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

Aug 17th– 24th, 2020

Agenda item: 8.2.2

Source: Moderator (QualcommIncorporated)

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 |
| Ericsson | Alt2, and to be more accurate, ALT2 should be modified:  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, **for every declared channel bandwidth.** |
| Potevio | Support Alt.2 |
| Sony | Alt 2 |
| Futurewei | In our understanding there is no ambiguity in the EN 302 567 regarding OCB. The regulator neither require OCB to be satisfied all the time nor for all the modes of operation. The OCB must be satisfied [at least] for “a mode of transmission with a necessary bandwidth … at least 70% of the declared nominal channel bandwidth” Therefore, we support Alt 2 with modifications as suggested by Huawei or Ericsson. |
| Convida Wireless | Alt 2 |
| Samsung | We support Alt 3 from Huawei, and RAN1 needs to further clarify the meaning of “a necessary bandwidth” in “a mode of transmission” as described in EN 302 567, using NR terminology. For example, does it mean BW of all signals/channels in the mode of transmission or BW of at least one signal/channel in the mode of transmission. |
| Lenovo, Motorola Mobility | In our view, Alt 2 and Alt 3 (proposed by Huawei) have the same intention just worded differently. So, we are ok with Alt 2. |
| Charter Communications | Supportive of Alt 2 or Huawei/Ericsson modifications. |
| Huawei/HiSilicon2 | To further explain our intention for proposing Alt. 3 option and as a remark to Nokia’s comment, please note that EN 302 567 OCB requirement should be viewed in the 3GPP context and terminology. A direct use of EN 302 567 OCB requirement as an agreement in 3GPP (e.g., Alt. 2 approach) can result in a completely unintended outcome. To provide some context, please note that:  In 3GPP, UE signals its supported DL and UL channel BWs for different numerologies as a part of UE capability signalling in channelBWs-DL and channelBWs-UL. Our understanding is that if a specific channel BW is signalled to be supported, UE is expected to support the corresponding “maximum transmission bandwith configuration” in terms of number of RBs given in Table 5.3.2-1 in 38.101-2 for FR2 and 38.101-1 for FR1. For instance, if 100 MHz channel bandwidth is signalled to be supported for 120 kHz SCS in channelBWs-UL, the **UE is expected to support (transmit signal/channel)** in 66 RBs which is more than 95% of the signalled supported BW. However, to meet the OCB requirement set by EN 302 567, there should be a transmission mode (e.g., an UL transmission configuration by the gNB) that ensures that at least 70% of the signalled supported channel BW is used. Again, this does not mean that the UE is required to support only 70% of the signalled supported channel BW (e.g., if 100 MHz is indicated in channelBWs-UL, this is not true that UE only needs to support transmitting in 70 MHz of it).  Given the above explanation, in our view, Alt2 is at odds with 3GPP specifications as Alt2 mentions “the device only need be able to support transmitting with at least 70% of the nominal channel bandwidth” and we cannot agree with it. |
| Spreadtrum | Support Alt 2 or Alt 3. In our understanding, the intention of Alt 2 and Alt 3 is the same. |
| ITRI | Alt 2 |

### Summary of discussion

On understanding requirement on OCB of latest version of EN 302 567, we have the following alternatives

* 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, for every declared channel bandwidth.
* 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.

Between Alt 2 and Alt 3, there are no fundamental difference. Alt 3 might be a more accurate way to describe the understanding. In the summary below, we don’t distinguish Alt 2 and Alt 3.

The company view on the understanding are

* Alt 1: LG (can be also considered)
* Alt 2/Alt 3: Qualcomm, Xiaomi, Sharp, Huawei/HiSilicon, Nokia, Vivo, LG, Apple, DoCoMo, InterDigital, Intel, ZTE/Sanechips, Wilus, Ericsson, Potevio, Sony, Futurewei, Convida Wireless, Samsung, Lenovo/Motorola Mobility, Charter, Spreadtrum, ITRI

Proposed conclusion:

* From RAN1 perspective, the OCB requirement of latest version of EN 302 567 implies that
  + 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.

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| Company | View |
| Samsung | We are ok the proposed conclusion. Moreover, as commented in the previous round, the term “transmission mode” should be explained in 3GPP terminology. |
| Huawei/HiSilicon3 | OK with the proposed conclusion and agree with Samsung. In fact, our suggested sub-bullet in Alt. 3 is to ensure that the transmission mode is well-defined. As such, we suggest to add the sub-bullet in Alt.3 to the proposed conclusion. |

## 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].

|  |
| --- |
| 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 theCCA 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 5ms 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.

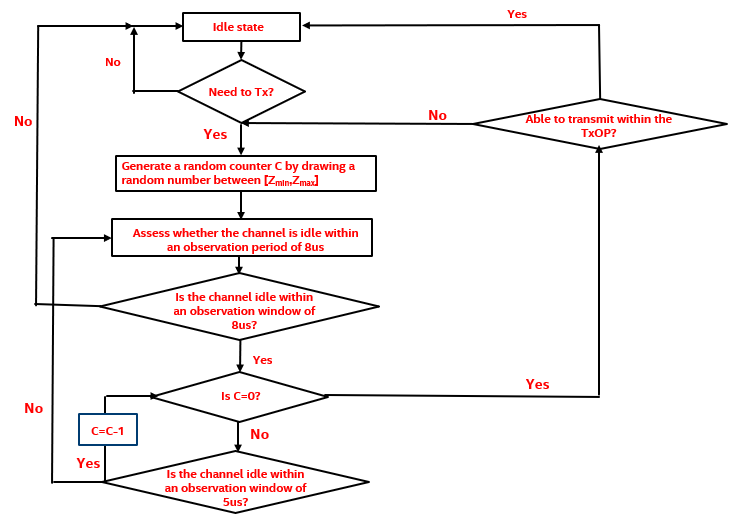


Figure 1 Channel access procedure from Intel contribution [11]. The counter C is ‘frozen’ where the channel is found not to be idle in this procedure.

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.

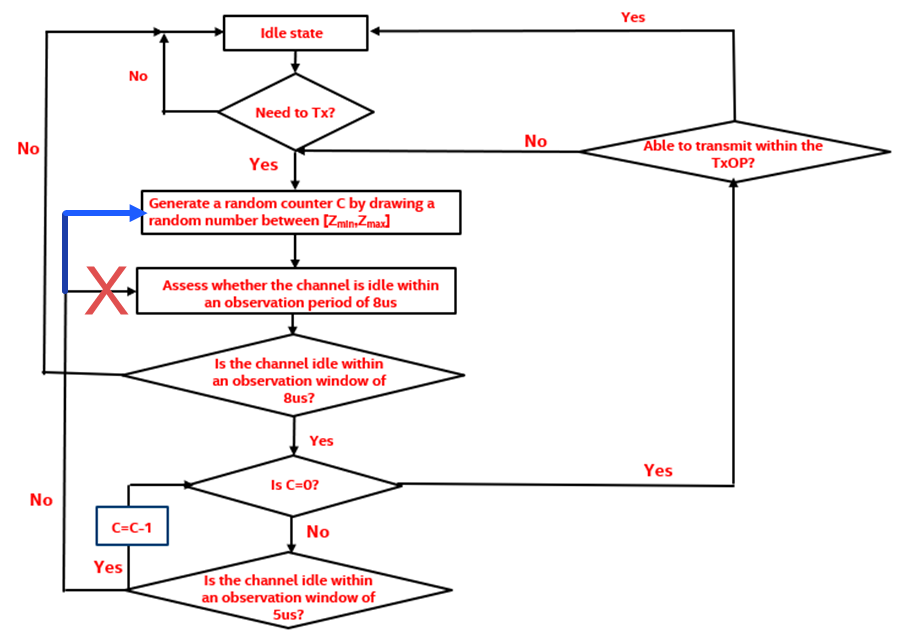


Figure 2 Channel access procedure modified from Figure 1. The transition marked X is replaced with the transition in Blue. The counter C is ‘reset/redrawn’ where the channel is found not to be idle in this procedure.

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 onstep 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. 2. 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. |
| Ericsson | A literal interpretation of the text would be aligned more with alternative 2 [even though most probably this is not intentional]. However, the diagram is still not completely accurate, since assessing whether the channel is idle within an observation period of 8us followed by the random BO generation. |
| Potevio | In our understanding, Alt.1 is closer to the procedure defined in EN 302 567 where no explicit indication of resetting counter is given. |
| Sony | We agree with Intel. Our understanding of EN 302 567 is closer to Alt 1. There is no explicit description regarding resetting counter. |
| Futurewei | In our view Alt 2 is the correct interpretation of EN 302 567. |
| Samsung | Alt 1 is more close to EN 302 567 in our understanding. Actually there is no clear description in EN 302 567 on how the counter is reset, but if the counter is reset whenever busy channel is detected, there is a device that cannot access the channel for a long time, so we believe Alt 1 is more proper. |
| Lenovo, Motorola Mobility | Alt. 3: The counter freezes, and will continue to count immediately when the interference is gone.  Reading step 2), we think there is no need to wait another 8 µs after busy time. The 8 µs wait applies only at the CCA Check initiation. This still fulfills the minimum deferral period according to step 4c) . In the diagram, this would mean that the "return arrow" goes to "Is C=0?" |
| Charter Communications | We don’t agree with the procedure in Figure 2, i.e., re-drawing a new counter every time a CCA slot is occupied. It is simpler to draw the random counter once the observation window of 8 μs is cleared. |
| Spreadtrum | In our understanding, Alt 1 is more close to EN 302 567. Re-drawing a new counter in Alt 2 may increase the channel access time of a UE. |
| ITRI | Alt 1 according to our understanding |

### Summary of discussion

On understanding of CCA procedure of the latest version of EN 302 567, we have the following alternatives:

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

* Alt 1. The counter freezes, 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
* Alt 3. The counter freezes, and will continue to count immediately when the interference is gone.

The summary of company views is:

* Alt 1: Vivo, LG, Apple, DCM, InterDigital, Intel, ZTE/Sanechips, Wilus, Potevio, Sony, Samsung, Charter, Spreadtrum, ITRI,
* Alt 2: Qualcomm, Sharp, Huawei/HiSilicon, Nokia, Ericsson, Futurewei,
* Alt 3: Lenovo/Motorola Mobility,

Compare the 3 alternative, Alt 3 is most aggressive and Alt 2 is most conservative, with Alt 1 in the middle. There is stronger support for Alt 1.

Proposal:

* Approach 1: Adopt Alt 1 an RAN1 understanding
* Approach 2: Send LS to ETSI for clarification, which can be quite slow

**Comment:**

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| Nokia, NSB | To us it is premature to conclude this based on a simple majority, given also that many of the companies active in ETSI BRAN assume Alt2. Our preference is to keep this open. We may also consider an LS to ETSI BRAN, but that may not help much given the long turnaround time and associated overhead. In case of ambiguity, the companies attending ETSI BRAN will likely clarify this anyway. |
| Ericsson | After careful check we think there is legitimacy in considering Alt1 as well.  I think the main issue is if:   1. Are there multiple CCA procedures? I mean, every time an interference is detected a new CCA procedure is initiated 🡪 which was our assumption. 2. There is only one CCA procedure and that can be interrupted by an interferer.   We tend to think that the second one can be a valid interpretation as well. The text is referring to **“a”** single CCA procedure and **“the CCA procedure”**. See my highlights below.  Based on this we would be OK with alternative 1. In the end, there is little difference between the two approaches, since unlike 5/6GHz, the CW here is fixed, and can be as small as 3 slots, so long deferral because of large BO is not expected.  We do not support sending LS to ETSI BRAN, for the same reasons listed by Nokia.  --  The LBT mechanism is as follows:   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.  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. |
| Huawei/HiSilicon3 | We prefer that this issue is resolved in this meeting as, according to 4.1, EN 302 567 CCA procedure, or some slight modifications of it, is likely to be used as a baseline LBT for SLS. In our view, the interpretation of EN 302 567 CCA procedure does not have a standalone value for this WG and the only relevance of EN 302 567 CCA procedure interpretation to this WG is its effect on the baseline LBT procedure for simulations. As the baseline LBT in this SI can essentially be any LBT procedure agreed in this WG, we do not see the value of spending too much time on which of Alt1 or Alt2 is a correct interpretation. Additionally, we do not believe that there is a fundamental system level performance difference with either of the interpretations.  Therefore, although we believe that Alt2 is the accurate interpretation of CCA procedure in the latest version of EN 302 567, we can accept the majority view and **agree with Alt1** as RAN1 understanding to avoid lengthy discussions on details of secondary importance. |

# 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 environmentand 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. |
| Ericsson | Support both No-LBT mode and LBT mode for operation. The mode for opera ion is at least based on the enforced regional regulations. Other considerations can be studied. |
| Potevio | Support both LBT and no-LBT mode operations according to local regulation and different scenarios. |
| Sony | Support both no-LBT and LBT operating mode. The details for these operation (e.g. condition, configuration, etc.) should be further studied. |
| Futurewei | Consider LBT (omni, directional, and receiver assisted LBT) and No LBT modes of operation. The conditions of the transitions between modes of operations, as well as the parameters for each mode need further investigation. We note that there are quite a few variations of possible LBT modes thus we should allocate enough time investigation in this meeting. |
| AT&T | Support both |
| Convida Wireless | Support both LBT and no-LBT modes for channel access mechanism. Some details, e.g., directional LBT, receiver assisted LBT should be further studied for LBT mode. |
| Samsung | Agree to support both in general, but we need to clarify the terms “no-LBT mode” and “LBT mode”. In NR-U, no-LBT channel access has already been supported, under certain condition. I believe the discussion here is different, in the sense that “no-LBT mode” refers to no channel access procedure for initializing channel occupancy by gNB/UE. |
| Lenovo, Motorola Mobility | We support LBT mode and we think that further discussion/investigation can be done on No-LBT mode. Also, it is a bit too early to discuss details such as when and how one of the two modes can be configured/indicated. So, such signalling/configuration details should not be included yet. |
| Charter Communications | Support both modes. |
| Spreadtrum | We support both LBT and no-LBT modes. Regarding to the conditions and the details of configurations, we think further study is needed. |
| ITRI | Support both mode considering regulations, coexistence and dynamic indication. |

### Summary of discussion

On if we should support both No-LBT mode and LBT mode for initiating device, the company views are summarized as follows (Note this is not about if LBT is needed for responding device sharing initiating device’s COT.)

* Support both: Qualcomm, Xiaomi (gNB configuration or dynamic indication), Sharp, Huawei/HiSilicon, Nokia (priority on no-LBT mode), Vivo, LG, Apple, DCM, InterDigital, Intel, ZTE/Sanechips, Ericsson, Potevio, Sony, Futurewei, AT&T, Convida, Samsung, Charter, Spreadtrum, ITRI
* Support LBT mode: Lenovo/Motorola Mobility (further study no-LBT mode).

Proposal:

* For gNB/UE to initiate a channel occupancy, both LBT mode and no-LBT mode are supported
* FFS: The conditions for each mode to be used, such as local regulation, performance, and deployment choice.
* FFS: operation restrictions for No LBT mode are needed, e.g. compliance with regulations, and/or in presence of ATPC, DFS, long term sensing, or other interference mitigation mechanisms
* FFS: The mechanism to switch between LBT mode and no-LBT mode (if local regulation allows)

Comments:

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| --- | --- |
| Company | Comment |
| Ericsson | The first and second FFS can be merged:   * FFS: if operation restrictions for each mode are needed, e.g. compliance with regulations, and/or in presence of ATPC, DFS, long term sensing, or other interference mitigation mechanisms |
| Huawei/HiSilicon3 | We prefer FL Proposal. |

## 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 | RAN 1 should study the channelization mechanisms based on the supported SCSs/numerologies and the (maximum) channel BW whether the channel BW may or may not align with (multiple integer of) 2.16 GHz. In addition, as 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. |
| Spreadtrum | Provided in R1-2006274  Proposal 1: Study the large channel bandwidth for above 52.6GHz and up to 71GHz, e.g. 2.16GHz. |

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 thatchannelization 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 |
| Ericsson | The maximum supported bandwidth should be taken as part of the other  thread. From channel access perspective it does not matter if we operate on  ~2GHz based on one wide carrier or based on CA. the channel access  mechanism would be the same either way. Besides, it is not clear why we need to specifically align with Wi-Fi, what about two NR-U networks each operating on a different bandwidth? It is exactly the same situation. And if there is an issue with this setup, then we can study possible solutions, which do not necessarily require enforcing single nominal bandwidth in NR. We can not conclude on that without having enough evaluations.  Generally speaking, ETSI EN 302 567 does not specify nominal channel bandwidth, and it clearly allow declaring multiple nominal channel bandwidths. So from BRAN perspective aligning the channel bandwidth is not needed for coexistence. According to our understanding, italso allows instantaneous transmission BW to be anything below the channel BW. So even if we operate on ~2GHz, transmissions can still be narrower than the full bandwidth. |
| Sony | For the co-existence with IEEE 802.11ad which operates using 2.16 GHz channelization, an operation mode using about 2 GHz bandwidth should be supported. Single-carrier or CA can be supported for this mode. |
| Futurewei | We believe that a fair coexistence with all technologies should be targeted. A fair coexistence does not require the use of the same channel bandwidth.  We believe that the channel bandwidth must be selected based on 3GPP design consideration (FFT size, numerology, deployment scenarios) and the fair coexistence validated through system level simulations.  Therefore, we do not support an a priori selection of the channel of 2.16 GHz without evidence from system level simulations that would show that this is necessary. For compatibility with 802.11 devices, if necessary, one mode of operation of 2GHz can be supported via CA, for instance. |
| Convida Wireless | Whether to support channel bandwidth 2.16 GHz and/or channel bandwidth  smaller than 2.16 GHz should be further studied. |
| Samsung | We prefer to at least support a single carrier with approximate 2.16 GHz channel bandwidth, and we are open to using CA to achieve similar bandwidth. |
| Lenovo, Motorola Mobility | We think that it is reasonable to support channel bandwidth equal to the channel bandwidth used for WiGig devices by using CA as well as a single carrier (occupying at least 70% channel bandwidth), unless there are serious implications to supporting a single carrier with such a large bandwidth |
| Charter Communications | We support 2.16 GHz as one channelization option, at least for technology parity. |
| Huawei/HiSilicon2 | Further to our earlier above comment and as a reply to Intel’s comment, although supporting 2.16 GHz BW is not required for a fair co-existence with 802.11 devices (as pointed out above by Huawei and multiple other companies), we can have sympathy with Intel’s argument in the sense that supporting a 2.16 GHz BW may seem beneficial for 3GPP devices in an ecosystem that competing devices may support 2.16 GHz BW.  We are in the SI phase and we of course support evaluating the performance of 2 GHz BW and analyse the underlying practical complications before deciding (probably in WI phase) whether or not such a large BW should be supported.  Having said that, we believe that evaluating and analysing how to support for 2 GHz BW (in a single CC or using a CA), if supported at all, should also be**a complete study and not be biased from the outset towards the single CC approach** as can be inferred from Intel’s comment.  To this end, we would like to further point out that given the FFT size of 4096, support for the 2GHz BW in a single CC is only possible using a 960 kHz SCS which has a 73 ns NCP (260 ECP if ECP supported). Then, besides the issues pointed out by Intel, it should also be studied how such a CP can handle 50ns channel delay spread, DL/UL MIMO TAE of 65/130 ns, Analog beam switching of about 100 ns, and multi-TRP delay that can be easily over 100 ns. Further, how the short symbol duration of 960 kHz SCS can provide the minimum coverage requirements. One may argue that 2GHz BW in a single CC is mainly for indoor usages where the coverage and multi-TRP delay are not major issues. However, still the UL MIMO TAE alone would be larger than the NCP of a 960 kHz SCS. More important, SID mentions multiple outdoor use cases including “dense urban, urban micro, urban macro, rural” for this Study Item. As such, the design should be as inclusive as possible to be able to meet the requirements in all (or at least most) agreed deployments.  Finally, since the issue of channelization is very much tied to the numerology, it is probably better that both be discussed in [102-e-NR-52-71-Waveform-Changes] ED. |
| Spreadtrum | In order to coexist fairly with 802.11ad/ay in 60GHz band, we should support a bandwidth equal or similar to that supported by 11ad/ay (~2.16 GHz). |
| ITRI | Considering coexistence with 802.11 ad/ay, we should support a single carrier with approximate 2.16 GHz channel bandwidth. |

### Summary of discussion

On if we need to at least support one mode that aligns with or comparable WiFi 11ad channels of 2.16GHz bandwidth, the company views are summarized as follows:

* Support: Qualcomm, Sharp, Nokia, Vivo, InterDigital, Intel, ZTE/Sanechips, Sony, Samsung, Lenovo/Motorola, Charter, Spreadtrum, ITRI
* Not needed: Huawei/HiSilicon, LG, Apple, Ericsson, Futurewei,
* Further study: Vivo, Apple(?), DCM, Convida

Observation: No consensus reached so far. Likely more study needed.

## 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. |
| Futurewei | Support directional and omni LBT |

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. |
| FUTUREWEI | 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 sendsan 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 neighborbehavior 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

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| **Company** | **Key Proposals/Observations/Positions** |
| Ericsson | The proposal gives the impression that operation with or without LBT is a system configuration and there is no mixing between the two (for example in COT sharing case).  We suggest rewording the proposal to:  Proposal: If No LBT mode can be agreed,   * Study if operation restrictions for No LBT mode are needed, e.g. compliance with regulations, and/or in presence of ATPC, DFS, long term sensing, or other interference mitigation mechanisms. * Study mechanisms to temporary operate without LBT even when LBT mode is used (e.g. COT sharing) |
| Futurewei | We agree with Ericsson, that the wording needs clarified. The use of No-LBT also needs to be clarified and investigated, short term No-LBT versus long-term LBT. The LBT and No-LBT modes do not exclude each other. |
| Huawei/HiSilicon2 | We also prefer Ericsson wording with some modification. In particular, similar to directional LBT and receiver-assisted LBT, we believe that other adaptivity mechanisms such as ATPC, DFS, long term sensing, or other interference mitigation mechanisms require to be validated by simulation results. As such, we propose the following modification to Ericsson’s proposal:  Proposal: If No LBT mode can be agreed,   * Study if operation restrictions for No LBT mode are needed, e.g. compliance with regulations, and/or in presence of ATPC, DFS, long term sensing, or other interference mitigation mechanisms.   + Interested companies are encouraged to provide evaluation results for ATPC, DFS, long term sensing, or other interference mitigation mechanisms. * Study the need, and if deemed needed, mechanisms to temporary operate without LBT even when LBT mode is used (e.g. COT sharing) |

### 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. |
| FUTUREWEI | 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. |
| Ericsson | If LBT is to be adopted, 5/6GHz channel access mechanism is not the baseline. The sensing procedure (minimum sensing time + random back-off) are obviously inherited. But there is no need to inherit the CW adjustment procedures, priority classes differentiation, COT sharing rules and other aspects. All those detailed aspects were regulated for the sub-7GHz to avoid coexistence issues in the sub-7GHz. Due to the nature of the sub-7GHz spectrum, interference can be much more evident as compared to 52+GHz spectrum. Many companies have already shown that interference is rarely observed at high frequency, so there is no need to over design the LBT procedures, if there is no real evidence that it will bring gains, specially that those aspects are not mandated by the regulations. Supporting LBT is of interest for vendors who would like to declare compliance with ETSI 302 567. So naturally, the requirements that are in ETSI 302 567 should be the main focus. |
| Charter Communications | Agree with Intel, Nokia |

### 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. |
| Potevio | Proposal 2: Parallel multi-beam transmission scheme should be studied at least for SSB transmission in unlicensed spectrum above 52.6GHz |
| Lenovo, Motorola Mobility | Multi-beam operation should be studied to take advantage of the diversity in the channel access mechanism |

## 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. |
| Ericsson | It is premature to discuss this topic at this early stage. But we should keep in mind that many of the restrictions that were added for sub-7 GHz COT sharing were adopted to resolve coexistence concerns even though they are neither mandated by the regulations nor were there any evaluations that proved that there would be coexistence issues if NR-U followed the regulation requirements without additional restrictions. (e.g. restrictions that were not mandated by the regulations: limited UL duration, limited DL duration in shared COT, limited pauses, etc..). The COT sharing mandated by the sub-7GHz regulations is much simpler than the one adopted by NR-U rel-16. Similarly, the COT sharing that is described in ETSI EN 302 567 is quite clear:   * Responding device can always go without LBT regardless of the gap duration * Any number of gaps in a shared COT is allowed * The gap is counted as part of the COT   Given that the interference and coexistence is less of an issue in 52+GHz spectrum, and at least for purpose of being compliant with ETSI EN 302 567, the above conditions are enough. Any diversion from that, or additional restrictions should have a strong justification. |

# 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 |
| Ericsson | In our view, at this stage, studying the need for LBT is the first priority before going into optimizations. As we explained in 3.4.5, the 1requirements that are in ETSI 302 567 should be the main focus and the starting point (i.e. alt2) |
| Potevio | We support Alt.2. |
| Futurewei | Alt 2 i.e. start with the current draft of EN 302 567 adaptivity rules specs. |
| Huawei/HiSilicon2 | We can go with the majority view about this and accept Alt2 as the baseline LBT for evaluation purposes. |
| Samsung | We prefer Alt 2. |

## Summary of discussion

On baseline LBT scheme for evaluation (not for adoption), we have the follow alternatives

* 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

The company views are summarized below:

* Alt 2: Qualcomm, Ericsson, Potevio, Futurewei, Huawei/HiSilicon, Nokia, NSB

Proposal:

* Use the LBT mechanism in latest version of EN 302 567 for the baseline LBT system evaluation.

**Comment:**

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| Huawei/HiSilicon3 | Our understanding is that interested companies have supported Alt2 which reads “Current draft of EN 302 567 adaptivity rules with possibly adjusted ED threshold”. We believe that this should be reflected in the proposal which, currently, proposes to use EN 302 567 LBT mechanism as a baseline (without any possible modification in the ED threshold). As such, we suggest adding a sub-bullet to your proposal as follows:  Proposal:   * Use the LBT mechanism in latest version of EN 302 567 for the baseline LBT system evaluation.   + Companies may modify the ED threshold to account for the BW, beamforming gain, or other factors in which case the description of the modified ED threshold should be provided. |

# Others

# Reference

1. R1-2005240, Discussion on channel access for NR beyond 52.6 GHz, Lenovo, Motorola Mobility
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
24. R1-2006726, Channel Access Mechanism for NR in 60 GHz unlicensed spectrum, NTT DOCOMO, INC.
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.