]dB beamwidth of the sensing beam
* Alt 2. Extending the beam correspondence framework and/or QCL/TCI framework to define “cover”
* Alt 3. Leave RAN4 to define cover

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| **Company** | **Key Proposals/Observations/Positions** |
| Apple | Proposal 3: 3GPP specification defines relationship of all applicable sensing beams “covers” the transmission beams. Proposal 4: Extend the TCI framework to signal the COT directivity based on sensing directivity. COT directivity can be signaled in DCI format 2-0 for gNB initiated COT, and CG-UCI for UE initiated COT.Proposal 5: Perform directional or omni-directional LBT at the beginning of COT with the sensing beam(s) that covers all TDM beams, with no LBT before each beam switch in the middle of COTProposal 14: Consider using omni and directional RSSI and channel occupancy for long term sensing.  |
| Convida Wireless | Proposal 1: Both omni-directional LBT and directional LBT should be supported for frequency range of 52.6GHz to 71GHz.Proposal 12: Enhancement of beam operation for unlicensed bands should be investigated to mitigate interference and optimize system performance due to hidden node for NR up to 71 GHz. |
| Ericsson | Observation 10 The effectiveness of LBT itself as medium access mechanism for co-existence in unlicensed spectrum in 60 GHz band is questionable. Therefore, any further enhancement on LBT baseline from the HS need to be justified both on the performance gain and the required complexity.Observation 11 Common understanding in ETSI and IEEE 802.11ad and IEEE 802.11ay specs are omni-directional LBT or quasi-omnidirectional LBTObservation 12 Simulation studies in general indicate no significant gain from using directional LBT.Observation 13 Directional LBT is currently not precluded in the existing regulations. EN 302 567¨s tests intrinsically ensure sensing beam is in the direction of the transmission beam for devices equipped with directional antenna systems.Observation 14 Notion of “beams” for sensing/LBT is non-existent in 37.213.Observation 15 Alt1 and Alt3 have more RAN4 spec impact and can be considered together under a single alternative.Proposal 8 Support omni-directional LBT or quasi-omni-directional LBT as the baseline LBT procedure for 60 GHz band.Proposal 9 Do not support Alt.2 on extending the beam correspondence framework and/or QCL/TCI framework to define “cover”.Proposal 11 RAN1 needs to decide on whether and how to specify directional LBT for single sensing beam case before further discussing multiple sensing beams. |
| FUTUREWEI | Proposal 3: For the CCA check procedure, the COT initiating device may use one or multiple spatial domains receive filters. For each transmission during the COT, there should be associated one or multiple spatial domains receive filters used in the CCA check procedure.Proposal 4: Consider the use of composite transmit angular power profile (APP) of an intended set of transmit beams to design sensing beam that “covers” that intended set.• Prominent directions of intended transmission, i.e., those for which composite transmit APP is with a fraction of the peak APP, should have relatively large sensing gain. • For EDT determination, define Pout as the maximum EIRP over that intended set of transmit beams.• Appropriate EDT incorporates shortfall (if any) in the sensing gain over prominent directions. • Enable augmented sensing to avoid blind spots without excessive exposed nodes.  |
| Huawei HiSilicon | Proposal 12: For operation in the 60 GHz band, specify the spatial relation between the LBT beam and the transmission beam(s).Proposal 13: For a COT with a single transmission beam, the spatial domain sensing filter for the LBT beam at the beginning of the COT can be configured to be the same as the spatial domain filter used for the transmission during the COT. Observation 2: (Quasi-)omni-directional simplifies the implementation but could lead to an ‘over protection’ problem and thus reduction of spatial reuse. Observation 3: 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. |
| Intel Corporation | 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.Proposal 14: Both omni-directional and directional LBT are supported. When directional LBT is used, a receiver-aided LBT should complement its CCA procedure.Proposal 15: 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 16: 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 17: When directional sensing is performed, and multiple concurrent COTs 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 18: RAN1 should further study how to efficiently allow beam-pairing due to LBT success. |
| InterDigital Inc. | 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 specified in Rel-17.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.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 4: Receiver based LBT should be considered for both omni-directional and directional LBT.Proposal 8: The UE receives configuration and indication of the channel access mode (omni-directional, directional, receiver assisted, no LBT) from the gNB using Alt. 2 (either cell specific or UE-specific indication) |
| ITRI | Proposal 1: In order to avoid resource wastage and hidden node problem, the LBT beam should be the same as the transmission beam. |
| Lenovo Motorola Mobility | Observation 1: For NR unlicensed bands between 52.6 GHz and 71 GHz, with directional LBT based channel access mechanism, LBT failure on a beam could require a beam update procedure and that results in increased latency.Observation 4: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz with LBT based channel access mechanism, when directional LBT is applied, then performing LBT only at the transmitted side may not guarantee an interference-free reception due to hidden nodes to the transmitterProposal 3: For NR unlicensed bands between 52.6 GHz and 71 GHz, with directional LBT based channel access mechanism, configuration and/or indication of multiple sensing beams to UE should be specified for beam-based UL transmissionProposal 4: For NR unlicensed bands between 52.6 GHz and 71 GHz, with directional LBT based channel access mechanism, explicit mapping between sensing beam(s) and UL transmit beam should be specified based on extension of TCI framework, where the association between the sensing and transmission beams can be configured based on the TCI association between to be:- One-to-one mapping between sensing beam and transmission beam- One sensing beam to many transmission beams mapping- Many sensing beams to one transmission mappingProposal 5: For NR unlicensed bands between 52.6 GHz and 71 GHz, with directional LBT based channel access mechanism, following two aspects should be specified:- Definition of cover could be such that the angle included in the [3] dB beamwidth of the transmission beam(s) is included in the [3] dB beamwidth of the sensing beam(s)- Indication/configuration of association between sensing beam(s) and transmission beam(s) according to extension of TCI frameworkProposal 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 feedbackProposal 15: For NR unlicensed bands between 52.6 GHz and 71 GHz with directional LBT based channel access mechanism, within a COT, PDCCH monitoring is not supported in the CORESETs corresponding to other COTs (PDCCH monitoring restricted to monitoring corresponding to only one COT at a time) |
| LG Electronics | Proposal #5: 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.Proposal #7: If the directional CCA procedure is introduced the followings points can be considered:l How to perform the CCA procedure for multiple-beam sweeping transmissionl How to define CWS management (e.g., per-direction or across-direction management)l How to manage the back-off counter valueProposal #9: 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 #10: 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).Proposal #11: 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.Proposal #12: To define the relative relationship between all applicable sensing beams and the transmission beam in 3GPP specification, adopt Alt-2 (Extending the beam correspondence and/or QCL/TCI framework to define “cover”). |
| NEC | Proposal 2: 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. |
| Nokia Nokia Shanghai Bell | Proposal 19: Leave the relationship between gNB LBT sensing beam(s) and transmission beam(s) 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 3: 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. However, that should be done in RAN4, not in RAN1. |
| OPPO | Proposal 7: consider using QCL/TCI framework to define ‘cover’. |
| Qualcomm Incorporated | Observation 2: At least some sensing in per beam channel access is necessarily directional.Observation 3: As shown in the simulation results in the contribution, the energy level sensed by directional beam is strongly affected by the directionality/beam forming gain of the sensing beamObservation 4: In a fair channel access procedure, for a given pre-determined transmission beam (and consequent interference footprint), it is desirable that the channel access probability should not depend on the sensing beam properties. Proposal 1: Adopt Alt-2, i.e. extend QCL/TCI framework and/or beam correspondence framework to support mismatched directional sensing and transmission. Beam correspondence should be extended to support many -to-many relationship between transmission beams and eligible sensing beams. QCL/TCI framework could be extended to support necessary signaling if any.Proposal 3: Use defined QCL/TCI framework to determine procedures to support independent per beam sensing and transmission of a multi-beam COT. |
| Samsung | Proposal 8:• Support extending the beam correspondence framework and/or QCL/TCI framework to define “cover” (Alt 2);• Support a new type of QCL assumption to define the sensing beam covering the transmission beam. |
| Sony | Proposal 8: For definition of the relative relationship between applicable sensing beams and the transmission beam(s), extending the beam correspondence and/or QCL/TCI framework to define and/or indicate “cover” is considered from the RAN1 perspective.Proposal 9: For a COT with MU-MIMO (SDM) transmission, both Alt 1 (Single LBT sensing at the start of the COT with wide beam ‘cover’ all beams to be used in the COT with appropriate ED threshold) and Alt 2 (Independent per-beam LBT sensing at the start of COT is performed for beams used in the COT) should be supported. |
| Spreadtrum Communications | Proposal 2: The directional LBT should be supported in 60GHz unlicensed band.Proposal 3: The relationship between all the LBT beams and the transmission beam should be defined and at least LBT beam “covers” the transmission beam. |
| vivo | Proposal 11: If UE capability supports beam correspondence, the receiving beam corresponding to the transmission beam is used as the sensing beam.Proposal 12: The “cover” for sensing beam is defined as: the angle included in the [3] dB beam width of the transmission beam(s) is included in the [3] dB beam width of the sensing beam. |
| ZTE Sanechips | Proposal 12: If directional LBT is supported, it is necessary to further define the relationship between LBT sensing/receiving beam(s) and transmission beam(s):l Under the assumption of channel reciprocity between transmission beam and LBT sensing/receiving beam, LBT sensing/receiving beam and transmission beam are actually equivalent.l Without the assumption of channel reciprocity between transmission beam and LBT sensing beam, when LBT sensing beam (e.g., reception beam) is wider than the transmission beam and/or partially overlapping with each other, certain method need to be further considered, e.g., introduce an additional factor to reflect the difference of transmission beam and reception beam, or extend QCL/TCI framework to define the relationship between transmission beam and LBT sensing/receiving beam. |

###  First Round Discussion

Based on the proposal for convergence a rough summary of company positions is presented below,

* Alt 1: To define “cover”, the angle included in the [3]dB beamwidth of the transmission beam(s) is included in the [3]dB beamwidth of the sensing beam
	+ Huawei?, FUTUERWEI? InterDigital? ITRI, vivo, ZTE
* Alt 2: Extending the beam correspondence framework and/or QCL/TCI framework to define “cover”
	+ Lenovo, LG, Samsung, Oppo, ~~vivo~~
* Alt 3 : Leave RAN4 to define cover
	+ Support: Ericsson
	+ Objection: Huawei, Apple, FUTUREWEI, Intel, InterDigital, NEC, Qualcomm

Before we make a decision, it might be good to have a clear understanding on what companies have in mind for the alternatives. It might be helpful to discuss how to select a sensing beam for a single transmission beam first.

Discussion 2.9.1-1

A few possible descriptions of sensing beam ‘covering’ a transmission beams are presented below. They are intended as next level of detail designs for Alt 2 and Alt 1. Please provide your view

* Alt 1: To define “cover”, the angle included in the [3]dB beamwidth of the transmission beam(s) is included in the [3]dB beamwidth of the sensing beam
* Alt 2: Extending the beam correspondence framework and/or QCL/TCI framework to define “cover”
	+ Alt 2-1: Introduce a new sensing beam and transmission beam correspondence relationship: “A sensing beam is considered to be corresponding to a transmission beam if the sensing beam gain measured along the direction of peak transmission direction is within X [FFS] dB of the transmission beam gain”
		- FFS: How to define/measure sensing beam gain and transmission beam gain.
	+ Alt-2-2: Introduce a new sensing beam and transmission beam correspondence relationship: “The sensing beam gain is measured in one or more directions where the transmission beam EIRP is within A [FFS] dB of the peak transmission beam gain. The sensing beam is considered to be corresponding to the transmission beam if the sensing beam gain measured along the chosen directions is within X [FFS] dB of the transmission beam gain in those directions.”
		- FFS: How to define/measure sensing beam gain and transmission beam gain.
	+ Alt 2-3: Extending QCL/TCI framework for sensing: If gNB configures some UE to use TCI state B as QCL source for TCS state A, then the beam used for TCI B can be used as a sensing beam for transmission of beam for TCI A. This extension allows gNB to define the relationship between its sensing beams and transmissions.
	+ Alt 2-4: Beam correspondence based extension: Beam correspondence framework can be extended to allow UE to select a valid sensing beam corresponding to a transmission beam.

Please provide your view, especially if you have other ways to define the “cover” in mind

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| Company | View |
| Nokia, NSB | We support Alt 3: Leave RAN4 to define coverDefinition of beam correspondence for the gNB is a very complicated task, while the benefits are unclear. It is enough to leave the relationship between gNB LBT sensing beam(s) and transmission beam(s) 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. RAN4 is anyhow expected to define a test that verifies that a device operates according to regional regulations. |
| Lenovo, Motorola Mobility | We support Alt 2-3. In our view, this is the most straightforward way of extending current TCI framework for indicating association between sensing and transmission beams. Furthermore, this method has the benefit of also providing complete flexibility in supporting following association types:* One-to-one mapping between sensing beam and transmission beam
* One sensing beam to many transmissions beams mapping
* Many sensing beams to one transmission mapping

This can somewhat also cover the scenario when no explicit association is indicated, then one-to-one mapping can be assumed or left up to vendor-specific implementations. |
| ZTE, Sanechips | For Alt 2-1 and Alt 2-2, we think that these two alternatives depend on the device’s capability. If capability allows, then we prefer to support Alt 2-2. otherwise, we support Alt 2-3, but for Alt 2-3, we are not sure how the gNB determines relationship between its sensing beams and transmissions relatively accurately.  |
| Intel  | We prefer the Alt 2 (or Alt-2 like) approach. While Alt 1 could be acceptable, practical beams could have many sidelobes or it could be complex beam composed of multiple lobes. In such case 3dB beamwidth, while might be possible to define, could have some other side effects. With this said, we are not necessarily objecting to Alt 1.As for Alt 2, there are other methods such as using the “spatial domain filter” description that is used in current NR specification to specify use of same beam for Rx and Tx.One example of such framework is in SRS. “…the UE shall transmit the targetSRS resource with the same spatial domain transmission filter used for the reception of the reference SS/PBCH block,…”Of course, RAN4 would need to further help define requirements as such, but for RAN1 defining some relationship between Rx and Tx concept is not new and this could be extended.Alt 2-1 and 2-2 seem to be more something that should be discussed in RAN4. From RAN1 perspective, we just need to define clear description of what needs to be done, and RAN4 can work out the details on how such behaviour can be enforced and tested. Of course, RAN1 should try not to define behaviours that would be impossible to test. However, for this case RAN4 has experience with beam correspondence and should have experience with concept of applying same spatial domain filter. We believe all the discussion here is relatively in the same bucket.So we are supportive of Alt 2-3 and Alt 2-4 approaches. |
| vivo | We corrected our position in the summary as we don’t support Alt 2. We only support Alt 1. The “beam correspondence” in our proposal 11 follows the current definition in the spec. We discussed the cases with beam correspondence and without beam correspondence in the contribution. We think there will be confusion if it is extended to include other cases. |
| Apple | Alt 1 and Alt 2. The adaptivity test case defined in EN 302.567 can be used as reference to define “cover”. The high-level description is copied below. The sensing beamwidth needs to be wider than the beamwidth of maximum EIRP transmission direction. Omni-sensing is always possible, since omni/quai-omni sensing beamwidth cover the transmission direction by default. *“5.3.8.2 Test method**The principle is to establish a communication between UUT and companion device, and then check the behaviour of UUT in the presence of an interferer.**The UUT may be connected to a companion device during the test. When performing this test of a UUT with directional antenna (such as array antenna system capable of beam-forming), the wanted communication link (between the UUT and the companion device) and the interference signal shall be aligned to the direction corresponding to the UUT's maximum EIRP.”* |
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## No LBT

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| Agreement:For regions where LBT is not mandated, gNB should indicate to the UE this gNB-UE connection is operating in LBT mode or no-LBT mode. Down-select between* Alt 1. Support cell specific (common for all UEs in a cell as part of system information or dedicated RRC signalling or both) gNB indication
* Alt 2. Support both cell specific (common for all UEs in a cell as part of system information or dedicated RRC signalling or both) and UE specific (can be different for different UEs in a cell as part of UE-specific RRC configuration) gNB indication
* FFS: Whether the indication of the decision on applying LBT mode or no-LBT mode is per beam (can be different for different UEs in different beams or can be different for different beam pairs between gNB and the UE) or per cell (can be different for different cells for a UE in carrier aggregation)
* FFS: Whether a gNB and its UE(s) can have different mode
* FFS: Whether L1 signalling can be used for both Alt 1 and Alt 2 for gNB indication
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| **Company** | **Key Proposals/Observations/Positions** |
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| CATT | Proposal 1: Both Cell-specific and UE-specific gNB indication should be supported to indicate LBT or No-LBT mode to the UE.Proposal 2: L1 signaling, such as DCI format 1\_0 scrambled by SI-RNTI/P-RNTI, could be used as Cell-specific gNB indication to indicate LBT mode or No-LBT mode to the UE. |
| Charter Communications | Proposal 5: For indication of LBT mode or no-LBT mode in regions where LBT is not mandated, support only cell specific (common for all UEs in a cell as part of system information or dedicated RRC signalling or both) gNB indication without L1 signalling. |
| Convida Wireless | Proposal 2: Adaptation between LBT modes and LBT sub-modes for optimizing system performance should be considered.Proposal 3: Both cell specific and UE specific gNB indication could be used. In UE specific gNB indication, LBT mode could be different for different UEs in a cell as part of UE-specific RRC configuration.Proposal 4: Both L1 signalling and higher layer signaling could be considered for gNB indication of LBT mode. |
| Ericsson | Proposal 21 Support Atl.2 where both cell specific and UE specific signals could be used for indicating LBT mode.Proposal 22 For NR operation in 52.6GHz to 71 GHz, gNB and UE(s) could have different LBT modes. |
| Fujitsu | Proposal 1: Regarding indication of LBT mode and no-LBT mode, Alt 2 should be adopted.• Alt 2. Support both cell specific (common for all UEs in a cell as part of system information or dedicated RRC signalling or both) and UE specific (can be different for different UEs in a cell as part of UE-specific RRC configuration) gNB indication. |
| FUTUREWEI | Proposal 10: For regions where LBT is not mandatory, a no-LBT mode can be defined and switching between LBT mode and no-LBT mode can be supported. Proposal 11: For indication of LBT mode and no-LBT mode, cell specific (common for all UEs in a cell) indication as part of system information and dedicated RRC signaling should be supported. • FFS: Supporting UE specific (i.e., different for different UEs in a cell) indication via dedicated RRC signaling.Proposal 12: In deployments without LBT consider specification of channel vacation policies accounting for disparity among co-existing devices. |
| Huawei HiSilicon | Proposal 21：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 22: For operation in the 60 GHz band, in regions where LBT is not mandated, support Alt 1, i.e., cell specific gNB indication common for all UEs in a cell as part of system information or dedicated RRC signalling or both.Within the same cell, all nodes, UEs and gNB, should apply the same channel access mechanism.Only higher layer signaling is supported for this gNB indication.Proposal 23: 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. Proposal 24: For operation in the 60 GHz band, in regions where LBT is not mandated, COT should be limited when no–LBT is used.Observation 6: When No-LBT is used in regions where LBT is not mandated by regulations, the hidden node issue would still persist. |
| Intel Corporation | Proposal 8: gNB indicates whether LBT or no-LBT procedure should be used via both system information and UE-specific RRC configuration.Proposal 9: A switching mechanism between LBT and no-LBT is defined, but it is up to gNB’s control to decide when to switch. |
| InterDigital Inc. | Proposal 9: The indication of channel access mode is received per cell and per beam. |
| Lenovo Motorola Mobility | Observation 5: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, long-term channel sensing could be useful for both LBT and no-LBT based channel access mechanism:- For LBT based channel access mechanism, long-term sensing at the UE could be utilized for receiver assistance LBT at the gNB- For no LBT based channel access mechanisms, long-term sensing could provide interference statistics in terms of potential interference from WiFi as well as interference from other NR operatorsProposal 22: 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 23: 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. |
| LG Electronics | Proposal #1: The channel access mechanism can be switched from LBT mode to no-LBT mode based on timer operation when receiving the information of the local regulation from the gNB (by cell specific or UE specific signaling) and satisfying certain conditions such as a low interference environment. |
| MediaTek Inc. | Proposal 1: Both cell-specific and UE-specific method should be supported for gNB to indicate UE operating in LBT or no LBT mode. |
| NEC | Proposal 7: For regions where LBT is not mandated, both cell specific and UE specific gNB indication for LBT/no-LBT mode operation should be supported. |
| Nokia Nokia Shanghai Bell | Proposal 28: UEs without LBT functionality are supported.Observation 8: Channel access mechanism without LBT should fulfil the expected requirements of EN 303 722 but also possibly EN 303 753.Proposal 34: Introduce Alt2 (both cell and UE specific) for channel access mode indication.Proposal 35: Leave any additional conditions/mechanisms/restriction/fallback modes on the no-LBT channel access mode for gNB implementation. |
| OPPO | Proposal 8: support both Alt 1 and Alt 2 for operation between LBT mode and non-LBT modeProposal 9: support gNB and UE having different modes.Proposal 10: support LBT mode per beam indication. |
| Qualcomm Incorporated | Proposal 15: Consider the use of beam specific indication of No-LBT or LBT mode.Proposal 16: Allow different modes for gNB and UE.Proposal 17: It is not necessary to use L1 signaling for cell specific and UE specific gNB indication. |
| Samsung | Proposal 1: For regions where LBT is not mandated,• support both cell-specific and UE-specific indication of the operation mode (Alt 2).o the cell-specific indication is a group of mode pairs, wherein each mode pair defines the modes of gNB and UE for a particular beam;o the UE-specific indication is a mode pair.• gNB determines its operation mode up to implementation. |
| Sony | Observation 1: In EU, no-LBT mode cannot be operated at least under the ‘C1’ mode 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 already been introduced in NR-U.Proposal 1: No-LBT mode is configured by the network based on measurement results of RSSI and channel occupancy.Proposal 2: For indication of LBT mode/no-LBT mode, both cell specific and UE specific gNB indication should be supported. |
| Spreadtrum Communications | Proposal 15: Support both cell specific and UE specific gNB indication for LBT mode or no-LBT mode. |
| vivo | Proposal 17: Both cell-specific and UE-specific indication of the channel access mode should be supported. Per-beam based channel access mode indication is not necessary.Proposal 18: The channel access mode can be selected based on the channel occupancy time, channel access rate, transmission priority, service requirement, or feedback information from the receiver, etc. |
| Xiaomi | Proposal 2: Support both cell specific (common for all UEs in a cell as part of system information or dedicated RRC signalling or both) and UE specific (can be different for different UEs in a cell as part of UE-specific RRC configuration) gNB indicationProposal 3: How to prevent long time continuous channel occupying for Tx using No-LBT should be further studied. |
| ZTE Sanechips | Observation 6: Once the transmission of DL/UL channels/signals considered as Short Control Signalling exceeds 10ms limitation, it is a nature way to switch from No LBT mode to LBT mode.Proposal 9: No LBT can be considered to be used in the following cases:• COT sharing case only if the later transmission starts within the maximum gap Y from the end of the earlier transmission.• Specific areas 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.Observation 8: No LBT should be workable only if some interference elimination mechanisms are applied on top of it. If no LBT is supported, the spec impact of introducing such enhancement should be further studied and evaluated.Proposal 11: Conditions for No LBT fallback to LBT should be further studied, e.g., based on the interference level or correctly decoding rate. |

### First Round Discussion

No LBT: For regions where LBT is not mandated, gNB should indicate to the UE this gNB-UE connection is operating in LBT mode or no-LBT mode, the following positions are reached by companies

* Alt 1. Support cell specific (common for all UEs in a cell as part of system information or dedicated RRC signalling or both) gNB indication
	+ Charter, Huawei, Inter-digital, OPPO
* Alt 2. Support both cell specific (common for all UEs in a cell as part of system information or dedicated RRC signalling or both) and UE specific (can be different for different UEs in a cell as part of UE-specific RRC configuration) gNB indication
	+ CATT, Convida, Ericsson, Fujitsu , (FFS for Futurewei), Intel, (LG?), MediaTek, NEC, Nokia, OPPO, Samsung, Sony, Spreadtrum, Xiaomi, Vivo
* FFS: Whether the indication of the decision on applying LBT mode or no-LBT mode is per beam (can be different for different UEs in different beams or can be different for different beam pairs between gNB and the UE) or per cell (can be different for different cells for a UE in carrier aggregation)
	+ Per Beam: Inter-digital, OPPO, Samsung, Qualcomm,
	+ Against: Vivo
* FFS: Whether a gNB and its UE(s) can have different mode
	+ Support: Ericsson, OPPO, Qualcomm
	+ Against: Huawei
* FFS: Whether L1 signalling can be used for both Alt 1 and Alt 2 for gNB indication
	+ For: Convida
	+ Against: Qualcomm

For regions where LBT is not mandated, gNB should indicate to the UE this gNB-UE connection is operating in LBT mode or no-LBT mode, between the two alternative, Alt 2 seems to have stronger support

Proposal 2.10.1-1

For regions where LBT is not mandated, gNB should indicate to the UE this gNB-UE connection is operating in LBT mode or no-LBT mode

* Support both cell specific (common for all UEs in a cell as part of system information or dedicated RRC signalling or both) and UE specific (can be different for different UEs in a cell as part of UE-specific RRC configuration) gNB indication

|  |  |
| --- | --- |
| Company | View |
| Nokia, NSB | We support the new proposal 2.10.1-1 |
| Charter Communications | OK with the proposal |
| Lenovo, Motorola Mobility | We support the proposal |
| ZTE, Sanechips | Agree with proposal 2.10.1-1 |
| Intel | We support the proposal. |
| vivo | Support the proposal. |
| Apple | Support the proposal  |

Discussion 2.10.1-2

If UE specific gNB indication on using LBT mode or no-LBT mode is adopted, please provide your view whether the indication of the decision on applying LBT mode or no-LBT mode is per beam (can be different for different UEs in different beams or can be different for different beam pairs between gNB and the UE) or not

* Support per beam indication of the decision on applying LBT mode or no-LBT mode:
* Do not support per beam indication of the decision on applying LBT mode or no-LBT mode:

|  |  |
| --- | --- |
| Company | View |
| Nokia, NSB | As a starting point, cell-specific indication seems sufficient. We may further consider beam-specific indication.  |
| Charter Communications | Do not support per beam indication |
| Lenovo, Motorola Mobility | In our view, per beam indication should be applied to indicate LBT or no LBT mode. It could be different for different beam pairs between gNB and UE |
| ZTE, Sanechips | Support per beam indication of the decision on applying LBT mode or no-LBT mode |
| Intel | We do not see the need to support this indication in terms of beams, so the proposal with first bullet removed is preferred.  |
| vivo | Per-beam channel access mode indication is not necessary. The beam pair link quality is changing due to UE moving or rotation. In general, TCI states are updated dynamically based on beam report, e.g. the gNB activates a set of TCI states via MAC CE or indicates TCI state by DCI. Therefore, per-beam channel mode indication by RRC will not adapt to the change of the TCI state. |
| Apple | Do not support per beam indication. UE beam is not known to network in general.  |

Discussion 2.10.1-3

If UE specific gNB indication on using LBT mode or no-LBT mode is adopted, please provide your view whether the indication of the decision on applying LBT mode or no-LBT mode is per cell (can be different for different cells for a UE in carrier aggregation),

* Support per cell indication of the decision on applying LBT mode or no-LBT mode:
* Do not support per cell indication of the decision on applying LBT mode or no-LBT mode:

|  |  |
| --- | --- |
| Company | View |
| Nokia, NSB | We support per-cell indication. In CA, different cells may in principle be operating according to different ETSI harmonized standards, e.g. depending on the type of the equipment. |
| Lenovo, Motorola Mobility | Per cell indication could also be indicated |
| ZTE, Sanechips | If the same interference situation is for UEs under cell, then we support per cell indication of the decision on applying LBT mode or no-LBT mode. Otherwise, we do not support per cell indication of the decision on applying LBT mode or no-LBT mode. |
| Intel | We support the per cell indication, and the proposal with the second bullet removed. |
| vivo | Support per cell indication of the decision on applying LBT mode or no-LBT mode |
|  |  |

Discussion 2.10.1-4

For regions where LBT is not mandated, please provide your view if gNB and UE can have different LBT or no-LBT mode

* Support a gNB and its UE(s) to have different mode:
* A gNB and its UE(s) are either both in LBT mode or both in no-LBT mode:

|  |  |
| --- | --- |
| Company | View |
| Nokia, NSB | Yes, if LBT is not mandated on a given region, enabling of LBT can be done separately for gNB and different UEs  |
| Charter Communications | Don’t see a technical justification but the flexibility to implement this should be available |
| Lenovo, Motorola Mobility | LBT can be enabled/indicated separately for gNB and UEs |
| ZTE, Sanechips | Support a gNB and its UE(s) to have different mode |
| Intel | Our view is that the gNB and its UE(s) can have different mode of operation. |
| vivo | Support a gNB and its UE(s) to have different mode |
| Apple | Support gNB and UE to have different mode. This allows only gNB perform sensing. |

Discussion 2.10.1-5

For regions where LBT is not mandated, please provide your view if L1 signalling is be introduced for gNB to indicate to the UE if the operation is in LBT mode or no-LBT mode

* Support:
* Not support:

|  |  |
| --- | --- |
| Company | View |
| Nokia, NSB | At least for initial access, the UE will need to get a L1 indication of whether or not LBT should be used. |
| Charter Communications | Do not support, higher-layer signaling can support all cases. |
| Lenovo, Motorola Mobility | We support L1 signalling introduction |
| ZTE, Sanechips | Share same views with Nokia. |
| Intel | We do not support L1 signalling for this purpose. |
| Vivo | If clear motivation or benefit can be seen, L1 signalling can be introduced. |
| Apple | Do not support L1 signaling for this purpose.  |

## Short Control Signaling and Contention Exempt Transmission

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| --- |
| Agreement:* Contention Exempt Short Control Signaling rules can be applicable to the transmission of SS/PBCH.
	+ FFS: What are the other DL signals and channels that can be multiplexed with SS/PBCH transmission under Contention Exempt Short Control Signaling rule
	+ FFS: Whether this can be applied to all supported SCS or specific SCS.
	+ FFS: Extension to discovery burst if it is defined including signals other than SS/PBCH
	+ Note: Restriction for short control signalling transmissions apply (10% over any 100ms interval)
* FFS: Other DL signals/channels can be transmitted with Contention Exempt Short Control Signaling rule, such as PDCCH, broadcast PDSCH, PDSCH without user plain data, CSI-RS, PRS, etc

Agreement:For contention exemption short control signalling based DL transmission of SS/PBCH, further consider if the following signals/channels can be multiplexed with SS/PBCH block transmission.* RMSI PDCCH and RMSI PDSCH
* Other broadcast PDSCH
* PDSCH without user-plane data
* PDCCH
* CSI-RS
* PRS
* Other signals/channels contained in Discovery Burst (i.e., exemption applies to Discovery Burst)

Note: Total exempted signals/channels should meet the restriction of 10% over any 100ms interval.FFS: If contention exemption short control signalling based DL transmission is allowed when not multiplexed with SS/PBCH block transmission. |

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| **Company** | **Key Proposals/Observations/Positions** |
|  |  |
| Apple | Proposal 7: Other DL signals and channels for control, management and beamforming RS that is FDMed together in the SSB symbol can be transmitted as short control signaling.Proposal 8: Transmission of SSB as short control signaling can be applied to 120KHz, 240KHz, 480KHz and 960KHz SCS. It is up to gNB implementation to ensure short control signaling regulation limitation is met. Proposal 9: For UL, at least PRACH should be considered as short control signaling. The 10% over any 100ms interval restriction is applicable to the msg1/msg3/msgA transmission from one UE perspective. |
| CATT | Proposal 16: The Contention Exempt Short Control Signaling rules can be applied to SS/PBCH transmission of all the supported SCS with the restriction that less than 10% duty cycle within 100ms has to be satisfied.Proposal 17: For UL signal, the Contention Exempt Short Control Signaling rules can be applied to Msg1/Msg A and ACK/NACK signaling.Proposal 18: The Contention Exempt Short Control Signaling can be applied to any signaling without user-plane data multiplexed with SS/PBCH block transmission.Observation 1: When the periodicity of SS/PBCH block is 20msec and the number of SSB beams is 64, the total duration of SSB transmission is more than 10% within 100ms.Proposal 19: In order to meet the rule of less than 10% duty cycle within 100ms, the Contention Exempt Short Signaling rules shall be applied to specific SSB beams for 120 kHz SCS. |
| Charter Communications | Proposal 4: The short control signalling exemptions for SS/PBCH blocks should apply at least to an entire SSB burst of any SCS that is not multiplexed with unicast control or data (subject to the duty cycle limits). |
| Ericsson | Observation 9 In HS EN 302 567, SCS transmissions have a duty cycle requirement but no limitations on the number of SCS transmissions within the observation period.Proposal 6 Support extending the Short control signalling transmissions exemption to Discovery Burst.Proposal 7 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 10 ms within an observation period of 100ms. The following signals/channels shall be classified as short control signaling transmissions:1 msg1 and msg3 for the 4 step RACH and MsgA for the 2-step RACH2 FFS: Other control transmissions not multiplexed with user data (subject to gNB configuration) |
| Huawei HiSilicon | Proposal 25: In regions where LBT is mandated, for contention exemption short control signalling based DL transmission of SS/PBCH, only channels/signals that can be multiplexed within the DB as defined for Rel-16 NR-U should be supported.Proposal 26: In regions where LBT is mandated, contention-exempt short control signaling rules do not apply to the transmission of msg1/msg3 for 4 step RACH and MsgA for 2-step RACH. |
| Intel Corporation | Proposal 19: It is left up to gNB to decide and apply SSE to any signals/channels which are additionally multiplexed with SS/PBCH, as long as when it does the 10% duty cycle over a 100ms observation period is met.Proposal 20: SSB transmission with no LBT is supported at least for 960 kHz and type0-PDCCH.Proposal 21: It is up to the gNB to decide and apply SSE to the discovery burst, as long as when it does the 10% duty cycle over a 100ms observation period is met.Observation 3: 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 22: Consider applying short control signal exemption to PRACH transmission by the UE. |
| LG Electronics | Proposal #2: The contention exempt short control signalling can be supported for SS/PBCH multiplexed with non-unicast information (e.g., SIB1, CSI-RS), where the transmission(s) duration is not exceed 10ms within an observation period of 100ms. |
| 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 14: NR-U design for 60 GHz bands supports transmission of the following DL and UL control and management signals as short control signalling without LBT: • Downlink: SS/PBCH blocks (already agreed), PDCCH, CSI-RS and other reference signals, e.g., for beam management, SIBs, Paging• Uplink: HARQ-ACK feedback on either PUCCH or PUSCH, Scheduling Request, CSI feedback, Sounding RS, e.g., for beam management, RACH related transmissionsProposal 15: For the UL transmissions, the 10% short control signaling allowance is shared by all the UEs in the cell.Proposal 18: Use of short control signal contention exemption and use of LBT is periodically cycled over the SSBs, evenly distributing the channel access uncertainty over the SSBs. |
| NTT DOCOMO INC. | Proposal 5: Contention Exempt Short Control Signaling rules can be applicable to the transmission of SS/PBCH and multiplexed signals/channels within a same transmission burst irrespective of SCS |
| OPPO | Proposal 14: PUCCH carrying HARQ-ACK information and SSB burst belong to short control signaling; while the duty cycle limitation should be met. |
| Qualcomm Incorporated | Proposal 12: Under the restrictions of duty cycle for short control signaling, allow SS/PBCH, PDCCH, CSI-RS and PRS for contention exempt transmissionProposal 13: Under the restrictions of duty cycle for short control signaling, allow PRACH, msg1, msg3, msgA, SRS, PUCCH and PUSCH without user plane data for contention exempt transmission |
| Samsung | Proposal 7: For “short control signalling”:• support discovery burst as part of the short control signalling;• support other periodic transmission with high priority can be part of “short control signalling”, including non-unicast information, PRACH, PDCCH, PUCCH, and RS.• support limitation on the duty cycle to use “short control signalling”, wherein the duty cycle are defined from the channel occupancy point of view. |
| Sony | Proposal 3: Contention exempt short control signalling should be adopted for transmission of RMSI PDCCH, RMSI PDSCH, and/or CSI-RS contained in Discovery Burst.Proposal 4: Contention exempt short control signalling should be adopted for PRACH transmission. |
| vivo | Proposal 19: The contention exempt short control signaling can be extended to discovery burst with duration less than 1ms.Proposal 20: The contention exempt short control signaling based SS/PBCH can be multiplexed with RMSI PDCCH, RMSI PDCH and CSI-RS. |
| ZTE Sanechips | Observation 7: For the case of the transmission of DL/UL channels/signals considered as Short Control Signalling is in a COT initiated by gNB or UE, it is suggested that such transmission should not be counted into 10ms limitation within the 100ms observation period.Observation 2: On 10ms limitation of Short Control Signalling, it is recommended that “ the total time corresponding to all transmitted symbols for a channel/signal that is regarded as short control signalling can be used to evaluate whether to meet 10ms limitation” should be considered.Observation 3: Other channel/signal is allowed to be multiplexed with a channel/signal that has been regarded as Short Control Signalling only if their total transmission time does not exceed 10ms limitation within 100ms observation period.Observation 4: l For 120 kHz SCS SS/PBCH, transmitted 64 SS/PBCH with 20ms SS/PBCH period exceeds 10ms limitation within a 100ms observation period required for short control signalling.l For larger SCS (e.g., 240/480/960kHz) SS/PBCH, transmitted 64 SS/PBCH with 20ms SS/PBCH period does not exceed 10ms limitation within a 100ms observation period required for short control signalling.Observation 5: Msg1 or Msg3 or MsgA can be considered to apply Contention Exempt Short Control Signaling rules.Proposal 7: SS/PBCH other than 120kHz SCS can be considered using Contention Exempt Short Control Signaling rules.Proposal 8: Msg1 or Msg3 or MsgA can be considered using Contention Exempt Short Control Signaling rules. |

### First Round Discussion

For Short Control Signaling exemption from LBT for uplink transmissions, following positions are roughly reached by the companies

* PRACH, Msg1/MsgA
	+ Apple, Ericsson, CATT, Intel, ZTE
	+ Against; Huawei
* PUCCH (all)
* Msg3
	+ Ericsson, ZTE
	+ Against: Huawei
* Ack/Nack on PUSCH (Nokia)
* CSI reporting on PUSCH (Nokia)
* SRS (all)

Proposal 2.11.1-1:

* Contention Exempt Short Control Signaling rules apply to the transmission of msg1 and/or msg3 for the 4 step RACH and MsgA for the 2-step RACH for all supported SCS.
	+ Note restriction for short control signalling transmissions apply (10% over any 100ms intervals)
	+ Alt 1: The 10% over any 100ms interval restriction is applicable to all available msg1/msg3/msgA resources configured in a cell
	+ Alt 2: The 10% over any 100ms interval restriction is applicable to the msg1/msg3/msgA transmission from one UE perspective
* FFS: Other UL signals/channels can be transmitted with Contention Exempt Short Control Signaling rule, such as SRS, PUCCH, PUSCH without user plain data, etc

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| --- | --- |
| Company | View |
| Nokia, NSB | We support the proposal. |
| Charter Communications | Support the proposal |
| Lenovo, Motorola Mobility | We support the proposal. Our understanding from the regulation is that the short control signalling exemption applies to a respective transmitter's perspective, i.e. Alt 2. Alt 1 would therefore be a tighter condition. |
| ZTE, Sanechips | Support proposal 2.11.1-1 and prefer to support Alt 1. and for main bullet, we understand if the total duration of Msg1 and Msg 3 exceeds to 10ms limitation, then this case cannot be seen as SCS transmission. |
| Intel | We support the proposal. |
| Apple | Support the proposal. Alt 2 should be used for 10% short control signaling overhead  |

## CWS and CAPC

|  |  |
| --- | --- |
| **Company** | **Key Proposals/Observations/Positions** |
| CATT | Proposal 7: No need to introduce CAPC and CWS. |
| Ericsson | Proposal 17 Do not support CAPC and CWS adjustment for NR operation in 52.6 GHz to 71 GHz. |
| Intel Corporation | Proposal 2: For operation unlicensed 60 GHz band, when LBT is used within the COT, the principle of the type 1 channel access procedure defined for the sub-6 GHz band should be reused, and the channel access parameters should be modified in accordance with numerologies provided by the ETSI BRAN Harmonized Standard.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. |
| ITRI | Proposal 6: CWS adjustment mechanism could be applied per beam-based in an independent manner for 60 GHz NR-U. |
| Lenovo Motorola Mobility | Proposal 19: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, CWS adjustment should be applied for each beam in an independent manner depending upon the corresponding CAPC (when Cat 4 LBT is done for each beam and COT is initiated for each of the beams), where the CWS adjustment for a transmit beam (TCI state) of a data channel can be based on the ACK/NACK feedback for the corresponding data channel with the same transmit beam (TCI state) |
| LG Electronics | Proposal #4: 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. |
| MediaTek Inc. | Proposal 4: For channel access mechanism, at least channel access priority class should be considered to prioritize different traffic. |
|  | Proposal 5: Current CAPC table can be a starting point for 52.6 – 71 GHz. |
| Nokia Nokia Shanghai Bell | Observation 1: We do not see a need for contention window adjustment mechanism for mitigating channel access collisions.  Proposal 1: LBT procedure uses fixed contention window size for random back-off. The size of the fixed contention window is FFS. Proposal 2: At most two CAPCs are supported.Proposal 17: High CAPC with short contention window of [3] CCAs is supported for SSB transmission.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. |
| Qualcomm Incorporated | Proposal 18: CWS adjustment need not be introduced for 60GHz band.Proposal 19: CAPC need not be introduced for 60GHz band. |
| Samsung | Proposal 5: No need to define CAPC for 60 GHz unlicensed band. |
| Sony | Proposal 5: Support fixed Contention Window.• gNB’s contention windows size is left to network implementation.• UE’s contention window size is configured by network.Proposal 6: Introduce Cat 2 LBT for 60 GHz unlicensed band operation |
| WILUS Inc. | Proposal 4: We propose to introduce CAPC, CWS and CWS adjustment mechanism for 60GHz band, with Rel.16 NR-U as baseline. |
| ZTE Sanechips | Proposal 10: 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.Observation 9: CWs adjustment can be considered to be introduced, which is beneficial in some highly congested scenarios and to friendly and fair coexistence with Wi-Fi. |

### First Round Discussion

Discussion 2.12.1-1

On if CWS adjustment is introduced, the following positions are collected.

* Support the introduction of CWS adjustment
	+ ZTE, WILUS, Lenovo, ITRI, Intel
* Do not introduce CWS adjustment
	+ SONY, Qualcomm, Ericsson, CATT, Nokia, NSB, vivo

Please provide additional views if any

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| --- | --- |
| Company | View |
| Nokia, NSB | Do not support CWS adjustment. ETSI 302 567 does not recognize CWS adjustment, and there is no clear reason why RAN1 should deviate from that. |
| Charter Communications | Do not support CWS adjustment, it is meaningless for Cat-3 LBT |
| Lenovo, Motorola Mobility | We prefer CWS adjustment per beam basis |
| ZTE, Sanechips | Support the introduction of CWS adjustment and its introduction is beneficial in some highly congested scenarios and to friendly and fair coexistence with Wi-Fi due to it had been introduced in 802.11ad/ay. |
| Intel | We think that the notion of CWS adjustment should be also introduced here, and the principles/framework used for sub-6 GHz band NR-U could be used as a baseline. |
| vivo | Do not introduce CWS adjustment. Added our position to the summary. |
| Apple | Do not introduce CWS adjustment |

Discussion 2.12.1-2

On if CAPC is introduced, the following positions are collected.

* Support the introduction of CAPC
	+ ZTE, WILUS, Lenovo, ITRI, Intel, Nokia (at most 2 classes), MediaTek,
* Do not introduce CAPC
	+ Samsung, Qualcomm, Ericsson, CATT, vivo

Please provide additional views if any

|  |  |
| --- | --- |
| Company | View |
| Nokia, NSB | This depends on the maximum CWS that is supported. We think that CWS = 3 is useful at least for SSBs (if short control signaling cannot be used), and other control signals. If the CWS is always =3, a single CAPC is sufficient; otherwise we may consider two CAPCs (and max CWSs), one (>3) for data, and another one for control signals. |
| Charter Communications | Do not introduce CAPC. The objective should be to serve traffic of all classes as quickly as possible given the transient nature of the link. |
| Lenovo, Motorola Mobility | We prefer CAPC adjustment per beam basis |
| ZTE, Sanechips | Support the introduction of CAPC to consider the requirement of different traffic type. |
| Intel | We support the introduction of a reduced set of CAPC compared to sub-6 GHz band NR-U. |
| vivo | Do not introduce CAPC. Added our position to the summary. |
| Apple | Do not introduce CAPC  |

## Long Term Sensing, Interference Mitigation, ATPC

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| --- | --- |
| **Company** | **Key Proposals/Observations/Positions** |
| Apple | Proposal 14: Consider using omni and directional RSSI and channel occupancy for long term sensing.  |
|  AT&T |  |
|  CAICT |  |
|  CATT |  |
|  Charter Comm. |  |
|  Convida Wireless |  |
|  Ericsson |  |
|  Fujitsu |  |
|  FUTUREWEI |  |
|  Huawei HiSilicon |  |
|  Intel Corporation |  |
|  InterDigital Inc. |  |
|  ITRI |  |
|  Lenovo Motorola Mobility | Observation 5: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, long-term channel sensing could be useful for both LBT and no-LBT based channel access mechanism:- For LBT based channel access mechanism, long-term sensing at the UE could be utilized for receiver assistance LBT at the gNB- For no LBT based channel access mechanisms, long-term sensing could provide interference statistics in terms of potential interference from WiFi as well as interference from other NR operatorsObservation 2: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, in order to adopt ATPC as potential channel access mechanism, receiver feedback such as long-term sensing would be neededProposal 20: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, ATPC could be adopted as one of the channel access mechanism, at least for regions where LBT is mandated by regulatory requirements |
|  LG Electronics |  |
|  MediaTek Inc. |  |
|  NEC |  |
|  Nokia Nokia Shanghai Bell |  |
|  NTT DOCOMO INC. |  |
|  OPPO |  |
|  Panasonic |  |
|  Qualcomm  |  |
|  Samsung |  |
|  Sony |  |
|  Spreadtrum Comm. |  |
|  vivo |  |
|  WILUS Inc. |  |
|  Xiaomi |  |
|  ZTE Sanechips |  |

## Other

|  |  |
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| **Company** | **Key Proposals/Observations/Positions** |
| InterDigital Inc. | Proposal 10: The UE can select a channel access mechanism as a function of measurements (e.g. RSRP) or prior LBT performance. |
| ITRI | Proposal 4: PDCCH monitoring enhancement for M-TRP operation should be supported for 60 GHz NR-U. Proposal 5: Configuring multiple SRIs for a CG transmission should be supported for 60 GHz NR-U. |
| Lenovo Motorola Mobility | Observation 3: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, depending on the configuration, a collision on CG resources can cause systematic collisions between corresponding subsequent retransmissions causing transmission failure of affected packets.Proposal 13: If a UE is going to transmit a set of consecutive PUSCH transmissions including both dynamically scheduled PUSCH transmissions and CG-PUSCH transmissions, the UE can select the latest indicated UL Tx beam to transmit the consecutive UL transmissions.Proposal 14: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, then following potential enhancements related to periodic transmissions of RS such as P-TRS should be specified to deal with LBT failure:- Termination of periodic RS transmission on beams where consecutive LBT failures are encountered- Dynamic switching of the QCL assumption (beams) for periodic RS transmission where consecutive LBT failures are encountered, where:o Multiple QCL assumptions (multiple beams) can be configured to the RS resource and beam switch can be triggered once the continuous number of LBT failures reach a certain threshold valueProposal 30: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, potential enhancements related to periodic transmission of DRS such as SSB/PBCH/CORESET#0 are needed including:- performing directional LBT prior to the transmission of SSB according to the ssb-PositionsInBurst- directional LBT on multiple beams at the same time at the beginning of the DRS window- Cat 2 LBT (depending on the gap) before actual transmission |
| ZTE Sanechips | Proposal 20: Study and evaluate the impact of LBT and the limitation of COT length on the procedure of beam failure detection. |
| Convida Wireless | Proposal 13: Increasing the number of SSB candidate positions to above 64 to increase transmission opportunities to cope with LBT failure should be considered. |

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