3GPP TSG RAN WG1 Meeting #102-e R1-200xxxx

Aug 17th – 24th, 2020

Agenda item: 8.2.2

Source: Moderator (Qualcomm Incorporated)

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

Document for: Discussion and Decision

# Introduction

This paper summarizes the email discussion for agenda item 8.2.2

[102-e-NR-52-71-Channel-Access] Email discussion/approval on channel access mechanism until 8/20; address any remaining aspects by 8/25 – Jing (Qualcomm)

# Regulatory updates

Multiple submitted papers suggest considering current regulation in EN 302 567 as baseline for channel access design. However, there seems to be no common understanding on the regulation. There are also proposals suggesting no LBT needs to be applied for regions and/or bands where there is no LBT requirements. This section is devoted to have a common understanding on what regulation we target the channel access design for, and what are the requirements from regulations.

## Regional differences in regulation

The regulations governing the unlicensed portions of the 57-71GHz band vary according to regions.

* FCC in the USA, imposes EIRP and maximum conducted output power limits for devices, but does not mandate a spectrum sharing mechanism
* Similarly, Listen Before Talk (LBT) protocol is not mandated in China, Japan, South Korea, Australia and Singapore.
* For EU, there are three regulations that govern the use of the spectrum that cover three types of deployment modes, under ‘C1’, ‘C2’, and ‘C3’.
  + In EU, regulated by ETSI BRAN, LBT with CCA is mandated only under the ‘C1’, for indoor and outdoor deployment (except outdoor fixed deployment) of Multiple Gigabit Wireless Systems devices, which is governed by regulation EN 302 567. Only this regulation has a stable version of channel access rule details defined.
  + In the same frequency band, fixed outdoor deployment technologies, Wideband Data Transmission Systems. ‘C3’ are governed by EN 303 722, whose agreed drafts do not mandate sensing/LBT but enforce that the deployment uses directional antennas with antenna gain exceeding 30 dBi.
  + Another ETSI BRAN work item, leading to specification EN 303 563 will define new spectrum access regulations, applicable to ‘C2’ deployments, which will cover indoor as well as outdoor deployments without the restriction to fixed links.

## Occupied Channel Bandwidth in ETSI BRAN EN 302 567

ETSI BRAN Harmonized standard EN 302 567 V2.1.20, the section on Occupied Channel Bandwidth, [1, Section 4.2.10.3] specifies the requirements for OCB criterion as follows.

4.2.10.3 Requirements

The Occupied Channel Bandwidth shall be less than the declared nominal Channel Bandwidth for all transmissions. The device shall support a mode of transmission with a necessary bandwidth as defined in Radio Regulation 1.152 (Article 1) [i.11] at least 70% of the declared nominal channel bandwidth. In case of smart antenna systems (devices with multiple transmit chains) each of the transmit chains shall meet this requirement.

Further ETSI EN 302 567 V2.1.20 Section on Occupied Channel Bandwidth, [1, Section 5.3.10.1] specifies the test conditions for the OCB criteria to be met as follows.

These measurements need to be performed at normal and extreme test conditions.

The device shall be configured to operate at its maximum output power level. If the device can operate with different nominal channel bandwidths, then for each nominal channel bandwidth the mode of transmission with the largest necessary bandwidth shall be used for this test

It will be beneficial to have a consensus on the understanding on the requirement on devices to support a mode of transmission that satisfies the OCB criterion related to the declared nominal bandwidth.

* Alt 1: A device is required to occupy at least 70% of the nominal channel bandwidth all the time
* Alt 2: A device is NOT required to occupy at least 70% of the nominal channel bandwidth all the time. Instead the device only need be able to support transmitting with at least 70% of the nominal channel bandwidth

Please provide your view below:

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| Company | View |
| Qualcomm | Alt 2 |
| Xiaomi | Support Alt 2 |
| Sharp | Alt 2 |
| Huawei/HiSilicon | First, as a note to above description in Section 2.1, our understanding is that EN 302 567 does not regulate only indoor deployment of Multiple Gigabit Wireless Systems devices. In fact, in Section 1 of EN 302 567, we read:  “The present document specifies technical characteristics and methods of measurements for radio equipment with integral antennas operating indoor or outdoor at data rates of multiple-gigabit per second in the 60 GHz frequency range”.  EN 302 567 only excludes fixed outdoor installations.  Second, our understanding of EN 302 567 is that, when one or multiple nominal channel BWs are declared by the manufacturer, the device must be able to support all the declared nominal channel bandwidths. Therefore, “device only need be able to support transmitting with at least 70% of the nominal channel bandwidth” in Alt 2 does not seem to be aligned with EN 302 567. However, for each declared nominal BW, there should be a transmission mode that occupies at least 70% of the corresponding nominal channel BW. As such, we propose the following Alt 3:  **Alt 3:** Device supports one or multiple declared nominal channel bandwidths. For each declared nominal channel bandwidth, there should be at least one transmission mode that occupies at least 70% of the nominal channel bandwidth.   * 3GPP should therefore design at least one such transmission mode. |
| Nokia | Alt 2. It is sufficient that the device has at least one transmit configuration (e.g. full PRB allocation) that fulfils the 70% OCB requirement. The test clause text quoted above further explains this. The background of the OCB requirement relates to the unwanted spectrum emission mask, which is a function of declared nominal channel bandwidth, i.e. with the 70% test condition manufacturers need to declare reasonable nominal channel bandwidths, and consequently apply reasonable unwanted emission masks. |
| vivo | Alt 2. |
| LG | Alt 2 is preferred. However, Alt 1 can be also considered since both alternatives don’t seem to violate the OCB requirements described in the latest draft of EN 302 567. |
| Apple | Our understanding is Alt. 2. We would like to clarify that this is just one specific mode and that the device may not always have to satisfy the OCB requirement.  On another issue, from our understanding, EN 303 722 governs both c2 and c3 as seen in the link below and as at May 2020, does not specify any OCB requirements. This means that similar to the idea of having multiple LBT modes of operation, **3GPP may want to design multiple OCB modes of operation**.  [EN 303 722 Reference](https://portal.etsi.org/webapp/WorkProgram/Report_WorkItem.asp?WKI_ID=58483&curItemNr=16&totalNrItems=392&optDisplay=100000&qSORT=HIGHVERSION&qETSI_ALL=&SearchPage=TRUE&qDIRECTIVE=2014%2F53%2FEU&qINCLUDE_SUB_TB=True&qINCLUDE_MOVED_ON=&qSTOP_FLG=N&qKEYWORD_BOOLEAN=OR&qCLUSTER_BOOLEAN=OR&qFREQUENCIES_BOOLEAN=OR&qSTOPPING_OUTDATED=&butExpertSearch=Search&includeNonActiveTB=FALSE&includeSubProjectCode=FALSE&qREPORT_TYPE=)  Develop Harmonized Standard for Wideband Data Transmission Systems (WDTS) for fixed network radio equipment operating in 57 - 71 GHz band taking into consideration ERC/REC 70-03 Annex 3 (frequency bands c2 and c3) and Commission Decision 2006/771/EC.  EN 303 722 v0.0.0.4 (2020-05) in Section 4.2.9.3 says:  The Occupied Channel Bandwidth shall be less than 100 % of the declared nominal channel bandwidth. In case of smart antenna systems (devices with multiple transmit chains) each of the transmit chains shall meet this requirement.  [Editor’s Note: It was agreed during BRAN#105 to replace “between 70% and 100%” with “less than 100%”. However, there was no discussion related to the possible value of a lower limit (the 70%) with respect to the use of “nominal channel bandwidth” in clause 4.2.7.2.] |
| NTT DOCOMO | Alt 2 |
| InterDigital | Alt 2 |
| Intel | Support Alt 3 from Huawei. |
| ZTE, Sanechips | Support Alt. 2. |
| WILUS | Support Alt-3 from HW |

## Adaptivity rules in ETSI EN 302 567

The following is an excerpt from the latest draft of the specification in the June 2020 draft of ETSI EN 302 567 V2.1.20 describing the adaptivity rule. This text is also quoted in Intel contribution [11].

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| 1. Before a single transmission or a burst of transmissions on an Operating Channel, the equipment that initiates transmission shall perform a Clear Channel Assessment (CCA) Check in the Operating Channel. 2. If it finds an Operating Channel occupied, it shall not transmit in that channel and it shall not enable other equipment(s) to transmit in that channel. If the CCA check has determined the channel to be no longer occupied and transmission was deferred for the number of empty slots defined by the CCA Check procedure, it may resume transmissions or enable other equipment to transmit on this channel. 3. The equipment that initiates transmission shall perform the CCA check using "energy detect". The Operating Channel shall be considered occupied for a slot time of 5 μs if the energy level in the channel exceeds the threshold corresponding to the power level given in step 7) below. It shall observe the Operating Channel(s) for the duration of the CCA observation time measured by multiple slot times. 4. CCA Check definition:   a) A CCA check is initiated at the end of an operating channel occupied slot time.  b) Upon observing that Operating Channel was not occupied for a minimum of 8 µs, transmission deferring shall occur.  c) The transmission deferring shall last for a minimum of random (0 to Max number) number of empty slots periods.  d) Max number shall not be lower than 3.   1. The total time that the equipment initiating transmission makes use of an Operating Channel is defined as the Channel Occupancy Time. This Channel Occupancy Time shall be less than 5 ms, after which it shall perform a new CCA Check as described in step 1), step 2), and step 3) above. 2. An equipment (initiating or not initiating transmission), upon correct reception of a packet which was intended for this equipment, can skip the CCA Check, and immediately proceed with the transmission in response to received frames. A consecutive sequence of transmissions by the equipment, without a new CCA Check, shall not exceed the 5 ms Channel Occupancy Time as defined in step 5) above. 3. The energy detection threshold for the CCA Check shall be -47 dBm + 10 × log10 (PMax / Pout) (Pmax and Pout in W e.i.r.p.) where Pout is the RF output power (EIRP) and Pmax is the RF output power limit defined in clause 4.2.2.1. |

Channel access procedures can be cast that conform to the Adaptivity rules specified above. Intel contribution [11] specifies the following flow chart that is meant as a reference procedure to conform the channel access procedure to the specification on Adaptivity in the June 2020 draft of ETSI EN 302 567 V2.1.20.



Figure 1 Channel access procedure from Intel contribution [11]. The counter C is ‘frozen’ where the channel is found not to be idle in this procedure.

The procedure depicted in Figure 1 corresponds to a ‘freezing’ of the counter when the medium is discovered to be occupied. An alternative interpretation of the draft ETSI Specification language, instead, appears to point to the counter being ‘redrawn/reset’ when the medium is occupied. The figure 2 below describes the resulting procedure.



Figure 2 Channel access procedure modified from Figure 1. The transition marked X is replaced with the transition in Blue. The counter C is ‘reset/redrawn’ where the channel is found not to be idle in this procedure.

It will be beneficial to have a consensus on the understanding of the EN 302 567 adaptivity mechanism. The different understanding of the channel access rule in EN 302 567 can be summarized as follows

When performing CCA before initiating transmission, during count down, when an observation slot failed ED,

* Alt 1. The counter freeze, and will continue count down 8us after the interference is gone
* Alt 2. The counter will be randomly re-drawn, and a fresh count down starts 8us after the interference is gone

Note that this is just to have a common understanding of this particular regulation. This is not a proposal for the LBT procedure for the study item. We should understand this as the minimum we should do for a channel access procedure intended to comply with this regulation.

Please provide your view below:

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| Company | View |
| Qualcomm | Alt 2 from our reading is closer to the procedure defined in EN 302 567 |
| Sharp | Alt 2 according to our understanding on step 4-c above. |
| Huawei/HiSilicon | Alt 2 is aligned with the channel access procedure in EN 302 567.  However, we are not sure we are clear about the purpose of this discussion. If the purpose is to come to a consensus on the interpretation of the LBT procedure in EN 302 567, we are fine with it. However, the decision on the baseline for the LBT procedure in NR-U-60 needs a separate a discussion that we would prefer to finalize in this meeting. |
| Nokia | Alt 2. We share Qualcomm’s view that Alt 2 is closer to the EN 302 567 definition. We see that EN 302 567 LBT should be used as baseline for LBT design. |
| vivo | Our understanding on the procedure defined in EN 302 567 is close to Alt 1. We have a similar question as Huawei on the intension of this discussion. Are we intended to define a baseline LBT procedure and parameters agreeable to all companies? |
| LG | We agree with Intel's interpretation (Alt 1) because we couldn't find any clue that the counter should be re-drawn when the channel is found not to be idle in the procedure described in EN 302 567. |
| Apple | We agree with Intel and LG that there is nothing that explicitly says we should reset the counter. Considering co-existence with other RATs that implement CSMA/CA with a freeze, implementing with a reset could put any 3GPP devices at a disadvantage. |
| NTT DOCOMO | Alt 1. Same reading as LG. |
| InterDigital | We agree with Intel, LG, Apple and DCM that the specification does not explicitly elaborate the reset/redrawn of the counter. |
| Qualcomm2 | The reason we prefer Alt 2 is, right after step 4c) follows step 4d), where 4c) says observe 8 µs of channel being not occupied, then start transmission deferring, and 4d) directly defines the transmission deferral “shall last for a minimum of random (0 to Max number) number of empty slots periods”. Anyway, consider the minimum requirement of transmission deferral time is only 15 µs, the difference between the two alternatives may be small. |
| Intel | We believe Alt 1 describes more correctly the LBT procedure. For the following reasons:   1. Sec. 4.2.5 of ETSI BRAN 302 567 does not provide detailed information regarding when the back-off counter should be redrawn, but in bullet 4) it only provides some high-level definitions, and the order of the bullets should not be interpreted as the steps of the procedure.      1. CCA Check definition:   a) A CCA check is initiated at the end of an operating channel occupied slot time.  b) Upon observing that Operating Channel was not occupied for a minimum of 8 µs, transmission deferring shall occur.  c) The transmission deferring shall last for a minimum of random (0 to Max number) number of empty slots periods.  d) Max number shall not be lower than 3.   1. The LBT procedure is not a new mitigation method and has been indicate in other ETSI BRAN ENs as a medium access method. With that said, the procedure described in EN 302 567 is meant to mimic the procedure performed by 11ad/11ay technology and its numerologies, which procedurally is not different than that adopted by LAA and NR-U. TR 36.889 provides a general flowchart of the LBT procedure (attached below for convenience), which clearly shows that the counter is not updated each time the channel is found to be occupied within a CCA observation period, but only when a device is not able to transmit within its TXOP.      1. If the back-off counter is updated every time within a CCA slot the channel is found to be occupied, this will be very detrimental, and may lead to cases where a device may never be allowed to transmit especially in high load scenario, since it may be sufficient to observe a CCA slot occupied to redraw the entire back-off counter value even if the counter was nearly to zero. In essence, redrawing the back-off counter value every time the medium is busy destroys any sense of contention control and we do not believe this should be the correct behaviour.     While we believe that we may not need to converge necessarily at this stage on the exact LBT procedure, it would be good to at least align for evaluation purposes, since the LBT procedure used may greatly influence the simulation results. |
| ZTE, Sanechips | Alt. 1 is close to the channel access procedure in EN 302 567 and agree the reason provided by Intel. Further, we think the target of this phase should focus on the evaluation while not the detail of channel access procedure, which can be discussed in the WID phase. |
| WILUS | We agree with Intel and LG that the procedure described in Sec. 4.2.5 of EN 302 567 as harmonized standard seems to be close to Alt-1. |

# Summary of contributions

The section summarises key proposals and observations from submitted contributions. A few proposals and questions to resolve based on the general leaning of the companies are captured in Section 4.

## Support No-LBT and LBT operating modes

There are multiple companies proposing Rel 17 should not mandate LBT procedures, but provide designs for them where they are needed by regulation or if useful, for performance enhancements.

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| Company | Key Proposals/Observations/Positions |
| Intel | LBT procedure is supported, but its use should be configurable. LBT should be allowed to be disabled in regions or for deployments where this is not required and mandated.  ITU region 1, band 75: Intel contribution interprets the regulation as a flow diagram Figure 1 which freezes countdown when medium is found busy,  Proposal 2: The LBT procedure detailed in the ETSI EN 302 567 should be used as a baseline to develop the LBT procedure for the system operating in band 75 within ITU region 1. |
| Huawei-HiSilicon | For operation in the 60 GHz band, Omni-directional LBT, directional LBT and No LBT should be considered for different scenarios. |
| ZTE-Sanechips | No-LBT can be considered for interference controlled environment and COT sharing case  Proposal 2: Release 17 NR-U should consider supporting different channel access modes for above 52.6 GHz, e.g., directional LBT and No LBT. |
| Apple | Proposal 1: Both a baseline LBT and no-LBT channel access mechanisms should be adopted unlicensed access. |
| Ericsson | Rel-17 should consider supporting two medium access mechanism modes for the 60GHz spectrum, one requiring LBT and one without LBT. |
| Qualcomm | Support No-LBT mode, Long-term-sensing mode and LBT modes. : Conditions for deployment modes where No-LBT or No Sensing is viable could be based on EIRP/transmit power, duty cycle of channel occupancy and spatial characteristics of transmission, or a combination thereof. |
| Nokia | Introduce multiple coexistence modes, e.g., with and without LBT.  Study the use of the coexistence mode without LBT e.g. in scenarios where:   * a cell is sufficiently spatially isolated, or * gNB and/or UE transmissions are sufficiently directional |
| Xiaomi | Proposal 2: For environment with controlled interference, LBT-free transmission should be studied. |
| NEC | Proposal 2: Consider no LBT, directional LBT and omni-directional LBT for NR on frequency above 52.6GHz. |
| DCM | Proposal 1:   Whether to mandate LBT based channel access even for the part of the unlicensed bands in 52.6 – 71 GHz where some regional regulations do not require it needs to be discussed at first in this SI.   The necessity of LBT based channel access should be considered with regional regulations and the actual benefit of LBT based channel access in high frequency range |
| LG | Proposal #4: Study whether or not the allowance of initiating channel occupancy without performing LBT is beneficial at least in a particular scenario such as low interference environment. |
| InterDigital | For modes of operation, supporting no LBT, omni-directional LBT and directional LBT should be considered. |

Question: Should we support both No-LBT mode and LBT mode of operation, where which mode to use is per gNB configuration according to local regulation and performance need?

Please provide your view below:

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| Company | View |
| Qualcomm | Support both |
| Xiaomi | Support both No-LBT mode and LBT mode. Which mode to use can be based  on gNB configuration or dynamic indication. |
| Sharp | Support both |
| Huawei/HiSilicon | We are in principle supportive of both No-LBT and LBT operations. However, it needs to be further studied whether or not the mode of operation (LBT vs. No-LBT) should always be based on the gNB configuration. For instance, in some scenarios such as COT sharing LBT/No-LBT may be specified. |
| Nokia | Support both, with priority to no-LBT mode. The configuration of mode should be according to deployment in addition to local regulation and performance (e.g. capacity loss due to LBT). |
| vivo | We think both no-LBT and LBT can be supported. But the details of how the system operates with these modes should be left for further study. So we cannot say yes to the 2nd part of question “where which mode to use is per gNB configuration according to local regulation and performance need”. |
| LG | Our understanding for this Question is for LBT mode of channel occupancy initiator. With this regard, LG’s corresponding proposal #4 is moved from Section 3.5 to this Section. As a response to FL’s question, we believe that both operating modes should be supported, and further discussion is needed on when and under what conditions they will be used/switched. |
| Apple | We support both modes of operation. Note that Section 2.3, step (6) is a no-LBT procedure “An equipment (initiating or not initiating transmission), upon correct reception of a packet which was intended for this equipment, can skip the CCA Check, and immediately proceed with the transmission in response to received frames.” This from our understanding means that both modes are supported to today with no-LBT supported in an existing COT (using the NR-U terminology). A separate mode with no LBT at all should be defined. |
| NTT DOCOMO | We support both No-LBT and LBT mode. On the detail of configuration, we think further discussion would be necessary. |
| InterDigital | We also support both modes of operation |
| Intel | LBT is certainly not mandated in all regions, and even within the ITU region 1 this is not required for all types of scenarios. Therefore, both mode of operations (i.e., LBT and no-LBT) should be supported, and for the initiating device when this acquires the COT this should follow gNB’s configuration. However, for the responding devices, and for operation of the initiating device within the acquired COT, this should be separately discussed. |
| ZTE, Sanechips | Both LBT and no LBT should be supported. Wherein, whether LBT should be used is depend on the local regulation, coexistence scenario and/or dynamic signalling indication. |

## Occupied Channel Bandwidth

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| Company | Key Proposals/Observations/Positions |
| Intel | Observation 3: RAN1 should account for the OCB requirements mandated in the ITU Region 1 by ETSI EN 302 567 when the system operates in band 75.  Observation 5: LBT and OCB requirements are not always mandated when operating in ITU region 1, but these requirements are imposed only for certain types of deployments and use cases. |
| Ericsson | Observation 4. To fulfil the OCB requirement specified in EN 302 567, for each of the declared channel bandwidths, the device has to support at least one mode of transmission where the transmission occupies at least 70% of the declared channel bandwidth.  The latest version EN 302 567 v2.1.20 will most likely be submitted as the final draft for approval to the EN Approval procedure (ENAP). Additional changes are not foreseen. |
| ZTE, Sanechips | In ETSI EN 302 567 [2], the Occupied Channel Bandwidth is the bandwidth containing 99 % of the power of the signal, which shall be between 70 % and 100 % of the declared Nominal Channel Bandwidth (NCB). However, such restriction is not required in the US, China, Japan, South Korea, Australia and Singapore. In this regard, some studies should be made for the constraints of OCB requirements on BWP or larger bandwidth. |

The discussion on this issue is in section 2.2.

## Channelization Considerations

A common question with position differences among companies is whether channelization need to be tied to the 2.16 GHz channelization used by WiGig devices. Multiple companies agree that bandwidths smaller than 2.16 GHz need to be supported. But there are differences in positions on its implications and relationship to coexistence procedures.

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| Company | Key Proposals/Observations/Positions |
| Nokia | Proposal 7: Channelization based on 2.16 GHz is assumed as a starting point in the coexistence mechanisms studies.  Proposal 8: Transmissions with a (channel) bandwidth smaller than 2.16 GHz, such as 400 MHz, are also considered in the coexistence mechanisms studies. |
| Apple | RAN 1 can study channel access mechanisms in the unlicensed band assuming a need to perform LBT on a bandwidth greater than the operating bandwidth. |
| Convida | Proposal 2: Wideband operation and coexistence with other RAT should be investigated considering UE power consumption and complexity. |
| CAICT | Proposal 4: Multiple LBT bandwidth could be considered for unlicensed band operation within 52.6-71GHz. |
| Sony | Proposal 4: NR devices support 2.16 GHz bandwidth in 60GHz spectrum. |
| Samsung | Proposal 1: The design of channel access mechanism shall comply to the regulation requirement, and guarantee fair coexistence with 802.11 ad operating on the 60 GHz unlicensed spectrum. |
| DCM | Observation 2:   Channel bandwidth and assignment for IEEE 802.11ad/ay may need to be considered for channel bandwidth and assignment for NR in 57 – 71 GHz |
| ZTE, Sanechips | Provided in R1-2005607  Proposal 1: When determining supported bandwidths for NR above 52.6 GHz, RAN1 should take co-existence of IEEE 802.11ad/ay into account at least in unlicensed band.  Proposal 2: 400 MHz (and/or its integral multiple e.g. 800/1600 MHz) and 2.16 GHz can be served as candidates of supported bandwidths for Rel-17 NR above 52.6 GHz. |

The exact set of channel bandwidths may need further discussion and is out of the scope of this agenda item. However, it might be good to discuss first if we at least support one mode that aligns with WiFi 11ad channels of 2.16GHz bandwidth.

Question: Shall we at least support one mode that aligns with WiFi 11ad channels of 2.16GHz bandwidth.

Please provide your view below:

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| Company | View |
| Qualcomm | We believe we should support channel bandwidth approximately equal to the 11ad channel bandwidth. This can be done with single carrier or CA, but it is preferred to have a non-CA design that can support the bandwidth already. |
| Sharp | We agree that channelization of 2.16GHz should be studied for harmonious coexistence with other wireless systems on 60GHz, e.g., 802.11ad/ay. |
| Huawei/HiSilicon | We do not believe that supporting the same bandwidth as in IEEE 802.11ad/ay is well motivated. It is not necessary from coexistence perspective. On the other hand, choosing to support 2.16 GHz bandwidth can result in significant challenges in practice as explained in R1-2005241.  We believe a fair co-existence with IEEE 802.11ad/ay compliant devices does not mandate the use of the same channel BW of 2.16 GHz. Please also note that  IEEE 802.11ad/ay does not mandate any OCB requirement. Therefore, even if a nominal channel BW of 2.16 GHz is supported, it is possible to always transmit only on a fraction of such channel bandwidth without violating any IEEE 802.11ad/ay requirement. As such, in our view, it is not very well justified to cite a fair co-existence with IEEE 802.11ad/ay compliant devices to motivate the support for the same channelization as IEEE 802.11ad/ay. |
| Nokia | We see that 2.16 GHz channelization should be supported as well as (sub-)channelization for narrower bandwidth options (e.g. 400 MHz). |
| vivo | As we discussed in our contribution in other agenda, on one hand, we think 3GPP system support a comparable channel bandwidth as other competing technology without relying only on carrier aggregation is beneficial so that 3GPP system design can be more competitive and maybe easy on channel access when co-existence with other RAT.  On the other hand, we think there’re other aspects not just channel access related to this decision in other agenda. We think a final conclusion can be drawn when we looked all aspects together. |
| LG | Since, the regional regulatory does not mandate supporting the same bandwidth as in 802.11ad/ay, aligning the channel bandwidth with 11ad/ay cannot simply justify introducing an extreme numerology (e.g., 960/1920 kHz SCS) or large carrier bandwidth (e.g., 2.16 GHz). If performance requirements (such as BLER, system throughput, coexistence) can be met in a reasonable range, we think CA based approach could be sufficient to coexist with 11ad/ay. |
| Apple | We see that there is a recommendation by ITU (and not a mandate) to support 2.16 GHz to be compatible with other RATs. As such,  (1) if we have to transmit at 2.16 GHz, a mode where a UE achieve this using CA only should be enabled.  (2) In LBT-mode, a mechanism is needed to allow for fair access for a device that has a smaller bandwidth than the LBT measurement bandwidth. |
| NTT DOCOMO | We believe larger BW than Rel-15/16 (i.e. 400 MHz) is necessary for 60 GHz to consider IEEE. However, whether to suppor 2.16 GHz BW itself should be discussed further. Huawei’s point would be valid in our understanding. |
| InterDigital | We also agree that supporting single bandwidth which equals to the 11ad channel bandwidth (i.e., 2.16 GHz) should be supported without CA operation. |
| Intel | We believe that in order to maintain competitiveness and coexistence with 11ad/11ay design, we should indeed support a bandwidth equal or similar to that supported by 11ad (~2.16 GHz). In terms of alignment, we would like to clarify that channelization should be done such that a single NR carrier bandwidth do not straddle one or more boundaries of 2.16 GHz channelization. In our opinion, this is as critical as selection of the bandwidths for NR.  As for whether this should be achieved through a single carrier or through CA, our preference is the former. The main reason is that having multiple CCs lead to increased complexity in building a proper RF subsystem, since multiple filtering is likely required, compared to the case when a single wideband RF is used, which is equipped with a single wider FFT. The uplink transmissions become more simplified with use of a single carrier versus multiple carriers for ~2 GHz band operation. Additionally, by supporting a wider single carrier bandwidth close to 2 GHz allows the possibility to use CA to bond even more 2 GHz channels to achieve a higher aggregate bandwidth. |
| ZTE, Sanechips | Considering coexistence with 802.11 ad/ay, We agree that channelization of 2.16GHz should be considered to be supported |

## Enhancements to channel access

When companies propose to study an LBT mode, many techniques to improve LBT have been discussed. This is summarized in this section.

### Directional Sensing / Beam based access procedures

Directional sensing is discussed in multiple papers

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| Company | Key Proposals/Observations/Positions |
| Huawei-HiSilicon | NR-U should support receiver-assisted LBT with directional LBT in 60GHz unlicensed band. |
| Intel | Further investigation into directional sensing and implication to physical layer specification |
| ZTE-Sanechips | Compared to omni-directional LBT, directional LBT is beneficial to increase the probability of channel access and the spatial reuse efficiency for NR-U, and the impact on the performance of the existed Wi-Fi system is negligible.  Proposal 2: Release 17 NR-U should consider supporting different channel access modes for above 52.6 GHz, e.g., directional LBT and No LBT.  Proposal 3: For multiple transmission(s) with different beams case, channel condition difference for different beams should be considered when designing the channel access schemes for COT sharing in NR unlicensed spectrum. |
| Vivo | Proposal 2: Directional LBT should be studied and evaluated in 60 GHz band, where the way of calculating CCA energy should be clarified. |
| Intel | Proposal 9: Further investigation of directional sensing and its implication to physical layer specification is needed. Suggest capturing potential issues and considerations for conclusion and potentially capture into the TR. |
| Qualcomm | Proposal 5: Consider the use of antenna gain of sensing beam and transmission beam to determine the suitability of using a given sensing beam in conjunction with another transmission beam. |
| LG | Proposal #3: If directional CCA procedure with beam based transmission is identified as beneficial, the followings for directional CCA procedure can be considered:   * CCA threshold setting * Relationship between transmission direction and CCA direction * Directional LBT for broadcast/unicast transmission * CWS management |
| Convida | Proposal 1: Directional LBT and interference mitigation including hidden node and exposed node issues should be studied. |
| Xiaomi | Proposal 1: Directional CCA can increase network efficiency compared to omnidirectional CCA. Directional CCA both at transmitter and receiver side should be studied. |
| ATT | Support of directional LBT |
| OPPO | Proposal 3: the feasibility of directional LBT for unlicensed spectrum between 52.6 GHz and 71GHz should be studied. |
| ITRI | Proposal 1: Directional LBT should be supported in R-17 NR-U.  Proposal 2: Study how to increase the transmission opportunity of a CG transmission considering directional LBT. |
| CAICT | Proposal 1: CAT2 based directional LBT could contain multiple CAT2 LBT processes with different directions at the same time and frequency resource.  Proposal 2: The mechanism of CAT2 based directional LBT for DRS and data transmission within a COT could be different.  Proposal 3: Multiple CAT4 based directional LBT processes should not be operated at the same time and frequency resource. |
| Lenovo-Motorola-Mobility | Proposal 1: For supporting NR beyond 52.6 GHz in unlicensed band in Rel. 17 and for fair coexistence with other users, directional (beam based) LBT operation at both the gNB and UE should be considered for enhanced channel access mechanism. |
| Sony | Proposal 5: Directional LBT should be studied on 60 GHz unlicensed operation |
| CATT | Proposal 2: The interference mitigation of beamforming based operation needs to be investigated in place of LBT based operation for distributed channel access scheme.  Proposal 3: For perform interference mitigation, following mechanism can be studied  • The procedure of directional LBT, beam width is similar with control/data’s.  • he shake mechanism (e.g measurement and report) , which enable gNB obtain the interference situation from RX UE view |
| NEC | Proposal 2: Consider no LBT, directional LBT and omni-directional LBT for NR on frequency above 52.6GHz. |
| TCL | Proposal 1: RAN1 shall study channel access mechanisms based on directional LBT.  Proposal 2: RAN1 shall study directional LBT at UE side to guarantee fair coexistence with 802.11ad.  Proposal 3: RAN1 shall study solutions to mitigate the effect of LBT deafness, beam orthogonality and beam imbalance in order to enable directional LBT at UE side without harming NR-U channel access efficiency.  Proposal 4: RAN1 shall consider the usage of directional LBT at gNB side.  Proposal 5: It is proposed to investigate the mechanisms which can avoid collisions due to double ownership of the shared carrier at beam transition events. |
| Samsung | Proposal 2: RAN1 shall study the channel access mechanism with directional channel sensing. |
| Spreadtrum | Proposal 1: The directional transmission and the conducted directional LBT in the high frequency range should be studied. |
| Interdigital | Proposal 1: Directional LBT is supported for channel access from 52.6GHz to 71GHz. |
| Sharp | Proposal 1: Directional LBT should be considered due to the beam-based operation in NR-U above 52.6GHz and for enabling spatial reuse. The following potential issues should be addressed to implement directional LBT: |
| DCM | Proposal 2:   Study LBT scheme for 60 GHz band, especially the following points:   Sensing duration for energy detection   Energy detection threshold   Directional LBT |
| Potevio | Proposal 1: Considering the attenuation characteristics of channel from 52.6GHz to 71GHz, channel access mechanism integrating directional LBT, receiver-aided LBT with corresponding handshaking scheme should be studied as a whole in comparison to no-LBT/ATPC based access mechanism. |
| Nokia, Nokia Shanghai Bell | **Observation 5:** *Both omnidirectional and directional LBTs need to be considered on the coexistence studies*  **Proposal 10:** *Beamforming for gNB’s LBT is left for implementation as much as possible.* |
| Apple | Support investigation of directional LBT mechanisms. |

Though there are many companies proposing the study or adopt directional sensing, we may need to wait for the next meeting to draw conclusions when more simulation comparison results are available. Propose to discuss this next meeting, and encourage all interested companies to provide results.

### Rx Assistance in LBT process

Multiple companies propose to study Rx Assistance for performance improvement. Rx Assistance performance gains should be evaluated with consideration of complexity/performance gain trade-offs.

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| Company | Key Proposals/Observations/Positions |
| Huawei-HiSilicon | NR-U should support receiver-assisted LBT with directional LBT in 60GHz unlicensed band. |
| SAMSUNG | Proposal 3: RAN1 shall study the channel access mechanism with handshake between transmitter and receiver. |
| Qualcomm | Proposal 6: Study and design channel access procedures and sensing guidelines that consider the prevalence of Tx Sensing-Rx mismatch. |
| Apple | Proposal 3: RAN1 to study the effect of an RTS/CTS-like mechanism to help in mitigating directional interference or potential hidden node issues. |
| ATT | Closed Loop LBT and further enhancements to receiver assisted LBT |
| Lenovo-Motorola-Mobility | Proposal 2: For supporting NR beyond 52.6 GHz in unlicensed band in Rel. 17, enhanced beamforming and interference management techniques should be considered. |
| FUTUERWEI | Proposal 5: Define a protocol for receiver assisted LBT for dynamic and semi-static channel occupancy. |
| Vivo | Proposal 3: The receiver assisted channel access scheme should be considered in 60 GHz band and how to implement this handshaking mechanism in NR systems should be studied. |
| Sony | Proposal 6: Receiver assisted LBT should be studied on 60 GHz unlicensed operation. |
| CATT | Proposal 3: For perform interference mitigation, following mechanism can be studied  • The procedure of directional LBT, beam width is similar with control/data’s.  • he shake mechanism (e.g measurement and report) , which enable gNB obtain the interference situation from RX UE view |
| NEC | Proposal 3: Consider to support the receiver assisted LBT for NR on frequency above 52.6GHz, but it is optional for the UE implementation. |
| Spreadtrum | Proposal 2: Hidden node problem for the directional transmission/LBT in the high frequency range should be studied. |
| Interdigital | Proposal 3: Receiver based LBT should be studied for both omni-directional and directional LBT.  Proposal 4: Receiver based directional LBT is supported for channel access from 52.6GHz to 71GHz.  Proposal 5: 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. |
| Sharp | Receive-assisted LBT should be studied with respect to the following aspects: |
| Potevio | Proposal 1: Considering the attenuation characteristics of channel from 52.6GHz to 71GHz, channel access mechanism integrating directional LBT, receiver-aided LBT with corresponding handshaking scheme should be studied as a whole in comparison to no-LBT/ATPC based access mechanism. |
| ZTE, Sanechips | In order to alleviate the impact of the hidden/exposed nodes problem, some methods may be considered and studied, e.g., the receiving node performs a LBT mechanism and sends an indication signal to alleviate hidden node problem. Besides, the transmitter performs sensing operation on the transmission beam range to reduce exposed node problem or mismatch sensing beam and transmission beam. |

Though there are many companies proposing the study or adopt RX assisted LBT, we may need to wait for the next meeting to draw conclusions when more simulation comparison results are available. Propose to discuss this next meeting, and encourage all interested companies to provide results.

### Threshold for Sensing

Multiple companies expressed interest to study adaptation of ED threshold to facilitate channel access

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| Company | Key Proposals/Observations/Positions |
| Vivo | Proposal 2: Directional LBT should be studied and evaluated in 60 GHz band, where the way of calculating CCA energy should be clarified. |
| Intel | Proposal 5: When operating in band 75 within ITU region 1, in order to allow fair coexistence among incumbent systems, the ED threshold calculation shall account not only for the maximum output power, but also at least for the bandwidth used. |
| DCM, | Assuming variable transmission bandwidth as in Rel-15/16 NR, the regulation on the energy detection threshold for 60 GHz band may need to be revisited. |
| Nokia | [Dependent on Bandwidth] Proposal 11: Study the need for LBT ensuring fairness between cells with different bandwidths while maintaining efficient spatial reuse between cells of same bandwidth. |
| FUTUREWEI | Proposal 2: To adapt the CCA ED threshold when sensing antenna beam (pattern) and antenna beam (pattern) used for the transmissions are different. |
| LG | Proposal #2: It is necessary to enhance the method of determining ED threshold with consideration of the maximum output power and the unit LBT bandwidth applied in NR and the fair coexistence with the incumbent system (e.g., WiGig) operating in frequency range from 52.6GHz to 71 GHz. |
| ZTE, Sanechips | If directional LBT mechanism is supported, then need to consider some enhancement methods, such as an enhanced calculation method of observed interference in the beam range, CCA detection threshold for directional transmission. |

This discussion may need to wait till we have a conclusion on adopting directional LBT.

### Other Coexistence Mechanisms

Some additional coexistence mechanism other than LBT before every transmission are proposed by multiple companies.

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| Company | Key Proposals/Observations/Positions |
| Nokia | Proposal 4: Study DFS and ATPC as candidate coexistence mechanisms in addition to LBT e.g. for relaying or IAB backhaul deployments.  Duty cycle adaptation can be studied further. |
| Qualcomm | Long term sensing as inputs for other coexistence mechanism should be studied  Proposal 1: Conditions for deployment modes where No-LBT or No Sensing is viable could be based on EIRP/transmit power, duty cycle of channel occupancy and spatial characteristics of transmission, or a combination thereof.  Proposal 2: Explore long-term sensing-based deployment modes further to allow a reuse friendly approach while still resolving catastrophic beam collisions. Provision for channel measurement gaps and/or long-term sensing gaps to facilitate the same. |
| Apple | Proposal 2: Adaptation methods between LBT-based access and non-LBT based access should be studied.  Proposal 4: RAN1 to study the use of UE-assisted channel selection. |
| Ericsson | Observation 5 In the initial draft of the ETSI EN 303 722 Harmonized Standard for c2 and c3 bands, ATPC is proposed as the medium access mechanism. LBT is not indicated in the draft. |
| Lenovo Motorola-Mobility | Proposal 3: For supporting NR beyond 52.6 GHz in unlicensed band in Rel. 17 and for fair coexistence with other users, channel access mechanism other than LBT could be further investigated, at least for regions where LBT is not mandated. |

The proposed designs can be summarized into two categories

* No measurement, autonomous good neighbor behavior e.g. Automatic Transmit Power Control
* Measurement/Long term sensing based solutions, e.g., DFS

There are also proposals to study the switching between No LBT mode and LBT mode.

Proposal: (If No LBT mode can be agreed)

* Study required conditions to enable No LBT mode, e.g. ATPC, DFS, long term sensing, duty cycle
* Study mechanisms to switch in and out of LBT mode

### Channel Access Parameters

When LBT is proposed, multiple companies discussed how to adopt or adjust CCA related parameters, including MCOT, CCA slot duration, etc.

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| Company | Key Proposals/Observations/Positions |
| Huawei-HiSilicon | [SI] should consider to reuse the channel access mechanisms for 5/6GHz and modify the channel access parameters in accordance with the ETSI BRAN Harmonized Standard if LBT is supported. The procedures specified for CWS adjustment and multi-channel access in Rel-16 NR-U should be considered for operation in the 60 GHz band with necessary modifications if LBT is supported. |
| Intel | Follow ETSI 302 567 closely for baseline LBT procedure : MCOT 5ms. |
| OPPO | Proposal 2: the LBT mechanism in NR-U, e.g., LBT with deterministic time duration for sensing, should be considered to develop LBT mechanisms for unlicensed spectrum between 52.6 GHz and 71GHz. |
| FUTUERWEI | Proposal 1: To specify the channel access procedures compliant with regulatory requirements with the consideration of possible values for beam switch time, beam report time (such as beamSwitchTime, beamReportTiming, and timeDurationForQCL) as defined in TS38.331 for operations beyond 52.6 GHz. |
| Nokia | **Proposal 9:** *LBT described in EN 302 567 draft V2.1.20 is used as baseline for LBT procedure design for 60 GHz unlicensed band* |
| Apple | Agree with Huawei that NR-U should serve as baseline and should be modified to satisfy the ETSI BRAN standard. |

### Other Enhancements to channel access

Multi-beam sensing and transmission support, beam adaptation, beam failure detection issues, SSB candidate positions and non-consecutive RO handling is proposed.

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| Company | Key Proposals/Observations/Positions |
| ZTE-Sanechips | Proposal 3: For multiple transmission(s) with different beams case, channel condition difference for different beams should be considered when designing the channel access schemes for COT sharing in NR unlicensed spectrum. |
| Xiaomi | Proposal 3: Multi-beam transmission should be studied to fully take advantage of spatial diversity. |
| Convida | Increasing the number of SSB candidate positions to above 64 to increase transmission opportunities to cope with LBT failure should be studied. |
| ATT | Closed Loop LBT for License Assisted Access |
| ITRI | Proposal 3: Study beam failure detection considering the uncertain BFD RS transmission on unlicensed band |
| CATT | Proposal 4: For increasing the channel access opportunities, the scheme of multi-beam ED measurement in a sensing slot can be studied.  Proposal 5: The enhancement of beam adaptation shall be studied to improve scheduling efficiency in distributed and non-coordinated accesses in unlicensed spectrum.  Proposal 6: The enhancement of LBT mechanism for SSB transmission shall be studied for narrow beamwidth beamformed operation up to 71 GHz. |
| DCM | Proposal 3:   Regarding potential required changes considering NR operation in unlicensed band,   LBT related issues, e.g. SSB candidate position and non-consecutive RO, may need to be discussed after the discussion on LBT.   PSD and OCB related issue such as interlaced UL transmission would need to be discussed. |

## COT Sharing

Multiple companies discussed COT sharing related aspects, including do we need CCA at responding devices,

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| Company | Key Proposals/Observations/Positions |
| Huawei-HiSilicon | No sensing for gap <3us |
| Intel | Proposal 7: No LBT shall be performed by a responding device within the initiating device’s acquired COT before attempting any transmission. |
| ZTE-Sanechips | No sensing for sharing device for same beam direction, Gap and LBT for DL/UL consecutive transmissions with different beams within COT  Proposal 3: For multiple transmission(s) with different beams case, channel condition difference for different beams should be considered when designing the channel access schemes for COT sharing in NR unlicensed spectrum. |
| Qualcomm | Proposal 4: Contention Exempt Transmissions: Investigate and identify conditions where some transmissions can be permitted in a contention exempt manner, i.e. a sensing medium is not a requirement before transmission, even within deployment modes which require some form of sensing. |
| Nokia | [No sensing when ] UE transmissions are limited to gNB initiated shared COTs, allowing for UE implementation without LBT |
| FUTUREWEI | Proposal 4: Define new LBT types for COT sharing there are consistent with COT definition. |
| LG | Proposal #5: 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. |

# LBT schemes to evaluation

* Huawei/HiSilicon
  + Proposal 1: RAN1 should study channel access mechanisms based on directional LBT in 60GHz unlicensed band.
  + Proposal 2: RAN1 should study receiver-assisted LBT in 60GHz unlicensed band.
  + Proposal 3: RAN1 should strive to agree on a baseline for the LBT mechanism in RAN1 102-e.

Explanation to proposal 3: There are a couple of LBT-related topics such as directional LBT (in 3.4.1) and receiver-assisted LBT (3.4.2) that are suggested to be further studied and discussed in the next meeting. As such, we believe it is important to agree on a baseline for the LBT mechanism in this meeting. There seems to be two main candidates for baseline LBT mechanism 1) LBT mechanism in Rel-16 NR-U; 2) LBT mechanism in Draft EN 302 567. It may also be possible to agree on a “middle ground” baseline: For instance, LBT mechanism in EN 302 567 plus ED threshold that depends on the sensing BW and/or includes multiple CAPC with different CW ranges.

HW brought up a very good point on reaching on common understanding of one or a few LBT schemes for evaluation. A few alternatives are listed below. Please provide your view. Note this is baseline LBT scheme (not receiver assisted version which may have even more variations). Also note this is not an intention to agree on LBT schemes. Instead, this is just an effort to make the LBT simulation results from different companies more comparable.

* Alt 1. Rel.16 NR-U channel access mechanism with bandwidth adjusted ED threshold
* Alt 2. Current draft of EN 302 567 adaptivity rules with possibly adjusted ED threshold
* Alt 3. Not defined. Providing details on LBT mechanism when submitting data

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| Company | Key Proposals/Observations/Positions |
| Qualcomm | We prefer Alt 2 as it is regulation defined for the band |
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# Others

# Reference

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2. R1-2005242, Channel access mechanism for 60 GHz unlicensed operation, Huawei, HiSilicon
3. R1-2005282, Considerations on directional LBT and spatial reuse, FUTUREWEI
4. R1-2005372, Discussion on channel access mechanism, vivo
5. R1-2005568, Channel access mechanism for 60 GHz unlicensed spectrum, Sony
6. R1-2005608, Discussion on the channel access mechanism for above 52.6GHz, ZTE, Sanechips
7. R1-2005700, Channel Access Mechanism in support of NR operation in 52.6 to 71 GHz, CATT
8. R1-2005735, Channel access mechanism for NR on 52.6-71 GHz, Beijing Xiaomi Software Tech
9. R1-2005765, Study on the channel access mechanism, NEC
10. R1-2005767, Channel access mechanism, TCL Communication Ltd.
11. R1-2005867, Channel Access Procedure for NR in 52.6 - 71 GHz, Intel Corporation
12. R1-2005921, Channel Access Mechanism, Ericsson
13. R1-2005950, Channel access mechanisms for NR from 52.6-71GHz, AT&T
14. R1-2006027, discussion on channel access mechanism, OPPO
15. R1-2006137, Channel access mechanism for 60 GHz unlicensed spectrum, Samsung
16. R1-2006275, Discussion on channel access mechanism for above 52.6GHz, Spreadtrum Communications
17. R1-2006305, Considerations on channel access mechanism to support NR above 52.6 GHz, LG Electronics
18. R1-2006453, On Channel access mechanisms, InterDigital, Inc.
19. R1-2006513, On Channel Access Mechanisms for Unlicensed Access above 52.6 GHz, Apple
20. R1-2006571, Channel access mechanism, Sharp
21. R1-2006629, On Channel Access for NR Supporting From 52.6 GHz to 71 GHz, Convida Wireless
22. R1-2006650, Channel access considerations for the indoor scenario, Charter Communications
23. R1-2006655, Discussion on channel access mechanism, ITRI
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25. R1-2006798, Channel access mechanism for NR in 52.6 to 71GHz band, Qualcomm Incorporated
26. R1-2006854, Discussions on channel access mechanism on supporting NR from 52.6GHz to 71 GHz, CAICT
27. R1-2006871, Discussion on channel access mechanism for NR from 52.6GHz to 71 GHz, Potevio
28. R1-2006908, NR coexistence mechanisms for 60 GHz unlicensed band, Nokia, Nokia Shanghai Bell
29. ETSI BRAN EN 302 567 v.2.1.20, “Multiple-Gigabit/s radio equipment operating in the 60 GHz band; Harmonised Standard for access to radio spectrum”, June, 2020.
30. ETSI BRAN EN 303 722, “Wideband Data Transmission System (WDTS) for Fixed Network Radio Equipment operating in the 57 - 71 GHz band; Harmonised Standard for access to radio spectrum”, May, 2020.
31. CEPT ECC, ERC, "ERC Recommendation 70-03: Relating to the use of Short Range Devices (SRD)," June 2019.