**3GPP TSG-RAN WG4 Meeting # 96-e R4-2011539**

**Electronic Meeting, 17 – 28 August 2020**

**Agenda item:** 7.1.1 & 7.1.3

**Source:** Moderator (Ericsson)

**Title:** Email discussion summary for [96e][106] NR\_unlic\_SysParameters

**Document for:** Information

# Introduction

This document summarizes the email discussion on topics related to NR-U system parameters in AI 7.1.1 and band combinations related AI 7.1.3. However, there were no contribution on AI 7.1.3 in this meeting .

The contributions presented in this AI cover the following topics:

* Introduction of 6GHz band,
* System parameters
  + 100MHz CBW in NR-U
  + Spectrum Utilization
* wideband operation and LS reply to RAN1

Documents R4-2009934, R4-2010671 on NR-U CA BW Classes and R4-2011330 on LO Leakage and NRU Mask Measurement are moved to [96e][107] NR\_unlic\_UE\_RF thread.

# Topic #1: Introduction of 6GHz band for NR-U operation

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| **R4-2010459** | LG Electronics Finland | The proposed rules for Korea are close but not entirely matching with ongoing RAN4 NR-U work and therefore more detailed analysis needs to be carried to properly support the Korea’s 6GHz band with RAN4 specifications covering the Shared spectrum channel access. In addition, as public consultation period in Korea will last until August 24, it is proposed that this work will be covered in future |
| **R4-2010495** | Huawei, HiSilicon | **Observation 1**: whether Further Notice of Proposed Rulemaking need to be considered in 3GPP specification should be discussed.  **Observation 2**: The limit and request for standard-power operation (sub-band U-NII-5 and U-NII-7) and indoor operation (the entire band) is different and need to define separate classes.  **Observation 3:** It is challenge to provide the needed attenuation for a BS filter covering the entire 5925-7125 MHz.  **Proposal 1:** It is proposed to further discuss the band plan for 6GHz. 3 bands for 6GHz considering current FCC regulatory requirements is proposed for further consideration.   * Standard-power operation: Band x: 5925 - 6425 MHz, Band z: 6525 - 6875 MHz * In door operation: Band y: 5924 - 7125 MHz   ***Observation 4:*** Reusing the same channel allocation as 802.11ax will result in resource waste.  **Proposal 2:** Revised channelization on top of 802.11ax should be considered for 6GHz band in NRU. |
| **R4-2010744** | *Nokia, Nokia Shanghai Bell* | ***Proposal 1: It is proposed to include band n96 for NR-U with 5925 – 7125 MHz range.***  ***Proposal 2: It is proposed to introduce at least 20 MHz, 40 MHz, 60 MHZ, and 80 MHz channel bandwidths for NR-U band in 6 GHz unlicensed band.***  ***Proposal 3. It is proposed to align channel raster for NR-U in band n96 with Wi-Fi channels in 6 GHz.***  ***Proposal 4. It is proposed to set 60 MHz channels only within 80 MHz channel i.e. to adopt channel bonding rule for 60 MHz CBW.***  ***Proposal 5: It is proposed to introduce 15 kHz as global frequency raster for band n96 and NREF numbers for respective CBW as in table 1.***  ***Proposal 6: It is proposed to introduce band n46 principles for synchronization raster for band n96 and GSCN numbers for respective CBW as in table 2.***  ***Proposal 7: It is proposed to reuse for band n96 as a baseline band n46 unwanted emission masks for both Local Area and Medium Range BS included on non-transmitted and two non-transmitted channels.***  ***Proposal 8: It is proposed to reuse band n46 other general BS Tx and Rx requirements for band n96 that are not depends on frequency.*** |
| **R4-2010958** | *ZTE Corporation* | **Observation 1: 3GPP didn’t discuss how to define AFC functionality for NR-U operation at 6GHz which is crucial for NR-U operation at 6GHz in certain regions.**  **Observation 2: coexistence** **between 6GHz and ITS band n47 is not discussed for safety usage of V2X service.** |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-1

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 1-1: 6GHz Band plan**

* Proposals
  + Option 1: Consider following bands for 6GHz: (Huawei)
    - Standard-power operation: Band x: 5925 - 6425 MHz, Band z: 6525 - 6875 MHz
    - In door operation: Band y: 5924 - 7125 MHz
  + Option 2: To include band n96 for NR-U with 5925 – 7125 MHz range. (Nokia)
* Recommended WF
  + Collect companies’ views in the 1st round.

### Sub-topic 1-2

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 1-2: Channelization**

* Proposals
  + Option 1: Do not reuse the same channel allocation as 802.11ax. Revised channelization on top of 802.11ax should be considered for 6GHz band in NRU. (Huawei)
  + Option 2: Adopt the following proposals: (Nokia)
    - It is proposed to introduce at least 20 MHz, 40 MHz, 60 MHZ, and 80 MHz channel bandwidths for NR-U band in 6 GHz unlicensed band.
    - It is proposed to align channel raster for NR-U in band n96 with Wi-Fi channels in 6 GHz.
    - It is proposed to set 60 MHz channels only within 80 MHz channel i.e. to adopt channel bonding rule for 60 MHz CBW.
    - It is proposed to introduce 15 kHz as global frequency raster for band n96 and NREF numbers for respective CBW as in table 1in R4-2010744.
    - It is proposed to introduce band n46 principles for synchronization raster for band n96 and GSCN numbers for respective CBW as in table 2, R4-2010744.
* Recommended WF
  + Collect companies’ views in the 1st round.

### Sub-topic 1-3

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 1-3: AFC functionality and coexistence with ITS (ZTE)**

* Define AFC functionality for NR-U operation
* Study coexistence between NR-U operation in 6GHz and ITS in band n47
* Proposals
  + Agreeable
  + Not agreeable
* Recommended WF
  + Collect companies’ views in the 1st round

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Charter Communications, Inc. | Sub topic 1-1:  **Issue 1-1: 6GHz Band plan**  Option 2: To include band n96 for NR-U with 5925 – 7125 MHz range. (Nokia)  In option 1, R4-2010495 makes an observation that, *“It is challenge to provide the needed attenuation for a BS filter covering the entire 5925-7125 MHz.”*  We have verified with RF F/E filter vendors that this is not the case. Fractional bandwidth for 5925-7125 MHz is 18.5%. There are filters today that can provide 24% of fractional bandwidth. An example is 3.3-4.2 GHz  Sub topic 1-2:  **Issue 1-2: Channelization**  Option 2   * It is proposed to introduce at least 20 MHz, 40 MHz, 60 MHZ, and 80 MHz channel bandwidths for NR-U band in 6 GHz unlicensed band. * It is proposed to align channel raster for NR-U in band n96 with Wi-Fi channels in 6 GHz. * It is proposed to set 60 MHz channels only within 80 MHz channel i.e. to adopt channel bonding rule for 60 MHz CBW. * It is proposed to introduce 15 kHz as global frequency raster for band n96 and NREF numbers for respective CBW as in table 1in R4-2010744. * It is proposed to introduce band n46 principles for synchronization raster for band n96 and GSCN numbers for respective CBW as in table 2, R4-2010744.   Sub topic 2-1:  **Issue 2-1: AFC functionality and coexistence with ITS (ZTE)**  Not agreeable  In R4-1011344 Qualcomm shows how to address emission requirements for n96 with the introduction of NS\_53 and NS\_54.  With regards to co-existence with b47, this issue was discussed in the FCC Report of Order and Further Notice of Proposed Rulemaking FCC 20-51 where in paragraph 197 the report states, “*We believe that a limit of -27 dBm/MHz is necessary to protect services outside the U-NII-5 and U-NII-8 bands, including the Intelligent Transportation Service below the U-NII-5 band and federal government operations above the U-NII-8 band”*  And in paragraph 198, the 5GAA ( Global Automakers Association) further clarifies the following, *“To protect Intelligent Transportation Services in the band below 6 GHz, 5GAA states that the -27 dBm/MHz standard we are adopting, when based on a root-mean-square (RMS) measurement is sufficient to protect those services from indoor device OOBE.517 RLAN proponents agree that the OOBE should be verified using an RMS detector or other appropriate techniques for measuring average power.518 We agree and will provide guidance to the test labs and telecommunications certification bodies which conduct equipment approval measurements and oversight that 6 GHz unlicensed device measurements may be conducted based on using an RMS detector”*  The FCC provided guidance to the test labs and telecommunication bodies to adopt this method of testing. |
| Skyworks | **Issue 1-1: 6GHz Band plan**  Option 2 is preferred, indoor/standard power are covered by NS53/54 and NS should clarify applicable frequency range  **Issue 1-2: Channelization**  In the scope of Release 16 we should focus on Option 2. In release 17, more channel bandwidths and channel locations can be added  **Issue 2-1: AFC functionality and coexistence with ITS (ZTE)**   * Define AFC functionality for NR-U operation: is this needed since NRU UE should have the same frequency precision as BS within 0.1ppm and BS can know which channels are usable.   Study coexistence between NR-U operation in 6GHz and ITS in band n47: is there regulation requiring this in the US (can be introduced later via NS if required for other regions)? In any case n46 does not protect n47 so why should this apply to n96? |
| Qualcomm | Issue 1-1: Support Option 2: To include band n96 for NR-U with 5925 – 7125 MHz range. A single band is consistent with regulatory rules so far and enables the greatest commonality and flexibility for deployments in the band and for support in devices.  Issue 1-2: Support option 2 on channelization. This provides the greatest compatibility with 802.11ax for effective coexistence. While there may be some lost efficiency in some U-NII bands as pointed out by Huawei for standard power deployments, defining a different channelization could degrade coexistence not only with 802.11ax but also with NR-U indoor deployments.  Issue 2-1: Not agreeable. AFC for standard power operation is not defined in 3GPP and is not needed for low power operation. Coexistence with ITS has already been studied by regulatory bodies in coming up with the technical rules. |
| Nokia | **Sub topic 1-1:**  **Issue 1-1:** Any regional power constrains are covered by the general regulatory output power statement e.g. as given in 38.104 *“In addition, for operation with shared spectrum channel access operation, the BS may have to comply with the applicable BS power limits established regionally, when deployed in regions where those limits apply and under the conditions declared by the manufacturer.”*. Furthermore, if specific regional regulations provide a need for additional UE requirements, these are included under NS. Therefore, Option 2 is proposed from our side (with both Local Area and Medium Range BS classes as allowed by FCC regulation).  **Sub topic 1-2:**  **Issue 1-2:** We propose Option 2 to align with 11ax as this would ensure better co-existence, as also done for the 5Ghz band (n46).  **Sub topic 1-3:**  **Issue 2-1:** Similarly, as Dynamic Channel Selection for LAA or SAS for CBRS, AFC shall be out of discussion in 3GPP. The intention of 3GPP is to define RF requirements for this band only as ITS has already been studied by regulatory bodies in coming up with the technical rules. |
| Huawei | Sub topic 1-1: 6GHz Band plan  Basically it will need more discussion to consider the regional regulations. Whether or not FNPRM need to be considered? Whether or not other regions such as Korea should be considered? The feasibility need to be studied before the conclusion.  Sub topic 1-2: Channelization  Option 1: Revised channelization on top of 802.11ax should be considered for 6GHz band in NRU. It is clear the channelization of current 802.11ax is not optimized, e,g, channels will cross the sub-band boundaries.  Sub topic 1-3: AFC functionality and coexistence with ITS  We agree 1. AFC is a new function and may need more time to study. 2. co-existence with ITS and/or n46 need to be addressed |
| MediaTek | **Issue 1-1: 6GHz Band plan**  Work on requirements first  Just to note that the decision here is conditioned on the fact that RAN4 can finalize corresponding requirements in Rel-16 in this meeting. We suggest to work on the detail requirement first and then visit this issue later.  **Issue 1-2: Channelization**  In order to align the WiFi channel, we need to first clarify which version of 802.11ax we are referring to. Maybe we also need to consider the coexistence with 802.11be?  **Issue 2-1: AFC functionality and coexistence with ITS (ZTE)**  AFC sets some additional rules for AP (BS) only, not for STA (UE). RAN4 can check if current BS requirements should be intervened by AFC. |
| LG Electronics | **Issue 1-1: 6GHz Band plan**  Option 2, new regions can be addressed later  **Issue 1-2: Channelization**  Option 2  **Issue 2-1: AFC functionality and coexistence with ITS (ZTE)**  Not agreeable |
| CHTTL | **Issue 1-1: 6GHz Band plan**  We support MTK and Huawei’s view.  **Issue 1-2: Channelization**  For clarification that if we focus on option 2 only now, it is still possible to add new channel location in the future?  **Issue 2-1: AFC functionality and coexistence with ITS (ZTE)**  Support to check the co-existence issues. |
| ZTE | **Issue 1-1: 6GHz Band plan**  For Rel-16, NR-U BS core requirements is left with lots of open issues and conformance testing is not started yet at this meeting, we could see big risk even for 5GHz. For 6GHz, lots of issues needs further discussion which is not easily concluded e.g. font-end of filter for NR-U BS as 6GHz is spanning over 1.2GHz which is much larger than the existing NR maximum 900MHz.  Power limitation of AFC for NR-U BS at 6GHz also still further discussion.  **Issue 1-2: Channelization**  The channelization of current 802.11ax still needs some further improvement to resolve the cross sub-band issues. For NR-U, alignment between NR-U and 802.11ax should also be up to that decision.  **Issue 2-1: AFC functionality and coexistence with ITS (ZTE)**  For AFC functionality, it should be defined by technical group instead of regulator. Due to FCC request on specific AFC system and testing method, then wifi alliance triggered the work for AFC, we think this should be applied for 3GPP group, we need to define our OWN AFC functionality. I think it should be not RAN4 work, maybe it should be RAN plenary discussion, otherwise these feature is not feasible to work due to missing functionality requested by regulator.  For coexistence with ITS bands, we think this work should also be conducted in 3GPP group instead of regulatory bodies only, currently 3GPP has defined NR-U and V2X techniques, then we have 3GPP coextensive scenarios, some evaluation work is essential. |
| Apple | **Issue 1-1: 6GHz Band plan**  Option 2. We have a preference for having one band covering 5925 – 7125 MHz. Any additional regional requirements and limitations can be covered with NS values.  **Issue 1-2: Channelization**  We are Ok with option 2 as a baseline. However, we would prefer not to slam the door for further technical discussions because different regions might have different allocations and restrictions. As noted by one of the proponents, it would be also worth (double-)checking whether regulations allow/do not allow crossing sub-bands boundaries and what it means for our specifications.  **Issue 2-1: AFC functionality and coexistence with ITS**  The way we see AFC for the 6GHz band is that it is very similar to the CBRS band and the SAS entity. From that perspective, interface between the base station and the AFC controlling entity is out of scope of 3GPP discussions (that does not preclude of course further technical discussions between 3GPP and the corresponding SDO that will be in charge of that interface). |
| Verizon | **Issue 1-1: 6GHz Band plan**  Option 2  **Issue 1-2: Channelization**  Option 2  **Issue 2-1: AFC functionality and coexistence with ITS (ZTE)**  Not agreeable |
| Ericsson | Issue 1-3:  Not agreeable. The AFC is not in the scope of 3GPP specifications. |

### CRs/TPs comments collection

*Major close-to-finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
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| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

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|  | **Status summary** |
| **Sub-topic#1**  6GHz Band plan | *Tentative agreements: No tentative agreement*  *Candidate options: No candidate Option*  *Option 1: Huawei, ZTE, MediaTek, CHTTL*  *Option 2: Qualcomm, Charter, Skyworks, Nokia, LG, Apple, Verizon*  *Recommendations for 2nd round: Companies continue the discussion, if consensus is not possible chairman intervention is needed* |
| **Sub-topic#2**  Channelization | *Tentative agreements: No tentative agreement*  *Candidate options: No candidate Option*  *Option 1: Huawei, ZTE, MediaTek, CHTTL*  *Option 2: Qualcomm, Charter, Skyworks, Nokia, LG, Apple, Verizon*  *Recommendations for 2nd round: Companies continue the discussion* |
| **Sub-topic#3**  AFC functionality and coexistence with ITS (ZTE) | *Tentative agreements: No tentative agreement*  *Candidate options: No candidate Option*  *Agreeable: Huawei, ZTE, MediaTek, CHTTL*  *Not Agreeable: Qualcomm, Charter, Skyworks, Nokia, LG, Apple, Verizon, Ericsson*  *Recommendations for 2nd round: Companies continue the discussion* |

*Recommendations on WF/LS assignment*

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|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

**Issue 1-1: 6GHz Band plan**

* Proposals
  + Option 1: Consider following bands for 6GHz: (Huawei)
    - Standard-power operation: Band x: 5925 - 6425 MHz, Band z: 6525 - 6875 MHz
    - In door operation: Band y: 5924 - 7125 MHz
  + Option 2: To include band n96 for NR-U with 5925 – 7125 MHz range
  + Option 3: Specify the requirements first and then define the band
* Recommended WF
  + Companies are encouraged to compromise and reaching the consensus

**Issue 1-2: Channelization**

* Proposals
  + Option 1: Do not reuse the same channel allocation as 802.11ax. Revised channelization on top of 802.11ax should be considered for 6GHz band in NRU. (Huawei)
  + Option 2: Adopt the following proposals: (Nokia)
    - It is proposed to introduce at least 20 MHz, 40 MHz, 60 MHZ, and 80 MHz channel bandwidths for NR-U band in 6 GHz unlicensed band.
    - It is proposed to align channel raster for NR-U in band n96 with Wi-Fi channels in 6 GHz.
    - It is proposed to set 60 MHz channels only within 80 MHz channel i.e. to adopt channel bonding rule for 60 MHz CBW.
    - It is proposed to introduce 15 kHz as global frequency raster for band n96 and NREF numbers for respective CBW as in table 1in R4-2010744.
    - It is proposed to introduce band n46 principles for synchronization raster for band n96 and GSCN numbers for respective CBW as in table 2, R4-2010744.
* Recommended WF
  + Companies are encouraged to reach consensus

**Issue 1-3: AFC functionality and coexistence with ITS (ZTE)**

* Define AFC functionality for NR-U operation
* Study coexistence between NR-U operation in 6GHz and ITS in band n47
* Proposals
  + Agreeable
  + Not agreeable
* Recommended WF
  + Collect companies view

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| **Company** | **Comments** |
| BT plc | Issue 1-1: 6GHz Band plan  We favor ‘option 1’ because it will permit a global NR-U eco-system to develop, based on release 16. However, this should not stop the development of a single NR-U band for the 5925 - 7125 MHz range.  It should also be noted, that the band 6425 – 7025 & 7025 – 7125 MHz is the subject of WRC-23 Agenda Item 1.2 as a potential mobile band for IMT.  We believe that RAN4 should explicitly identify the 5925 – 6425 MHz band for Europe, even if this is seen as duplicating the proposed 5925 – 7125 MHz band for the US. |
| Deutsche Telekom | Issue 1-1: 6GHz Band plan  We support ‘option 1’ and believe that 5925 – 6425 MHz band should be explicitly defined for Europe. |
| Skyworks | 1-1: From a UE perspective only option 2 makes sense as there is no incentive to fragment the solution especially for unlicensed band. To createlarge UE ecosystems, we already use “WW bands” like n77 (covering n78, n48, B42, B43, and different spectrum ranges in Japan, China, Europe and the US) and the different regional requirements are based on NS. This can be applied for n96 in the same way and is already the way n46 is dealing with different spectrum allowance and emission requirements. We should not create unnecessary UE fragmentation for n96 and reuse n77/79/46 approach. If BS requirements may be different this can be dealt with sub-bands like for 46/n46. |
| Charter Communications | Topic # 1 Introduction of 6GHz band for NR-U operation  Issue 1-1: 6 GHz Band Plan  We agree with option 2 (To include band n96 for NR-U with 5925 – 7125 MHz range). Regulatory framework has been ruled in the US and introduction in Rel-16 is a business time to market requirement for US companies.  Issue 1-2 Channelization  We agree with option 2 (Nokia’s proposal) as it provides more effective spectrum utilization with other technologies  Issue 1-3 AFC functionality and co-existence with ITS  Not agreeable. BS vendors have provided comments in round 1 to address power classes for BS. We agree with their comments. |
| Qualcomm | 1-1: We support option 2. The current proposal defines the band only for the US which is the only country where regulations are finalized. In the future, when other countries complete their regulations, they may also be able to adopt Band n96 if compatible. If not, then at that time another band can be defined as warranted. But for now, we don’t see any reason why a band should not be defined to enable deployment in a country where regulations are already finalized. Both option 1 and option 2 include the 5925 – 7125 MHz Band n96 so we don’t see any disagreement here and any reason we should not move forward with this definition. The only difference is option 1 proposes to additionally defined two other bands which we do not believe are necessary. There is no disagreement against defining 5925 – 7125 MHz Band n96 now.  1-2: Channelization proposed by Nokia facilitates more efficient coexistence scenarios. Other channelizations might be better suited if NR-U is the only technology in the band, but since this is a shared band where WiFi 6E has already announced plans, it makes the most sense to follow the proposed channelization.  1-3: AFC is out of scope of 3GPP. And it is only applicable for standard power deployments. It is completely irrelevant to low power deployments. Coexistence with ITS is already considered in the regulatory limits. |
| Qorvo | 1-1: We support option 2. This matches the band as described in the FCC Report and Order issued in April. We agree with other comments that this will create a general purpose band definition which can support other subsets such as 5925 – 7125 MHz |
| AT&T | 1-1: We support option 2 in the Rel-16 timeframe to allow for development based on a 3GPP-defined band since the FCC regulations are clear. Further delay in the band definition will disadvantage 3GPP-defined solutions in this unlicensed band for US operators. |
| Huawei | 1-1: Option1. We think more discussion based on option1 is needed. Feasibility need to be studied before the conclusion. Based on our feasibility study so far, we need 3 bands to cover both standard-power and indoor operation.  1-2: Option 1. Revised channelization on top of 802.11ax should be considered for 6GHz band in NRU. Current 11ax channelization is strange and low efficiency in spectrum usage which was published 11-2019, at the time no regulation can be referred. And it was called as “draft standard”. It does not make sense to use an unapproved draft in IEEE as a basis for 3GPP when we find it can be optimized.  1-3: agree to check the co-existence issues |
| Apple | Issue 1-1 6GHz band plan: We support Option 2, i.e. adding one band which is defined at least in US. Once regulatory discussions are completed in other countries, we can revise this issue and agree whether introduction of new bands is necessary.  Issue 1-2 Channelization: We agree with Nokia proposal as a baseline, but we are also open to check further details.  Issue 1-3 AFC: As commented by other companies, this is similar to SAS and band n48, so this interface is out of scope of 3GPP specifications. |
| CableLabs | Issue 1-2: we support option 2 that avoids potential mutual interference between NR-U and other technologies. Option 1 may optimize spectrum efficiency near the edges of U-NII-6 band for standard power operation in U-NII-5 and 7, but option 2 is more efficient for low-power indoor (LPI) operation throughout the entire 1200 MHz spectrum.  Issue 1-3: not agreeable. AFC is out of scope of 3GPP. |
| Nokia | Issue 1-1: Support option 2. It seems there is some confusion about the introduction of 6GHz band for Europe. As indicated by Qualcomm, the current proposal is related to operation in US only since regulations are not finalized in other countries. Once regulations are clear in other countries, 3GPP will discuss if n96 can be re-used in these countries or not. Finally, since this is a spectrum item where all regulations are known, we do not see any argument why the band cannot be finalized in this meeting.  Issue 1-2: Support option 2.  Proposals from option 2 reuse 5GHz approach i.e.:   * Similar to band n46 set of channel bandwidths (except 10MHz) used * Alignment with 11ax for channel raster points for 20/40/60/80 MHz channel bandwidth * Bonding rule adopted for 60 MHz channels within 80MHz – ensure of coexistence with Wi-Fi * For synchronization raster (SSB) also 5GHz approach was used, discussed long time in RAN4 (single point per 20 MHz)   Issue 1-3: Not agreeable. As commented in the first round, AFC is similar functionality as DFS (Dynamic Frequency Selection) for Band 46 or SAS for Band 48 which was not considered in 3GPP (RAN4 defined RF requirements for these bands only and should do the same for n96). Other organizations (WFA, WinnForum) are working on the technology neutral solution (including incumbent interference protection) which can be used by 3GPP technology. There is no need to study co-existence with ITS as it was already considered in the regulatory limits. |
| Qualcomm | On channelization, the stated concern is that the usage of U-NII-6 is inefficient according to the 802.11ax channelization and since the regulatory rules are different between U-NII-5 and U-NII-6, then such inefficiency would not allow placement of an 80 MHz channel in U-NII-6, for example. Notwithstanding the concerns with regard to coexistence with 802.11ax for the moment, I would still like to better understand what is the problem and when it occurs. For an indoor deployment, the same rules apply across all 4 U-NII bands, so there is no problem in my understanding. For an outdoor deployment, operation within U-NII-6 is not allowed so what does is matter if the channelization is inefficient for U-NII-6 from an outdoor deployment perspective? Thus, I don’t see the motivation to change the channelization thereby disrupting coexistence with 802.11ax and NR-U indoor for the sake of improving efficient channelization outdoors if it cannot be used. |
| U.S. Cellular | 1-1: Support option 2 in the Rel-16 timeframe for a new band aligned with the FCC requirements. |

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

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| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #2: NR-U system parameters

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| **R4-2009901** | Charter Communications Inc. | **Observation 1: It can be noticed that for 60 MHz channel bandwidth configurations, the channel rasters were defined to fall inside the 80 MHz channel bonding configurations in Wi-Fi. This assures fair co-existence with both technologies.**  **Observation 2: There are several co-existence issues with the proposed channel rasters for 100 MHz channel bandwidth in [1] and [2].**  **Observation 3: Wideband multi-channel access operations for 100 MHz channel bandwidth needs to consider multiple CAT4 LBT procedures to insure fair co-existence with Wi-Fi.**  **Proposal 1: RAN4 should not define** **100 MHz channel bandwidth for NR-U in 5 GHz (n46) in Release 16.** |
| **R4-2010499** | Huawei, HiSilicon | **Observation 1: If using Type A multi LBT sub-band channel access, there is no issue for 100MHz CBW in band n46.**  **Proposal 1: Channel raster for 100MHz CBW in NRU as listed in Table.1 should be supported**  **Proposal 2: The spectrum emission mask for 100MHz channel bandwidths in NRU should be supported as below:**  **- for full bandwidth transmission, the general spectrum emission mask in NRU is applied.**  **- for single punctured channel in the middle, the emission mask of the puncture center is limited at -23dBr.**  **- for multiple punctured channels in the middle, the emission mask in the middle is floored at -25dBr.**  **- for punctured channel(s) at the edge, the emission mask edge is floored at -28dBr.** |
| **R4-2009933** | Apple Inc. | **Proposal 4:** **For 60kHz SCS, adopt alternative 1 for intra-carrier guard bands (i.e. 5 RBs for in-carrier guard band with 23-5-23 pattern).** |
| **R4-2010498** | Huawei, HiSilicon | ***Proposal 1: 25PRB for 20 MHZ channel bandwidth should be mandatory for a UE supporting 60 kHz SCS.***  ***Proposal 2: Alt.2 for 60kHz intra-carrier guardbands should be supported.*** |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 2-1: 100 MHz channel bandwidth for NR-U in 5 GHz

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 2-1-1:**

* Proposals
  + Option 1: Define 100 MHz channel bandwidth for NR-U in 5 GHz (Huawei)
  + Option 2: Do not define 100 MHz channel bandwidth for NR-U in 5 GHz (n46) in Release 16 (Charter)
* Recommended WF
  + Collect companies’ views in the 1st round

**Issue 2-1-2:**

“If 100 MHz channel bandwidth is defined for NR-U in 5 GHz, the spectrum emission mask for 100MHz channel bandwidths should be specified as in document R4-2010499”. (Huawei)

* Proposals
  + Agreeable
  + Not Agreeable
* Recommended WF
  + Collect companies’ views in the 1st round

### Sub-topic 2-2: Spectrum utilization

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 2-2:**

* Proposals
* Option 1: (Huawei)
  + 25 PRB for 20 MHZ channel bandwidth should be mandatory for a UE supporting 60 kHz SCS.
  + 25 PRBs for 60kHz intra-carrier guard bands should be supported.
* Option 2 (Apple)
  + 24 RBs for 20MHz channel with 5 RBs for in-carrier guard band
* Recommended WF
  + Collect companies’ views in the 1st round

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Charter Communications, Inc. | Sub topic 2-1:  **Issue 2-1-1:**  Option 2: Do not define 100 MHz channel bandwidth for NR-U in 5 GHz (n46) in Release 16 (Charter)  In our paper R4-2009901 we showed fundamental challenges that need to be resolved before including 100 MHz channel bandwidth in n46.  **Issue 2-1-2:**  Not agreeable. As indicated above 100 MHz channel bandwidth inclusion requires further study before addressing other technical aspects such as emission mask  Sub topic 2-2:  Option 2: 24 RBs for 20MHz channel with 5 RBs for in-carrier guard band  As indicated in previous meetings, we are deeply concerned about shortening the guard bands and creating potential interference |
| Skyworks | **Issue 2-1-1:**  At this time it seems that we won’t have all the requirement in place for the UE for 100MHZ in this meeting. 100MHZ mat be postponed to rel17 for both n46 and n96.  **Issue 2-1-2:** See above |
| Qualcomm | Issue 2-1-1: Option 2, do not define 100 MHz channel bandwidth. However, for clarification, the proposal from Charter was not to define 100 MHz in Rel-16. It is not precluded to introduce it in a later release if agreed.  Issue 2-1-2: While we don’t think 100 MHz channel bandwidth should be specified in Rel-16, the emission mask from Huawei is ok if 100 MHz is added in the future.  Issue 2-2: Support option 2 from Apple for 24 RB’s at 60 kHz SCS in a 20 MHz channel |
| Huawei | Sub topic 2-1:  We still think 100MHz should be defined for NRU in R16, larger bandwidth is obviously benefit for NRU. The standard effort for 100MHz is relatively small. The only concern from some companies is the coexistence with WiFi when 100MHz is used, however, as analyzed in our paper, if type A multi-channel LBT is performed, there is no coexistence issue.  Sub topic 2-2:  Option 1. We understand that 60kHz SCS is optional for UE, however, the logic here is that in NRU, if 60kHz is supported, 25PRB for 20MHz should be supported, which has been agreed for a long time. Accordingly guardband defined based on 25PRB should be adopted, since anyway intra-carrier guardband is only specified for NRU. |
| LG Electronics | Issue 2-1-1: Option 2: Do not define 100 MHz channel bandwidth for NR-U in 5 GHz (n46) in Release 16 |
| CableLabs | Issue 2-1-1:  Option 2: Do not define 100 MHz channel bandwidth for NR-U in 5 GHz (n46) in Release 16.  There are many technical concerns presented in R4-2009901 co-sourced by Charter and CableLabs. The 100 MHz bandwidth could be discussed in R17 once all our concerns are addressed.  Issue 2-1-2:  Huawei’s SEM is not agreeable since it only specifies power level, the corresponding frequency points are missing in Proposal2 of R4-2010499. We have expressed our concerns about interior punctured SEM in the May meeting R4-2006141, and proposed alternative SEMs. Again, we would exclude the 100 MHz bandwidth from R16. Let us discuss this topic in R17 meetings.  Issue 2-2:  We support option 2 with 24 PRBs. |
| ZTE | Issue 2-1-1:  We support option 1 to introduce 100MHz in Rel-15. This could benefit NR-U system performance close to licensed band 100MHz.  Issue 2-2:  We support option 1with 25 PRBs. |
| Apple | Issue 2-1-x 100MHz: Our view is that 100MHz channel does not have all the technical input in place to finish this work in Rel-16. This topic can be of course discussed further in Rel-17.  Issue 2-2-1: We support option 2 with 24 PRBs. |
| Intel | **Issue 2-1-1:**  Option 2: Given limited time for Rel-16, we are pessimistic to define 100 MHz. This can be further discussed in Rel-17.  **Issue 2-1-2:**  Our preference is single requirement -25 dBr but we are ok with the proposal as a baseline for future discussion. RAN4 could discuss and down select from the three values, or comptonization. Important point is the 100 MHz requirement should have consistency with CBW up to 80 MHz.  **Issue 2-2:**  Support Option 1. This has been agreed quite a long time ago and we do not understand technical motivation of other option, i.e., Option 2. |
| Ericsson | Issue 2-1-1:  100 MHz can be specified in the next release if requirements cannot be completed in Rel-16  Issue 2-1-2:  Agreeable. The Huawei proposal follows the European regulation that has been used for all other bandwidths.  Issue 2-2:  Option 2 preferred |

### CRs/TPs comments collection

*Major close to finalize Wis and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going Wis, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic#1**  **Issue 2-1-1**  **Issue 2-1-2**  100 MHz channel bandwidth in Rel 16 | *Tentative agreements: No tentative agreement*  *Candidate options: No candidate option*  *Option 1: Huawei, ZTE,*  *Option 2: Qualcomm, Charter, Skyworks, LG, CableLabs, Intel, Ericsson, Apple*  *Recommendations for 2nd round: Continue discussion in round 2* |
| **Sub-topic#2** Spectrum utilization | *Tentative agreements: No tentative agreement*  *Candidate options: No candidate option*  *Option 1: Huawei, ZTE, Intel*  *Option 2: Qualcomm, Charter, CableLab , Ericsson,*  *Recommendations for 2nd round: Continue discussion in round 2* |

*Suggestion on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

**Issue 2-5-1: 100 MHz channel bandwidth for NR-U in 5 GHz**

* Proposals
  + Option 1: Define 100 MHz channel bandwidth for NR-U in 5 GHz (Huawei)
  + Option 2: Do not define 100 MHz channel bandwidth for NR-U in 5 GHz (n46) in Release 16 (Charter)

**Issue 2-5-2:**

“If 100 MHz channel bandwidth is defined for NR-U in 5 GHz, the spectrum emission mask for 100MHz channel bandwidths should be specified as in document R4-2010499”. (Huawei)

* Proposals
  + Agreeable
  + Not Agreeable

**Issue 2-5-3:**

* Proposals
* Option 1: (Huawei)
  + 25 PRB for 20 MHZ channel bandwidth should be mandatory for a UE supporting 60 kHz SCS.
  + 25 PRBs for 60kHz intra-carrier guard bands should be supported.
* Option 2 (Apple)
  + 24 RBs for 20MHz channel with 5 RBs for in-carrier guard band

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Skyworks | 2-5-1&2: We anyhow miss a number of UE requirements for 100MHz and have not fully developed aspects like MPR/A-MPR |
| Charter Communications | Topic #2 NR-U System parameters  Issue 2-5-1 100 MHz channel bandwidth for NR-U in 5 GHz  We agree with option 2; Do not define 100 MHz channel bandwidth for NR-U in 5 GHz (n46) in Release 16  Many companies have provided challenges that need to be further studied with the introduction of 100 MHz channel bandwidth. Companies in favor of 100 MHz channel bandwidth have not provided technical arguments against the challenges provided in round 1. These challenges are:   1. Some of the channel rasters proposed by other companies cause interference and misalignments with channel bonding configurations with Wi-Fi 2. Other channel rasters use edge non bonded channels that required tighter emission considerations from the FCC. 3. Using edge channel non-bonding channels required per ETSI specification special multi carrier channel procedures 4. Companies have identified disagreements in the SEM proposals in R4-2010499   Issue 2-5-2 “If 100 MHz channel bandwidth is defined for NR-U in 5 GHz, the spectrum emission mask for 100MHz channel bandwidths should be specified as in document R4-2010499”. (Huawei)  Not agreeable. As identified above, there are companies that have provided comments in round 1 against this proposal.  Issue 2-5-3 Spectrum utilization  We agree with option 2 (24 PRBs for 20MHz channel with 5 RBs for in-carrier guard band) and have provided comments concerning with the shortening of the GB as a results of option. |
| Qualcomm | 2-5-1: Support option 2. We don’t have the requirements for 100 MHz channel bandwidth and haven’t seen any proposals from the proponents for the requirements.  2-5-3: Option 2 |
| Huawei | See our comments in 1st round  2-5-1: Support option 1  2-5-3: Support option 1 |
| Apple | 2-5-1: We support option 2.  2-5-3: We support option 2. |
| CableLabs | Issue 2-5-1: option 2  Issue 2-5-2: not agreeable  Issue 2-5-3: option 2  We described our technical concerns in round 1 discussion. None of them was solved in the past week. Our opinions still hold. |
| Nokia | Issue 2-5-1 – We are fine with option 2 |

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #3: Wideband capabilities and LS reply to RAN1

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| **R4-2010310** | *MediaTek inc.* | **Observation 1: UE’s Rx RF setting is actually the same for Cases 2a, 2b, 3 and 4 for the all receptions during a COT.**  **Observation 2: When one of the configured subband is occupied by other non-serving transmissions, UE is not able to suppress it via the RF filter which already assumes WB. AGC setting will be not accurate and the reception performance is going to be bad.**  **Observation 3: There is no any RF requirements for subbands with partial LBT success nor any RRM requirements which allows UE some spare time to adopt the DL RF filter setting.**  **Observation 4: When the LBT is done by UE, only UL WB operation Case 3 is practical for UE implementation.**  **Observation 5: When the LBT is not done by UE, UL WB operation Case 3 remains the baseline UE behavior, while capabilities can be introduced for Cases 1 and 2.**  **Proposal 1: DL WB operation Case 4 (Mode 1) is supported in Rel-16 with capability signaling.**  **Proposal 2: DL WB operation Cases 2a, 2b and 3 are not supported in Rel-16**  **Proposal 3: UL WB operation Case 3 is supported in Rel-16 with UE capability signaling.**  **Proposal 4: UL WB operation Cases 1 and 2 are supported with UE capability signaling in Rel-16, only if UE does not need to perform LBT before UL transmission.** |
| **R4-2011447** | Nokia, Nokia Shanghai Bell | **Proposal 1: Define additional UE capabilities for NR-based access to unlicensed spectrum as given in section 4.**  **Proposal 2: Respond to the RAN1 LS on UE capability on wideband carrier operation for NR-U as given in the draft LS provided in section 5.** |
| **R4-2009933** | Apple Inc. | **Proposal 1a:** **Clarify that DL wide-band transmission mode 1 assumes that LBT is successful in all LBT sub-bands *irrespective* of which sub-bands are scheduled with data.**  **Proposal 1b:** **Clarify whether UL wide-band transmission mode 1 assumes that LBT is successful in all LBT sub-bands *irrespective* of which sub-bands are scheduled with data or only in those LBT sub-bands where UL data is scheduled.**  **Proposal 2a:** **Wide-band transmission modes should have separate UE capabilities.**  **Proposal 2b:** **It can be discussed further whether we need to have strict differentiation between all three modes / sub-modes or whether transmission mode 1 can be construed as the baseline NR-U functionality.**  **Proposal 3:** **Wide-band transmission modes should be differentiated between DL and UL.** |

## Open issues summary

RAN4 received a LS from RAN1 (R1-2004965). The LS includes several questions regarding whether to add UE capabilities for Mode 1, Mode 2 and Mode 3.

### Sub-topic 3-1: Considerations on wideband operation, R4-2009933 (Apple)

**Issue 3-1-1:**

Proposal 1a: Clarify that DL wide-band transmission mode 1 assumes that LBT is successful in all LBT sub-bands irrespective of which sub-bands are scheduled with data, CSI-RS, and SSB.

* Proposals
  + Agreeable
  + Not Agreeable

**Issue 3-1-2:**

Proposal 1b: Clarify whether UL wide-band transmission mode 1 assumes that LBT is successful in all LBT sub-bands irrespective of which sub-bands are scheduled with data or only in those LBT sub-bands where UL data is scheduled.

* Proposals
  + Agreeable
  + Not Agreeable

**Issue 3-1-3:**

Proposal 2a: Wide-band transmission modes should have separate UE capabilities.

* Proposals
  + Agreeable
  + Not Agreeable

**Issue 3-1-4:**

Proposal 2b: It can be discussed further whether we need to have strict differentiation between all three modes / sub-modes or whether transmission mode 1 can be construed as the baseline NR-U functionality.

* Proposals
  + Agreeable
  + Not Agreeable

**Issue 3-1-5:**

Proposal 3: Wide-band transmission modes should be differentiated between DL and UL.

* Proposals
  + Agreeable
  + Not Agreeable
* Recommended WF
  + Collect companies’ views in the 1st round

### Sub-topic 3-2: LS reply to RAN1 on DL operation to add UE capabilities

*Open issues and candidate options before e-meeting:*

**Issue 3-2:**

Question 1: Is there any difference in DL reception among DL Cases 1, 2a, 2b, 2, and 3 with respect to AGC when at least one of the sub-bands of a [BW or carrier] is not part of gNB’s acquired channel occupancy and contains interference from devices other than the UE’s serving gNB e.g. near-by WiFi AP? Does RAN4 think AGC issues may prevent UE to meet RAN4 requirements for Mode 2 and Mode 3?

* Proposals:
  + Option 1: UE implementation for AGC is the same, but the performance is different between Case 2a/2b/3 and Case 4. For Case 2a/2b/3, UE is not able to suppress it via the WB RF filter. AGC setting will be inaccurate, and the reception performance is going to be bad. RAN4 does not introduce RF requirements for Mode 2 and Mode 3 in Rel-16. (MediaTek)
  + Option 2: The question is dependent on the chosen implementation approach. In principle, there is no difference in between DL case 1, 2a, 2b and 3 in regards to AGC levels. Sufficient dynamic range of the AGC is needed but this is no different as compared to Rel-15 NR and for that case LAA intra-band CA for DL case 1, 2a and 2b. (Nokia)
  + Option 3: Other

Question 2a: Is there a difference in UE capability between any of DL Cases 2a/2b and DL Case 3?

* Proposals:
  + Option 1: UE capability should be different for DL Case 1 and DL Case 4. Due to no requirement, Case 2a/2b/3 are not considered In Rel-16 (MediaTek)
  + Option 2: Difference between a UE supporting DL case 2a/2b and DL case 3 is the capability of receiving in the intra-cell guardband(s). This capability is discussed further within RAN4. (Nokia)
  + Option 3: Other

Question 2b: Is there a difference in UE capability between any of DL Cases 2a/2b/3 and DL Case 4?

* Proposals:
  + Option 1: UE capability should be different for DL Case 1 and DL Case 4. Due to no requirement, Case 2a/2b/3 are not considered In Rel-16 (MediaTek)
  + Option 2: Difference between DL case 2a/2b/3 and DL case 4 is that UE for DL case 4 needs to support the entire configured bandwidth as a single carrier. As the mandatory support of an NR band is 100MHz and no bandwidth above 80 MHz is currently defined then all NR UEs should be able to operate in DL case 4 with no additional UE capability. Further, a UE operating in DL case 4 does not have to expect or cope with potential interference in the LBT sub-bands which have failed CCA as it is only considering ‘all-or-nothing’. That implies that If DL case 4 is supported then DL case 1, 2a, 2b and 3 should also be supported if the UE is capable of coping with potential interference on failed LBT sub-bands. (Nokia)
  + Option 3: Other

Question 2c: Is there a difference in UE capability between any of DL Cases 2a/2b/3/4 and DL Case 1?

* Proposals:
  + Option 1: UE capability should be different for DL Case 1 and DL Case 4. Due to no requirement, Case 2a/2b/3 are not considered In Rel-16 (MediaTek)
  + Option 2: As mentioned in relation to question 1 only DL case 3 and 4 is different from DL case 1, 2a and 2b as they rely on the capability of the UE being able to receive in the intra-cell guard bands. (Nokia)
  + Option 3: Other

Question 3: From RAN4 point of view, does “all LBT sub-bands” for Mode 1 refer to LBT sub-bands of configured carrier or BWP?

* Proposals:
  + Option 1: From UE implementation point of view, all LBT subbands for Mode 1 refer to the BWP. From RAN4 requirement point-of-view, BWP is always configured the same the carrier BW. (MediaTek)
  + Option 2: It is RAN4 understanding that per RAN1 design the configured carrier could be e.g. 80 MHz but the BWP could be chosen as a subset e.g. 40 MHz. This means that some ambiguity could be related to the statement “all LBT sub-bands”. However, as current NR considers requirements related to the carrier and not the BWP, RAN4 are of the understanding that it shall be all LBT sub-bands per configured carrier. (Nokia)
  + Option 3: Other
* Recommended WF
  + Collect companies’ views in the 1st round

### Sub-topic 3-3: LS reply to RAN1 on UL operation to add UE capabilities

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 3-3:**

Question 4: Is change of transmit filtering required (as shown in Figure 1 for WB Mode 2B) to meet RAN4 requirements for any of UL Cases 1-3?

* Proposals:
  + Option 1: Yes for Case 1 and 2. No for Case 3. (MediaTek)
  + Option 2: There should be no need for filter adaptation for UL case 1, 2 and 3. (Nokia)
  + Option 3: Other

Question 5: Is there any difference if intra-cell GBs between scheduled contiguous sub-bands are scheduled or not?

* Proposals:
  + Option 1: There is no significant difference in RF requirement and UE’s RF implementation. Only UE’s baseband processing will be different. (MediaTek)
  + Option 2: There is no difference in filter adaptation dependent on scheduled intra-cell guardband(s) or not. For UL case 2 and 3 this is dependent on the UE capability of transmitting in the intra-cell guardband(s). This capability is discussed further within RAN4. (Nokia)
  + Option 3: Other
* Recommended WF
  + Collect companies’ views in the 1st round

### Sub-topic 3-4

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 3-4:**

If the answer to any of Questions 2a/2b/2c/4/5 is yes and capabilities for any of the cases are deemed needed, RAN1 would like to request RAN4 to define the corresponding UE capabilities**.**

* Proposals:
  + Option 1: DL WB operation Case 4 (Mode 1) and UL WB operation Case 3 are supported in Rel-16 with capability signaling. DL WB operation Cases 2a/2b/3 are not considered in Rel-16. UL WB operation Cases 1/2 are supported with capability signaling, only if UE does not need to perform LBT before UL transmission. (MediaTek)
  + Option 2: Define additional UE capabilities for NR-based access to unlicensed spectrum as given in section 4 in R4-2011447 (Nokia)
  + Option 3: Other
* Recommended WF
  + Collect companies’ views in the 1st round

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Charter Communications, Inc. | Sub topic 3-1:  **Issue 3-1-1:**   * Agreeable   **Issue 3-1-2:**   * Agreeable   **Issue 3-1-3:**   * Agreeable   **Issue 3-1-4:**   * Agreeable   **Issue 3-1-5:**   * Agreeable   **Sub topic 3-2**  **Issue 3-2-: LS reply to RAN1 on DL operation to add UE capabilities**   * Question 1: option 2 * Question 2a: option 2 * Question 2b: option 2 * Question 2c: option 2 * Question 3: option 2   **Sub topic 3-3:**  **Issue 3-3: LS reply to RAN1 on UL operation to add UE capabilities**   * Question 4: option 2 * Question 5 : option 2   **Sub topic 3-4:**  **Issue 3-4:**  If the answer to any of Questions 2a/2b/2c/4/5 is yes and capabilities for any of the cases are deemed needed, RAN1 would like to request RAN4 to define the corresponding UE capabilities**.**  Option 2: |
| Skyworks | **Issue 3-1-2:** Clarification that for release 16 the assumption on the UL side was that LBT needed to be successful in all scheduled sub-bands for the UE to transmit and that only contiguous sub-bands could be scheduled.  **Issue 3-1-3:** Capability will be needed to cover future cases in UL  **Issue 3-1-5:** At least in release 16 wide-band transmission modes are different in DL and UL. |
| Qualcomm | Issue 3-1-1: Do not agree. If a sub-band is not scheduled in DL, it should not have any bearing on whether scheduled sub-bands should be received.  Issue 3-1-2: Do not agree. Same as 3-1-1 but for the UL.  Issue 3-1-3 to 3-1-5: Needs further discussion. The UE is required to support all bandwidths defined for the band, including the wideband channel 40, 60, and 80 MHz. However, for Rel-16 the receiver requirements have so far been defined with all sub-bands within the channel fully allocated. Therefore, it may not be meaningful to define capabilities for a mode in which there are not requirements. One possibility is not to define the capability now, but only after requirements are defined perhaps in a future release. Another possibility is to define the capability now, but to restrict it to Mode 1 until requirements for other modes are defined in the future.Issue  3-2-1: The performance will depend on the blocking requirements. For Rel-16, there are no blocking requirements defined to differentiate Mode 1, 2, and 3 so the performance will be the same.  Issue 3-3: For Rel-16, UL is assumed to occur only in contiguously allocated sub-bands within the wideband channel. ACS and SEM requirements are defined without filter adaptation to the sub-band configuration (only to the channel).  Issue 3-4: Needs further discussion. If we define capabilities, there should be requirements associated with them in order for them to be meaningful. In the event that requirements are not available, then either the capability should not be defined or it should be forced to a particular value for Rel-16 to reflect the capabilities supported by the current version of the RAN4 specifications. |
| Xiaomi | Issue 3-1-1 and 3-1-2:  Not sure about the necessity of the clarification. At least from our view, these seems to be already stated in Mode 1 description.  Issue 3-1-3: and 3-1-4:  These two issues have some overlap with the reply LS. We believe that the capability will be different at least the mode 3 non-contiguous transmission should be differentiated.  Issue 3-1-5:  Agreeable since the behavior will be different for UE or BS who does the LBT.  Issue 3-2:  Question 1: option 2  The performance degradation will need to consider both the in-band and out-of-band blocking requirement depending on the interference signal frequency. For the in-band interference, the baseband filter and digital AGC can help for different cases.  Issue 3-3  Question 4: Option 2  Question 5: Option 2 |
| Nokia | **Sub topic 3-1:**  **Issue 3-1-1:** We are of the understanding that mode 1 assumes LBT to be successful in all LBT sub-bands of a given wideband carrier which is also discussed further in our R4-2011447. That said, even if LBT passes in all sub-bands that does not necessarily protect the DL transmission for the LBT sub-bands which is not scheduled, due to e.g. low load traffic, as other stations/gNBs could find these sub-bands unused and initiate transmission. This is a mechanism which can not be avoided when operating in opportunistic spectrum. In other words, irrespective of Mode 1 or Mode 2/3, certain degree of Adjacent channel rejection at the UE is required.  **Issue 3-1-2:** Similar as above - Here it can be emphasized that we should also clarify the difference between per BWP or per carrier as further discussed in our R4-2011447.  **Issue 3-1-3:** It is a bit unclear if all the modes are referred to here. In our understanding Case 4 (Mode 1) should be supported by default for a NR UE in DL and for UL a capability is already defined per RAN1 design. Case 2a/b (Mode 2/3) should be supported if also intra-band CA is supported for NR-U and a capability already is defined for this so in our opinion they could be linked. The main difference is the possibility scheduling og intra-cell guardbands (Case 3) but for this separate optional capability are already proposed. It can be discussed if mode 3 should have its own separate capability.  **Issue 3-1-4:** We are open to this discussion. However, perhaps a better baseline is Mode2 as this is similar to intra-band CA when intra-cell guardbands are not scheduled. Mode 2/3 allows for more flexible gNB operation (from LBT point of view), similar to (e)LAA, compared to Mode 1, and as argued above, Mode 1 does not guarantee zero co-channel interference.  **Issue 3-1-5:** Yes, as further discussed in our R4-2011447.  **Sub topic 3-2:**  Our understanding as provided in the summary.  **Sub topic 3-3:**  Our understanding as provided in the summary.  **Sub topic 3-4:**  We support Option 2  **Issue 3-4:** In our opinion there is no need for capability signalling for DL WB operation Case 4 (Mode 1) and UL WB operation Case 3 besides support for NR-U as this is fundamental NR operation. It can be noted that in our opinion mode 1 is sub optimal and therefore we should perhaps focus on mode 2 which is in principal similar to UL intra-band CA operation when no scheduling of intra-cell guard bands is performed. Further, DL case 2 (Mode 2) is similar to intra-band CA. There are already capability signalling for intra-band CA and if this is signalled supported then DL case 2 should also be supported. In principal DL case 3 should also be supported but this is dependent on capability of scheduling in intra-cell guardbands as also discussed further in our R4-2011447. To our understanding there is already capability signalling for UL WB operation Case 3 in RAN1 design and as this UL case req. LBT passes for all sub-bands no further capability is needed defined. And finally, for UL we think that transmission within one RB-set in the UL BWP should be baseline here. i.e. Case 1.  **Question to MediaTek –** Regarding Proposal 4 in your contribution. Not sure this proposal is understood; how can a transmission happen in unlicensed spectrum without LBT? Is this in a BS initiated COT or only ‘short LBT’? |
| Huawei | Agree with Issue 3-1-1 and 3-1-2.  For issue 3-1-3, we don’t think that wide-band transmission modes should have separate UE capabilities, if we reuse the terminology in the LS(R1-2004965/ R4-2009509), only separate UE capabilities for DL case 2 and case 3 should be defined.  For issue 3-1-4, generally, we don’t think there is strict differentiation among these modes, but we are open to discuss.  Agree with issue 3-1-5.  Sub topic 3-2:  Q1: option 2  Q2a: option 2  Q2b: case 4 is not UE capability, if the bandwidth is supported, then it should be mandatory for UE, no capability signaling is needed.  Q2c: CA is an independent UE capability.  Q3: we understand that from RAN1’s perspective, it should be BWP, but from RAN4’s perspective, it should be carrier.  Sub topic 3-3:  Q4: No difference  Q5: No difference  sub topic 3-4:  Only single UE capability “reception in intra-carrier guardband” should be defined, which is intended to differentiate the DL case 2 and case 3. |
| MediaTek | **Issue 3-1-1:**  Not Agreeable.  From UE perspective, this is just like licensed DL transmission: Even if the channel bandwidth is 20MHz, network does really have to transmit data on every RBs to a single UE. If UE#1 is only scheduled with a subset of RBs, the reception behaviour is irrelevant to whether the remaining RBs are empty or used by other purpose. (although the performance may be different.)  **Issue 3-1-2:**  The proposal should be revised to 1) irrespective of which sub-bands are scheduled with data or 2) only in those LBT sub-bands where UL data is scheduled.  From our view, 2) is more reasonable. If a certain subband has actually no UL data to be transmitted, performing LBT on that subband jointly with other subbands is only to decrease the chance of UL transmission.  **Issue 3-1-3:**  Need more discussion.  At least in our view, UE capabilities for some WB transmission modes without requirements are not needed in Rel-16.  **Issue 3-1-4:**  Need more discussion  In our view, the UE behaviour is the same for all sub-modes, it is only the outcome of LBT results different (single or multiple successful subbands). But we would like to hear more views from companies.  **Issue 3-1-5:**  Agreeable.  At least whether the behavior on guard band transmission is already different between DL and UL. For DL whether to receive on intra-carrier guardband is configured by network, while for UL, the transmission on intra-carrier guardband is mandatory.  **Issue 3-2: question 1**  Option 1.  We should consider the requirement from 2 aspects. One is the static requirement (the DL scheduling is always the same), and the other is dynamic (LBT results on different subbands change from COT to COT.) We do not think the current requirements are really ready from both aspects for Case 2a/2b/3.  Regarding AGC, Case 2a/2b/3 definitely have an issue when a subband is occupied by WiFi, which could be extremely closed to UE. The situation is the same as Case 4 where all signals are transmitted by the same node (UE’s serving cell).  **Issue 3-2: question 2a/2b/2c**  Option 1.  Same comment as question 1. The requirements are not ready.  **Issue 3-2: question 3**  Option 1.  Open to discuss.  **Issue 3-3: question 4**  Option 1  At least from current running CR, the SEM is based on the remaining transmitted channels. Therefore filter adaptation is needed for UL WB operation Case 1/2.   |  | | --- | | 6.5F.2.2.1 Spectrum emission mask for non-transmitted channels In the case of non-transmitted 20 MHz channel(s) on the edges of an assigned channel bandwidth the spectrum emission mask for operation with shared spectrum channel access, specified in Table 6.5F.2.2-1, is applied by using the total bandwidth of the remaining transmitted channels. The spectrum emission mask for non-transmitted channels is floored at -28dBr. |   **Issue 3-3: question 5**  Both Options are fine.  **Issue 3-4:**  Option 1.  As we mentioned in **Issue 3-2: question 1**, if the requirements (both static and dynamic) are not ready, introducing UE capability is only to cause coexistence problem with WiFi or LAA and to confuse the market. We should not define UE capabilities for those features without corresponding requirements. |
| LG Electronics | **Issue 3-4:**  Option 2: |
| Apple | **Issue 3-1-1:**  **@Qualcomm**: Referring to your comment “*If a sub-band is not scheduled in DL, it should not have any bearing on whether scheduled sub-bands should be received*”, the intention is not say that a UE has to receive data in a sub-band where data is not scheduled. The overall intention is to clarify mode 1 behaviour when the network configures e.g. 60MHz channel, but the data is scheduled only in sub-bands #0 and #1. In other words, what “successful LBT” would mean in this case from the overall system behaviour as it has some implications on what a UE is expected to do next in sub-band #2.  **@Nokia**: You made an interesting comment, “*even if LBT passes in all sub-bands that does not necessarily protect the DL transmission for the LBT sub-bands which is not scheduled, due to e.g. low load traffic, as other stations/gNBs could find these sub-bands unused and initiate transmission*”. Does it effectively mean that mode 1 exists only theoretically? Practically speaking, even if you perform DL LBT in all sub-bands but do not transmit, then any other node can cease an empty sub-band and from the UE perspective mode 1 will turn into mode 2 or even mode 3.  **Issue 3-1-2:**  **@Mediatek:** Yes, we agree that initial wording was not crystal clear and should be ideally formulated as you suggest. The proposal can be revised to e.g. “*Clarify whether UL wide-band transmission mode 1 assumes that 1) LBT is performed in all sub-bands irrespective of which sub-bands are scheduled with data or 2) only in those LBT sub-bands where UL data is scheduled*”. So the intention was clarify whether it is option 1 or 2. Practically speaking option 2 makes more sense, but for instance response from Nokia implies that it a UE should perform LBT in all sub-bands.  **Issue 3-1-3 and 3-1-4:**  **@Nokia:** We are open to discuss further whether mode 1 can become part of the baseline NR-U functionality, but that will also depend on further clarifications of what mode 1 actually means in terms of practical matters. For mode 2, we are not entirely sure how you devised a conclusion that “*Case 2a/b (Mode 2/3) should be supported if also intra-band CA is supported for NR-U and a capability already is defined for this so in our opinion they could be linked*.”. If there is a 60MHz channel, you can of course configure 3x20MHz CA configuration, but that should not automatically mean that 1x60MHz configuration will support mode 2/3. These are completely different things from UE perspective.  **@Qualcomm**: You raised an interesting point whether we should introduce wideband mode capabilities if the corresponding performance requirements are not defined, or can we introduce the capabilities now and define requirements later. Either way should be in principle fine and we saw both cases for 3G/4G technologies in the past.  **Issue 3-1-5:** As explained in our paper,we see a need to differentiate between DL and UL UE capabilities. |
| Intel | **Issue 3-1-1:** Not Agreeable  **Issue 3-1-2**: Not Agreeable  **Issue 3-1-3**: Not Agreeable  At least DL Case 4 (or Mode 1) where all LBT sub-bands are successful, should be supported without any capability. For other cases, we are open for further discussion.  **Issue 3-1-4**: We are ok to further discuss  **Issue 3-1-5**: Agreeable  **Issue 3-3:**   * Question 4: Option 1 * Question 5: Option 2   **Issue 3-4:**  DL wideband operation Case 4 (Mode 1) should be supported without capability. We might consider other Cases with capabilities depending on further discussion. |
| Ericsson | Issue 3-1-1:  (We assume these questions concern Mode 1/2/3)  Not agreeable. The original definition of Mode 1 means that all LBT sub-bands of the wideband carrier are successful.  Issue 3-1-2:  The UE only transmits if LBT is successful in all scheduled UL. For Mode 1 RAN4 made the restriction that these LBT sub-bands must be contiguous.  Issue 3-1-3:  Two FGs are already specification. The capabilities addressed in the RAN1 LS depend on the specification of in-channel selectivity, which has not yet been agreed by RAN4. This could motivate further capabilities, which should be identified for the earliest possible release (for release independence).  Issue 3-1-4:  Mode 1 with GB allocated could be the baseline functionality since requirements are specified for this case, remaining functionality is UE capability. (The UE is of course always subject to regulatory requirements regardless of operating mode.)  Issue 3-1-5:  UL/DL differentiation is probably needed. A UE will not transmit if any LBT sub-band fails regardless of configuration. This does not apply to reception.  Issue 3-2  Proposal:  No difference between DL case 1 (intra-band CA) and other cases from an ACG implementation perspective unless the aggregated CA bandwidth is large (could depend on RX partitioning).  Question 2a/2b: DL case 1 (intra-band CA) and case 4 (Mode 1 transmission) are different from a capability perspective, e.g. for the case of 20 MHz CCs.  Issue 3-3  Question 4: the initial assumption for the wideband mode was that filter adaptation should not be needed but some UE vendors claim it is needed in some cases.  Question 5: scheduling in the GB appears to be a baseband capability as such.  Issue 3-4:  It appears that DL Mode 1 and UL case 3 could be the baseline functionality, intra-cell GB allocated, remaining functionality capability. Requirements are specified in Rel-16 for the baseline functionality. |

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic#3-1**  **Issue 3-1-1:**  Proposal 1a | *Tentative agreements:* Proposal 1a is *Agreeable (Further clarify proposal 1a is with respect to carrier or BWP), Agreed in GWT Aug 20*  *Candidate options: Agreeable*  *Recommendations for 2nd round: Further clarify proposal 1a is with respect to carrier or BWP, this is addressed in Question 3* |
| **Sub-topic#3-1**  **Issue 3-1-2:**  Proposal 1b | *Tentative agreements: No Tentative agreements*  *Candidate options:*  *Recommendations for 2nd round: further discussion is needed* |
| **Sub-topic#3-1**  **Issue 3-1-3:**  Proposal 2a | *Tentative agreements: No Tentative agreements*  *Candidate options:*  *Recommendations for 2nd round: further discussion is needed* |
| **Sub-topic#3-1**  **Issue 3-1-4:**  Proposal 2b: | *Tentative agreements: No Tentative agreements*  *Candidate options:*  *Recommendations for 2nd round: further discussion is needed* |
| **Sub-topic#3-1**  **Issue 3-1-5:**  Proposal 3 | *Tentative agreements: Proposal 3 is Agreeable, Agreed in GWT Aug 20*  *Candidate options: Agreeable*  *Recommendations for 2nd round: No further discussions* |
| **Sub-topic#3-2**  **Issue 3-2:**  Questions 1, 2a, 2b, 2c and 3 | *Tentative agreements: No Tentative agreements*  *Candidate options:*  *Recommendations for 2nd round: further discussion is needed* |
| **Sub-topic#3-3**  **Issue 3-3:**  Questions 4 and 5 | *Tentative agreements: No Tentative agreements*  *Candidate options:*  *Recommendations for 2nd round: further discussion is needed* |
| **Sub-topic#3-4**  **Issue 3-4:**  UE capabilities | *Tentative agreements: No Tentative agreements*  *Candidate options:*  *Recommendations for 2nd round: further discussion is needed* |

*Suggestion on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 | LS reply to RAN1on UE capability on wideband carrier operation for NR-U | MediaTek |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

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| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

The LS reply to RAN1 is under discussion in ‘[96e][106]NR\_unlic\_SysParameters - reply LS on WB operation’ email thread.

Considerations on wideband operation, R4-2009933 (Apple)

**Issue 3-1-2:**

Proposal 1b: Clarify whether UL wide-band transmission mode 1 assumes that LBT is successful in all LBT sub-bands irrespective of which sub-bands are scheduled with data or only in those LBT sub-bands where UL data is scheduled.

* Proposals
  + LBT is successful in all LBT sub-bands irrespective of which sub-bands are scheduled with data
  + LBT is successful only in those LBT sub-bands where UL data is scheduled

**Issue 3-1-3:**

Proposal 2a: Wide-band transmission modes should have separate UE capabilities.

* Proposals
  + Agreeable
  + Not Agreeable

**Issue 3-1-4:**

Proposal 2b: It can be discussed further whether we need to have strict differentiation between all three modes / sub-modes or whether transmission mode 1 can be construed as the baseline NR-U functionality.

* Proposals
  + strict differentiation between all three modes / sub-modes
  + transmission mode 1 can be construed as the baseline NR-U functionality

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm | 3-1-2: Our understanding is the second one “LBT is successful only in those LBT sub-bands where UL data is scheduled”. The UE will not perform LBT on sub-bands for which it is not scheduled to transmit. |
| Apple | 3-1-2: Based on the comments expressed by companies during the GTW session, it seems that the first option was the understanding of RAN1 when it was defined. However, echoing Qualcomm feedback, we could not help but wonder whether it is a reasonable assumption. In other words, why would a UE perform LBT on those UL sub-bands where it is not supposed to transmit (thus reducing its chances for transmission)? Yet on the other hand, if the second option is the common understanding of how it works, then UL transmission mode 1 does not really exist because it can always turn into 2A or 2B.  3-1-3: Based on the RAN1 feature list, it seems that it is already the case, i.e. each transmission mode is formulated as a separate feature.  3-1-4: Based on the RAN1 feature list, it seems that it is already the case, i.e. each transmission mode is formulated as a separate feature. The only open question is whether we can assume that transmission mode 1 is mandatory for the UE, but that will depend on further clarifications for 3-1-2. Thus, for time being our preference is to consider all transmission modes as having separate capabilities. |
| Nokia | **Issue 3-1-2:** In our understanding when UE transmit based on LBT only in those sub-bands which have scheduled data this is UL Case 1 and 2 from the RAN1 LS. If all sub-bands are scheduled this is UL case 3. That said it only makes sense for the UE to perform LBT in sub-bands where it intends to transmit (i.e. data is scheduled).  For reference the RAN1 cases are inserted below:  The following DL wideband operation cases are discussed.   * **DL Case 1**: Intra-band CA * **DL Case 2**: Wideband carrier operation Modes 2/3 without scheduling intra-cell guard bands   + DL Case 2a: Mode 2 where single wideband carrier when LBT is successful in a subset of the LBT sub-bands which are contiguous [1]   + DL Case 2b: Mode 3 where single wideband carrier when LBT is successful in a subset of the LBT sub-bands which are non-contiguous [1] * **DL Case 3**: Wideband carrier operation Modes 2/3 with scheduling intra-cell guard bands between transmitted contiguous LBT sub-bands * **DL Case 4**: Wideband carrier operation Mode 1 where single carrier wideband operation when LBT is successful in all LBT sub-bands [1]   The following UL wideband operation cases are discussed.   * **UL Case 1**: UL wideband operation Mode 2A (UL-WB Mode 2A) where UE transmits if LBT passes for single scheduled LBT sub-band * **UL Case 2**: UL wideband operation Mode 2B (UL-WB Mode 2B) where UE transmits if LBT passes for scheduled multiple contiguous LBT sub-bands * **UL Case 3**: UL wideband operation Mode 1 (UL-WB Mode 1) where UE transmits only if LBT passes for all LBT sub-bands of BWP   **Issue 3-1-3:** Not agreeable as further described in Issue 3-1-4. We would like to emphasize that the capabilities related to wideband operation in the RAN1 featurelist (R1-2006462) is all in brackets as they are not agreed yet due to them waiting for our response to the LS (R4-2009509) send to us.  **Issue 3-1-4:** As commented for Issue 3-1-2 at least for UL the baseline should be UL Case 1 or 2 but not Case 3 by default if not all sub-bands are scheduled with data. For DL mode 1 can be baseline (DL Case 4) but if UE supports DL intra-band CA (for which capability already exists) then it should also support DL case 2a/2b. DL case 3 have additional UE capability for reception in inter-cell guardbands as already conveyed to RAN2 in LS. |

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |