**3GPP TSG-RAN WG4 Meeting #94-e R4-200xxxx**

**Electronic Meeting, Feb.24th – Mar.6th 2020**

**Agenda item:** 8.14.1.3, 8.14.1.4, 8.14.1.7

**Source:** Moderator (Qualcomm Incorporated)

**Title:** Email discussion summary for RAN4#94e\_#22\_NR\_RF\_FR2\_req\_enh\_Part\_3

**Document for:** Information

# Introduction

Scope of this email discussion is listed in Table 1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **#** | **Email title** | **WI** | **Topic areas** | **AI** |
| 22 | RAN4#94e\_#22\_NR\_RF\_FR2\_req\_enh\_Part\_3 | R16 NR FR2 RF | * Intra-band cont DL CA for aggregated BW larger than 1400 MHz
* Intra-band non-cont DL CA for aggregated BW larger than 1400 MHz
* Inter-band DL CA
 | 8.14.1.3, 8.14.1.4, 8.14.1.7 |

In round 1 of discussion (see R4- 2002695) the following topics were addressed

**Sub-topic 1: Intra-band cont DL CA for aggregated BW larger than 1400 MHz**

**Sub-topic 2: Intra-band non-cont DL CA for aggregated BW larger than 1400 MHz**

 TP to TR, CRs, other proposals to be addressed after convergence on above

**Sub-topic 3: Inter-band DL CA**

 TP to TR, CRs, other proposals to be addressed after convergence on above

In round 2 of discussion, we continue discussion with open topics and consider LS, dCRs, TPs, etc.

# Topic #1: Intra-band contiguous DL CA for aggregated BW larger than 1400 MHz

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

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** | **Title** | **Company** | **Proposals / Observations** |
| **R4-2000756** | FR2 CA bandwidth classes for aggregated channel BW > 1200 MHz | MediaTek Inc. | ***Proposal 1****: RAN4 to consider the following two options on handling the objective of defining UE RF requirements for intra-band contiguous DL CA for aggregated channel bandwidth larger than 1200 MHz in FR2 RF requirement enhancement work item.** ***Option 1****: Remove this objective in the work item.*
* ***Option 2****: At least define CA bandwidth classes for aggregated channel BW > 1200 MHz and allow the completion of the work item without any real CA combination proposed in these CA bandwidth classes.*

***Observation 1****: Compared to LTE, it is less straightforward to comprehend the relation between the CA bandwidth class notations and the number of component carriers in NR due to the multiple fallback groups, especially for FR2.* ***Observation 2****: The approach of introducing new CA bandwidth classes as shown in Table 2-2 would make the relation between the CA bandwidth class notations and the number of component carriers in each fallback group even less straightforward to comprehend than the Rel-15 CA bandwidth class definition.* ***Proposal 2****: If RAN4 adopts option2 in proposal 1, it is proposed to only introduce new CA bandwidth classes in fallback group “1” for aggregated channel bandwidth up to 2400 MHz as highlighted in Table 2-3 for Rel-16.* |

## 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: Intra-band DL CA for aggregated BW larger than 1400 MHz

**Issue 1-1.1: RAN4 to determine if new contiguous BW classes must be defined**

***Proposal 1****: RAN4 to consider the following two options on handling the objective of defining UE RF requirements for intra-band contiguous DL CA for aggregated channel bandwidth larger than 1200 MHz in FR2 RF requirement enhancement work item.*

* ***Option 1****: Remove this objective in the work item.*
* ***Option 2****: define new CA bandwidth classes for aggregated channel BW > 1200 MHz*
* Recommended WF
	+ TBA

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Issue** | **Company Comments** |
| Issue 1-1.1: RAN4 to determine if new contiguous BW classes must be defined | **Qualcomm**: We agree with the options. We would however like to continue studying the technical issues with very wide signals (>1 GHz) with common analog beam forming towards making a decision.**Intel:** Option 1 (Remove contiguous DL CA enh from WID)**Huawei**: It depends on deployment demand. We are open to both options. If there is no real deployment demand, we would prefer option1 since larger aggregated channel bandwidth will cost some resource on UE design. We all know power consumption is very limited factor for FR2.**Nokia:** We think that the proposal how to create new CA bandwidth classes by combining two exiting classes is very good and if it not agreeable to introduce these into spec at least an WF or similar could be agreed how to come up with new Classes. We are ok to introduce these proposed classes to TS but we do not think that any technical work is anymore possible for REL16.**Apple**: We have not seen operator requests for new CA BW classes. Based on this, we recommend Option 1.**MTK**: Our preference is option 1 if there is no real demand for aggregated channel BW wider than 1200 MHz. Thanks Nokia for supporting the idea on how to introduce the new CA BW classes in FR2. We are fine to delay this effort to a later release. |

## 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**  |  |
| Issue 1-1.1: RAN4 to determine if new contiguous BW classes must be defined | *Agreement possible?* Remove from the Rel-16 Fr2 Rf enhancement WID, the WI to introduce contiguous BW classes > 1200 MHz [unless there is operator demand in RAN#87-e]. |  |

*Recommendations on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title**  | **Assigned Company,****WF or LS lead** |
| R4-2002826 | WF on Intra-band contiguous DL CA | MediaTek |

## Discussion on 2nd round (if applicable)

|  |  |  |
| --- | --- | --- |
|  | **Status summary**  | **Company comments** |
| Issue 1-1.1: RAN4 to determine if new contiguous BW classes must be defined | *Agreement possible?* Remove from the Rel-16 Fr2 Rf enhancement WID, the WI to introduce contiguous BW classes > 1200 MHz [unless there is operator demand in RAN#87-e]. |  |

## 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 #2: Intra-band non-contiguous DL CA for aggregated BW larger than 1400 MHz

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

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** |  | **Company** | **Proposals / Observations** |
| [**R4-2000013**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000013.zip) | Remaining issues with the FR2 frequency separation class | Apple Inc. | **Proposal 1:** **RAN4 to introduce Fsd according to Alt 1 in the WF from RAN4 #93, such that the spectrum covered by the DL-only frequency separation shall be extended equally on both sides (half on each side) relative to bidirectional spectrum.****Proposal 2:** **RAN4 should discuss whether an additional restriction on CC allocation according to Case 3 is needed.****Proposal 3:** **Assuming RAN4 can finalize the open issues related to the signaling aspects for DL-only frequency spectrum, a CR is needed to merge the technically endorsed content from RAN4 #93 with the additional agreements.** |
| [**R4-2000014**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000014.zip) | CR to 38.101-2 on FR2 frequency separation class enhancement | Apple Inc. |  |
| [**R4-2000015**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000015.zip) | Views on FR2 DL intra-band CA REFSENS | Apple Inc. | Observation 1: The wider bandwidth will lower the Q-factor, which will increase the noise figure of the receiver. Consequentially the increase of the NF will affect directly the receiver reference sensitivity.**Proposal 1:** **Define 1.0 dB for the EIS relaxation ΔRIB for a cumulative aggregated channel BW from 1400 MHZ to 2400 MHz in intra-band non-contiguous CA reference sensitivity requirement.** |
| [**R4-2000207**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000207.zip) | FR2 DL Intra-band CA BW Enhancement Feature Parameters | Qualcomm Incorporated | Observation 1: It is not clear if the network benefits from a UE with split DL-only spectrum coverageObservation 2: A UE with contiguous DL-only spectrum leaves no gaps in UL coverage.**Proposal 1: DL-only spectrum shall be restricted to a single contiguous spectrum.****Proposal 2: (Definition) ‘DL-only spectrum’ is the width of contiguous UE frequency spectrum available to the network to configure a DL CC but not an UL CC, in addition to and adjoining the DL spectrum capability declared via ‘DL frequency separation class’ signalling.** **Proposal 3: Send LS to RAN2 to inform them of definition of new per-band capability parameter ‘DL-only Spectrum Class’ describing the UE’s enhanced DL intra-band CA BW.**  |
| [**R4-2000208**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000208.zip) | TP to TR38.831: FR2 UE architectures for DL Intra-band CA BW Enhancement | Qualcomm Incorporated |  |
| [**R4-2000209**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000209.zip) | LS on FR2 DL Intra-band CA BW Enhancement Feature Parameters | Qualcomm Incorporated |  |
| [**R4-2000210**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000210.zip) | FR2 enhanced DL BW definitions | Qualcomm Incorporated | Observation 1: In Rel-15 Ues, a UE’s bidirectional spectrum capability was captured by its DL frequency separation class declaration. **Proposal 1: (Definition) ‘DL frequency separation’ is the frequency span between lower edge of lowest component carrier and upper edge of highest component carrier in DL CA configuration, limited by the DL frequency separation class declaration.****Proposal 2: (Definition) ‘DL-only spectrum’ is the width of UE frequency spectrum available to the network to configure a DL CC but not an UL CC, in addition to and adjoining the DL spectrum capability declared via ‘DL frequency separation class’ signalling.**  |
| [**R4-2000211**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000211.zip) | Draft CR to 38.101-2: DL CA BW Enhancement for Rel-16 | Qualcomm Incorporated |  |
| [**R4-2000759**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000759.zip) | On FR2 DL intra-band CA cumulative aggregated BW enhancement | MediaTek Inc. | ***Observation 1****: For DL-only frequency separation class (Fsd) where the extended separation can only be equally added to both sides of the UL/DL common coverage range, the usage scenario is quite restricted and the architecture is less likely be practically implemented.* ***Observation 2****: The receiver chain dependent frequency separation signalling would not really benefit UE implementation nor the network scheduling to optimize the spectrum utilization.* ***Proposal 1: For DL intra-band CA cumulative aggregated BW enhancement, adding the new frequency separation classes up to 2400 MHz as technically endorsed in RAN4 #93 meeting is sufficient. It is not necessary to introduce additional DL-only frequency separation class (Fsd) and new signalling capability.*** ***Observation 3****: To support DL frequency separation wider than 1400 MHz, the receiver likely would suffer higher sensitivity degradation regardless of the number of down-conversion paths used to receive the signal*.***Proposal 2: Rel-16 RIB EIS relaxation requirement is revised as in the table below to support DL intra-band non-contiguous CA with cumulative aggregated bandwidth > 1400 MHz and up to 2400 MHz.******Proposal 3: Rel-16 MPR requirements for CA are revised as in the table below (PC3 used as example) to support DL intra-band non-contiguous CA with cumulative aggregated bandwidth > 1400 MHz and up to 2400 MHz.*** |
| [**R4-2001044**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2001044.zip)(from AI 8.14.1.7) | Discussion on FR2 intra-band DL CA enhancement | Nokia, Nokia Shanghai Bell | ***Proposal 1: Alt 1 shall be supported for the signalling for DL-only frequency spectrum. (****Introduce a new DL-only frequency separation class, ‘Fsd’)****Proposal 2: There shall be no restriction in UL spectrum coverage when the maximum DL separation Fs+Fsd is configured in downlink, i.e., uplink shall be configurable for the entire Fs+Fsd (though not simultaneously).*** |
| [**R4-2001760**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2001760.zip) | On intra-band NC DL CA\_FR2 | Huawei, HiSilicon | ***Proposal 1: two sided DL only spectrum shall be dropped.*** *Observation 1: one sided DL-only spectrum UE capability also have deployment/configuration limitation for network/operators.**Observation 2: there is RF solution for the problem of spectrum position limitation.**Observation 3: one sided DL-only spectrum can be only served for multi receiving chains architecture****.******Proposal 2: Extending separation class into a List in Rel-16, each separation class value belongs to each chain. The List can be described as below:***

|  |  |
| --- | --- |
| FreqsSeparationSet  | Separation class capability belongs to each chain |
| 1 | One of separation Class(I,II,III,IX) |
| 2 | One of separation Class(I,II,III,IX) |
| … |  |
| maxNrofFreqSeparationSet | One of separation Class(I,II,III,IX) |

***Proposal 3: considering potential limitation on the FR2 deployment, we prefer there is no limitation on the DL-only spectrum position, one-sided or two-sided or un-symmetrically two sided shall be mandatory supported by the UE.*** |
| [**R4-2002147**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2002147.zip)(from AI 8.14.1.6)  | Beam squint analysis for FR2 PC3 UEs | Qualcomm Incorporated | **Proposal: RAN4 to discuss how to capture consideration for radiative degradation mechanisms like beam squint for larger frequency separation.** |

## 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: DL-only spectrum type supported by UE

**Issue 2.1-1: Current Proposals**

* (for reference only: some proposals are inconsistent with WF [1])
	+ Option 1: contiguous, extends on one side relative to bidirectional spectrum
	+ Option 2: split (2-sided), extends equally on both sides (half on each side) relative to bidirectional spectrum
	+ Option 3: split (2-sided), no restriction on how DL-only spectrum is arranged on either side of bidirectional spectrum
* Recommended WF: Please limit discussion to DL-only spectrum options outlined in WF [1]



### Sub-topic 2-1: the EIS relaxation ΔRIB

**Issue 2.2-1: Breaks in frequency for row definition**

* Proposals
	+ Option 1:

|  |  |
| --- | --- |
| **Cumulative Aggregated Channel BW (MHz)** | **ΔRIB (dB)** |
| ≤ 800 | 0.0 |
| > 800 and ≤ 1400 | 0.5 |
| > 1400 and ≤ 2400 | 1.0 |

* Option 2:

|  |  |
| --- | --- |
| **Cumulative Aggregated Channel BW (MHz)** | **ΔRIB (dB)** |
| ≤ 800 | 0.0 |
| > 800 and ≤ 1400 | 0.5 |
| > 1400 and ≤ 2000 | TBD |
| > 2000 and ≤ 2400 | TBD |

**Issue 2.2-2: Relaxation dB values**

* Proposals
	+ Option 1: 1 dB for > 1400 MHz
	+ Option 2: TBD

### Sub-topic 2-3: Relaxation for Beam squint

**Issue 2.3-1: Should RAN4 discuss how to incorporate EIS/ REFSENS degradation due to beam squint**

* Proposals
	+ Option 1: Yes
	+ Option 2: No

## Companies views’ collection for 1st round

### Open issues

| **Issue** | **Options** | **Company Comments** |
| --- | --- | --- |
| 2.1-1: DL-only spectrum type supported by UE, per [1] | Option #1:Only 1 type allowed: contiguous (extends on one side) | **Qualcomm**: We are ok with either option, but we note that choosing option #1 simplifies signaling and network management. With Fs > Fsd, option 1 has no holes in UL coverage.**Huawei**: in the last meeting, there is agreements that up to 3 subblocks in UL NC CA. before discussing on whether DL only spectrum is contiguous, we would like to make it clear that whether it means DL NC CA will also limited into 3 subblocks in Rel-16. And the agreement shall be captured into the WF.For options, there is another option shall be captured that no limitation on DL-only. As discussed in our paper, both 1sided and 2 sided have limitation deployment, we strongly RAN4 agrees on the “no limitation” option.**Nokia:** We prefer option 1 as if UE only supports both side extension, then a part of the UL spectrum cannot be used for UL when the maximum DL separation is configured in DL.**Apple**: In our contribution (0013) we explain our view and propose the two-sided equally on both sides, which is not reflected in Option#1 neither Option #2. Therefore, an Option #3 should be included, where only the two-sided is allowed.**Qualcomm**: we would not like to introduce new options for DL-only spectrum at this stage. We wish to stay consistent with the WF [1]**MTK**: Our preference is not to introduce new signaling requirement for Fsd. This is also beneficial to the network for the flexibility of UL/DL allocation scheduling, as described in our paper. |
| Option #2:Both types allowed:1. Contiguous (extends on one side)
2. split (2-sided), extends equally on both sides
 |
| 2.2-1: EIS relaxation table breaks | Treat 1400 to 2000 MHz range separately from 2000 to 2400 MHz | **Huawei**: would like to clarify that ∆Rib is only for peak direction or both peak and CDF point? Recommend both peak and CDF point. Then we may need two tables.For the table range, prefer option 2(with 4 parts), but may need further evaluation the segment point.**Apple**: In our contribution (0015) we propose a 1dB EIS relaxation for the complete range from 1400 to 2400 MHz. We would like to ask Mediatek, what is the reason for the division at 2000 MHz in your Table?**MTK**: Thanks Apple for the question. At the time of our contribution, we were still evaluating the relaxation values for the extended frequency range. We think within such wide frequency range, we may allow two different incremental relaxation values. We can also confirm if Apple’s proposal can be accepted by us by the end of this meeting. |
| Treat 1400 to 2400 MHz as one range |
| 2.2-2: EIS relaxation values | 1.0dB | **Apple**: In this subsection, the EIS values are discussed. Mediatek’s contribution (0759) consider from 1400 to 2000 MHz TBD and from 2000 to 2400 MHz TBD. We would like to ask Mediatek, if the EIS relaxation for 1400 to 2000 MHz is defined as 1 dB, what would be the delta value for 2000 to 2400 MHz compared to the 1dB for 1400 to 2000 MHz? |
| TBD |
| 2.3-1: RAN4 to discuss how to capture EIS/EIRP degradation due to beam squint | Yes/No | **Intel**: Yes**Huawei**: Yes. Would like to clarify whether it belongs to ∆Rib discussion for Rx part? Since DL beam squint will impact on EIS requirement.**SONY:** Yes**Nokia**: Should EIS degradation be already included in the above relaxation budget? For EIRP, we think further relaxation should not be included for DL extension. |

## 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.*

| **Issue** | **Status Summary** | *Recommendations for 2nd round:* |
| --- | --- | --- |
| 2.1-1: DL-only spectrum type supported by UE, per [1]**Option #1:**Only 1 type allowed: contiguous (extends on one side)**Option #2:**Both types allowed:1. Contiguous (extends on one side)
2. split (2-sided), extends equally on both sides
 | **Option #1:** 2 companies (Nokia Qualcomm)**Option #2:** no support**Other options:** There is no unanimous understanding. * 3 companies each want to introduce a unique new option. None of the 3 new options from the 3 companies comply with agreements in WF [1] (Huawei, Apple, MTK).
* 1 company opposes new options outside WF (Qualcomm)
 | WF [1] clearly limits DL-only spectrum to option #1 or #2, and other options are precluded: *The spectrum covered by the DL-only frequency separation shall be located relative to bidirectional spectrum(\*) in one of two configurations:** *Extends on one side*
* *Extends equally on both sides, half on each side*
	+ *FFS if both-sided DL-only spectrum can be dropped for rel-16.*
	+ *Single bit can be used to indicate configuration if both possibilities retained*

**Continue discussion if option 1 can be confirmed** |
| 2.2-1: EIS relaxation table breaks**Option #1:** Treat 1400 to 2000 MHz range separately from 2000 to 2400 MHz**Option #2:** Treat 1400 to 2400 MHz as one range | **Option #1:** 2 companies (MTK, Huawei)**Option #2:** 1 company (Apple) | (Continue Discussion)[MTK] We propose to postpone the discussions for both ranges and exact relaxation values to next meeting as it is not clear whether the beam squinting effect should be included in **ΔRIB** or not.  |
| 2.2-2 (a): EIS relaxation values**Option #1:** 1.0 dB**Option #2:** TBD | **Option #1:** 1 company (Apple)**Option #2:** 2 companies (MTK, Huawei) | (Continue Discussion)[MTK] We propose to postpone the discussions for both ranges and exact relaxation values to next meeting as it is not clear whether the beam squinting effect should be included in **ΔRIB** or not. |
| 2.2-2 (b): EIS relaxation values clarification | **Is** ∆Rib only for peak direction or both peak and CDF point? Recommend both peak and CDF point. Then we may need two tables. | (Continue Discussion) |
| 2.3-1 (a): RAN4 to discuss how to capture EIS/EIRP degradation due to beam squint**Yes/No** |  **Yes:** 4 companies (QC, Intel, Huawei, Sony)**No for Rx relaxation:** no support**No for Tx relaxation due to DL extension:** 1 company (Nokia) +2 companies in other email threads (Qualcomm, Intel) | **Possible agreement: RAN4 to discuss how to capture EIS/EIRP degradation due to beam squint in standard** |
| 2.3-1 (b): RAN4 to discuss how to capture EIS/EIRP degradation due to beam squint | Does squint belongs to ∆Rib discussion for Rx part?  | (Continue Discussion) |

*Suggestion on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title**  | **Assigned Company,****WF or LS lead** |
| R4-2002824 | WF on Intra-band non-contiguous DL CA | Qualcomm |

## Discussion on 2nd round (if applicable)

| **Issue** | **Status Summary** | **2nd round Discussion:** |
| --- | --- | --- |
| 2.1-1: DL-only spectrum type supported by UE, per [1]**Option #1:**Only 1 type allowed: contiguous (extends on one side)**Option #2:**Both types allowed:1. Contiguous (extends on one side)
2. split (2-sided), extends equally on both sides
 | **Option #1:** 2 companies (Nokia Qualcomm)**Option #2:** no support**Other options:** There is no unanimous understanding. * 3 companies each want to introduce a unique new option. None of the 3 new options from the 3 companies comply with agreements in WF [1] (Huawei, Apple, MTK).
* 1 company opposes new options outside WF (Qualcomm)
 | WF [1] clearly limits DL-only spectrum to option #1 or #2, and other options are precluded: *The spectrum covered by the DL-only frequency separation shall be located relative to bidirectional spectrum(\*) in one of two configurations:** *Extends on one side*
* *Extends equally on both sides, half on each side*
	+ *FFS if both-sided DL-only spectrum can be dropped for rel-16.*
	+ *Single bit can be used to indicate configuration if both possibilities retained*

**Continue discussion if option 1 can be confirmed** |
| 2.2-1: EIS relaxation table breaks**Option #1:** Treat 1400 to 2000 MHz range separately from 2000 to 2400 MHz**Option #2:** Treat 1400 to 2400 MHz as one range | **Option #1:** 2 companies (MTK, Huawei)**Option #2:** 1 company (Apple) |  |
| 2.2-2 (a): EIS relaxation values**Option #1:** 1.0 dB**Option #2:** TBD | **Option #1:** 1 company (Apple)**Option #2:** 2 companies (MTK, Huawei) |  |
| 2.2-2 (b): EIS relaxation values clarification | **Is** ∆Rib only for peak direction or both peak and CDF point? Recommend both peak and CDF point. Then we may need two tables. | **Qualcomm**: In our view, since intra-band CA has only a REFSENS requirement, but no spherical coverage requirement, the EIS relaxation value applies in peak direction only. |
| 2.3-1 (a): RAN4 to discuss how to capture EIS/EIRP degradation due to beam squint**Yes/No** |  **Yes:** 4 companies (QC, Intel, Huawei, Sony)**No for Rx relaxation:** no support**No for Tx relaxation due to DL extension:** 1 company (Nokia) +2 companies in other email threads (Qualcomm, Intel) | **(please see thread RAN4#94e\_#23\_NR\_RF\_FR2\_req\_enh\_Part\_4 - draft WF R4-2002826 for this discussion)** |
| 2.3-1 (b): RAN4 to discuss how to capture EIS/EIRP degradation due to beam squint | Does squint belongs to ∆Rib discussion for Rx part?  | **Qualcomm**: Please see WF R4-2002826 in sub-directory for #22We prefer to start treating beam squint separately from conducted domain mechanisms because of increasing BW in Rel-16Intel: this beam squint only happens when DL BM reference signals and interested UL/DL control and/or data channels are not within the same CC. Need to focus only this aspect. |

## 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: Inter-band DL CA

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

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** | **Title** | **Company** | **Proposals / Observations** |
| [**R4-2000017**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000017.zip) | Views on FR2 DL inter-band CA REFSENS | Apple Inc. | Observation 1: The wider bandwidth will lower the Q-factor, which will increase the noise figure of the receiver. Consequentially the increase of the NF will affect directly the receiver reference sensitivity.**Proposal 1: Define 1.0 dB for the EIS relaxation ΔRIB for inter-band CA combination (CA\_n257-n258, CA\_n258-n261, CA\_n259-n260) with a frequency separation span larger than 1400 MHz.** |
| [**R4-2000018**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000018.zip) | EIS spherical coverage for inter-band CA in FR2 | Apple Inc. | **Proposal 1: RAN4 assumes Alt. 1 (UE is assumed to have common beam management) for beam management for the bands that are part of supported band configuration in inter-band CA for 28 GHz + 28 GHz or 39 GHz + 39 GHz combinations.****Proposal 2: Equal PSD among 28+28 and 39+39 band groups can be confirmed for the conformance test configuration.****Proposal 3: RAN4 to study further the conformance test configuration for the 28+39 CA scenario.**Proposal 4: The common spherical coverage CDF is computed using the joint criterion of {EIS1≤s and EIS2≤s}, such that the resulting function of signal level s is equivalent to the diagonal of the joint empirical CDF P(EIS1≤s1,EIS2≤s2)*Observation 1: A requirement on the value at the 50th percentile of this common CDF can be derived in terms of the degradation relative to the strongest CC and defined in the specification as an absolute value*Observation 2: The value of the 50%-tile of the common CDF for 28+28 and 39+39 band groups is degraded by up to 6 dB relative to the strongest carrier in the combination.Observation 3: The value of the 50%-tile of the common CDF for 28+39 band groups is degraded by up to 7.5 dB relative to the strongest carrier in the combination.. Proposal 5: RAN4 continues to study further the common CDF definition and parameters for CA within 28+28/39+39 band groups and does not pursue the common CDF for CA within 28+39 band groups. |
| [**R4-2000115**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000115.zip) |  Inter-band CA remaining open requirements | Qualcomm Incorporated | **Proposal 1: Relaxation for spherical coverage for inter-band CA between 28 GHz and 39 GHz band groups is 1.5 dB****Proposal 2: Relaxation to peak EIS for inter-band CA between 28 GHz and 39 GHz band groups is 1.5 dB** **Proposal 3: No additional multiband relaxations are defined because of inter-band CA** **Proposal 4: UE requirements at sensitivity level conditions are valid for maximum 6.5 dB PSD difference between the bands part or inter-band CA configuration for CA between 28 and 39 GHz band groups** **Proposal 5: In band blocking and adjacent channel selectivity requirements will be specified in same manner as for LTE and NR FR1 inter-band CA.**  |
| [**R4-2000116**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000116.zip) | draftCR: Introduction of inter-band CA to 38.101-2 | Qualcomm Incorporated |  |
| [**R4-2000357**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000357.zip) | Inter-band CA with/without independent Rx beam  | Qualcomm Incorporated | Observation 1: Inter-band CA with independent beam management for both bands is well understood and work could be concluded in this meeting. Observation 2: Inter-band CA with common beam management needs more work and requirements may differ from inter-band CA with independent beam management**Proposal: Distinguish two sub-categories for FR2 inter-band CA in the WID [1] objective** |
| [**R4-2000395**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000395.zip) | PSD imbalance in Inter-band DL CA | Intel Corporation | **Proposal 1: on EIS spherical coverage, equal PSD is assumed among 28+28 and 39+39 band groups.****Proposal 2: In OTA conformance test of FR2 inter-band DL CA, both 28GHz and 39GHz bands should be within a common single AoA.**Observation 1: Based on reasonable hardware design, 30dB power imbalance can be tolerated at sensitivity level with non-zero MSD. **Proposal 3: For inter-band CA between two band groups, 30dB PSD imbalance between bands in different band groups should be specified at sensitivity test with MSD = 0.5dB.**  |
| [**R4-2000443**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000443.zip) | Test system for inter-band DL CA in FR2 | Anritsu Corporation | *Observation 1: Test system needs to be designed flexible as much as possible to avoid adding an impact on the existing (Rel-15) and future requirements. Otherwise even the existing core requirements and test requirements will have to be revisited by adding multiple CA test cases****.*** ***Proposal 1: Figure out possible necessary requirements in Release 16 which are related to FR2 inter band CA.******Proposal 2: Allow a use of additional offset antennas for measurement of FR2 RF TRx requirements even with one AoA measurement condition. FFS if there is any needs of additional measurement uncertainty caused by the offset antennas.*** |
| [**R4-2000444**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000444.zip) | Consideration on two-DL spherical coverage test with power imbalance | Anritsu Corporation | *Observation 1: By having a power imbalance between 28 GHz and 39 GHz bands, two DL inter-band spherical coverage test becomes rather a part of out-of-band blocking test.**Observation 2: As far as a frequency of the higher PSD signal is defined only at one test point, its condition cannot always be the worst case as the spherical coverage test with a blocker.* *Observation 3: Out-of-band blocking requirement for FR2 was extensively discussed and concluded that the in-band blocking requirement covers the OOB test.* ***Proposal 1: There is no need to define the power imbalance condition with two DL signals for the inter-band spherical coverage test.****Observation 4: To avoid an unnecessary impact to the existing Rel-15 test requirements, it is reasonable to choose a test system configuration which incorporates independent offset antennas for the inter-band CA test cases.**Observation 5: On condition that the test configuration is assuming multiple antennas for transmission of each band, achievable power imbalance is roughly 20 dB@50 MHz CBW, 17 dB@100 MHz, 14 dB@200 MHz and 11 dB@400 MHz in a case the spherical coverage test is carried out with n260 band. Note this estimation does not include multi-band relaxation****.*** |
| [**R4-2000445**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000445.zip) | Consideration on capability of multi signal transmission from single AoA in FR2 OTA test system | Anritsu Corporation | *Observation 1: It is not possible for the system simulator to create multiple DL signals simultaneously which are not within a range of pprox.. 1 GHz by single DAC.**Observation 2: It is challenging to apply method 1 without giving an impact on the existing Rel-15 RF test requirements and test systems.**Observation 3: Method 2 has a limitation with a polarization of the test signals which can be transmitted simultaneously from SS. (i.e. two signals with same polarizations cannot be transmitted)**Observation 4: It is reasonable to add a flexibility of using offset antennas for secondary cell or blocker* ***signal.******Proposal 1: Allow a flexibility of using offset antennas in the FR2 test configuration for inter-band/ blocking measurements and assume it as a system with single AoA.*** |
| [**R4-2000446**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000446.zip) | Influences of multiple offset antennas in FR2 chamber | Anritsu Corporation | *Observation 1: It is important that the FR2 OTA test system has a capability of its calibration incorporating multiple measurement antennas to maintain a compatibility and a flexibility to multiple test cases.**Observation 2: There is a possibility that an influence of a mutual coupling effect can be seen in a case offset antennas are arranged in a vicinity of the in-band antenna.**Observation 3: Reduction of gain with the AUT due to the offset antenna measurement was approximately 2 to 3 dB at the worst case.**Observation 4: The gain reduction of reference antenna in a case of measurement from the offset antenna can be reduced by an optimization of chamber / antenna arrangement / reflector design and also by a calibration of the loss at the center of the quiet zone.**Observation 5: Input from the UE vendor/ chipset vendor is appreciated whether a significant impact can be expected by the angular error from the offset antenna (pprox.. 2 to 4 degrees’ angular error at the center of QZ).**Observation 6: By an electromagnetic field simulation, in a case aluminium blocks are arranged at both sides of the in-band antenna, the mutual coupling effect was observed with the horizontal polarization source from the feed antenna, and the gain of the in-band antenna increased pprox.. 0.25 dB at 23.45 GHz. Influence of pprox.m blocks is small with the vertical polarization source (< 0.1 dB).* *Observation 7: In a case an pprox.m block is arranged above the in-band antenna, the mutual coupling effect was observed with both the horizontal and vertical polarization sources, and the gain of the in-band antenna varied pprox.. 0.2 dB at 23.45 GHz within +/- 10 degree range.**Observation 8: Though a gain reduction of the reference antenna caused by an offset of feed antennas can be observed, it is possible to minimize this influence by a proper design in a chamber and also the calibration of the loss with the reference antenna at the center of the quiet zone. Necessity of the additional MU with regards to the gain loss of the reference antenna or the antenna in a UE is FFS.**Observation 9: Though a mutual coupling occurs by the existence of offset antennas, it is possible to calibrate out this influence by including it as the QoQZ measurement uncertainty.****Proposal 1: Interested companies are encouraged to bring views on the impact of the angular error to the UE caused by the offset antenna measurement.***  |
| [**R4-2000796**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000796.zip) | FR2 inter-band DL CA relaxation framework | MediaTek Beijing Inc. | ***Proposal1:*** *Apply extended relaxation framework after considering FR2 inter-band DL CA as Fig 2.****Proposal2:*** *Define ∑DLCAP as UE FR2 inter-band DL CA relaxation factors for peak EIS****Proposal3:*** *Define ∑DLCAs (dB) as UE FR2 inter-band DL CA relaxation factors for EIS spherical coverage****Proposal4:*** *Use Table 2 as table format for UE FR2 inter-band DL CA relaxation factors.****Proposal5:*** *Companies are encouraged to share market demand on specific FR2 inter-band DL CA operations and associated multiband operations.****Proposal6:*** *Apply peak EIS and EIS spherical coverage test reduction:**．If UE passes equal DL CA peak EIS requirement, the non-CA peak EIS requirement can be skipped.**．If UE passes equal DL CA EIS spherical requirement, the non-CA EIS spherical requirement can be skipped.* |
| [**R4-2001494**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2001494.zip) | Views spherical coverage relaxation for inter band DL CA | Sony, Ericsson | Observation 1: Distribute the total relaxation on each band equally demands a smaller total relaxation comparing to place all the relaxation on one single band. **Proposal 1: UE is assumed to have common beam management for the bands that are part of supported band configuration in inter-band CA for 28 GHz + 28 GHz or 39 GHz + 39 GHz combinations.****Proposal 2: Define the relaxation for inter-band CA operation per band rather than the total relaxation.****Proposal 3: For high band + low band inter-band CA spherical coverage, allowing 2 dB relaxation on each band for the UE to meet the common spherical coverage requirement.**  |
| [**R4-2001776**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2001776.zip) | On inter band DL CA\_FR2 | Huawei, HiSilicon | ***Proposal 1: For 28GHz+39GHz inter-band CA, RAN4 do not define PSD difference limitation when define the RF requirement.******Proposal 2: For 28GHz+39GHz inter-band CA, a test case with 30dB PSD difference shall be evaluated and defined.******Proposal 3: RAN4 defines 10% relaxation on spherical coverage requirement for inter-band 28GHz+39GHz CA, where spherical coverage means the common spherical coverage range between the 2 bands.******Proposal 4: 3dB per band is defined additionally for inter-band 28GHz+39GHz CA on min peak EIS.******Proposal 5: RAN4 Define UE capability simultaneous Tx/Rx optional for inter-band 28GHz+39GHz, UE behavior shall be dependent on implementation.****Observation 1: common beam management and equal PSD for 28+28 and 39+39 inter-band CA actually requires for collocated deployment only.****Proposal 6: If collocated deployment is confirmed in RAN4 for 28+28 and 39+39 inter-band CA, separation class extends to be indicated per band combination per receiving chain.******Proposal 7: If both collocated and non-collocated deployment are existed for 28+28 and 39+39 inter-band CA, same conclusion as in inter-band 28+39GHz CA on beam management and PSD condition shall be utilized.***  |
| [**R4-2001779**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2001779.zip) | TP for inter-band CA refsens FR2\_Rel-16 | Huawei, HiSilicon |  |
| [**R4-2002114**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2002114.zip) | PSD imbalance for FR2 Inter-band DL CA of 28GHz + 40GHz | NTT DOCOMO INC. | Observation:The required capability for PSD imbalance should be 15 dB for co-located scenario and 25dB for non-co-located scenario.**Proposal:****Take either of below options for FR2 inter-band DL CA of 28GHz + 40GHz:*** **Option 1: Specify 25dB PSD imbalance requirement and test in RF conformance testing.**
* **Option 2: Introduce a new UE capability signalling to distinguish the capability of handling PSD difference for co-located or non-co-located scenario**
	+ **When the capability is set to 0, 15dB PSD imbalance requirement shall apply.**
	+ **When the capability is set to 1, 25dB PSD imbalance requirement shall apply.**
 |

## 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 3-1: Quantifying spherical coverage for inter-band CA

**Issue 3.1-1:**

* Proposals
	+ Option 1: spherical coverage for each band determined separately and common coverage area established. (see R4-2000116 for detail)
	+ Option 2: common CDF shall be used for L+L, common CDF shall not be used for L+H
* Recommended WF: Please limit discussion to options outlined in WF [2]



### Sub-topic 3-2: LB + LB, HB + HB inter-band CA

**Issue 3.2-1: PSD difference as a capability**

* Proposal: UE capability to distinguish UE’s capability of handling PSD difference
	+ Option 1: Yes
	+ Option 2: No

**Issue 3.2-2: PSD difference**

* Proposals
	+ Option 1: ≥ 25 dB, ≤ 30 dB
	+ Option 2: 6.5 dB
	+ Option 3: 0 dB

**Issue 3.2-3: EIS Relaxation Framework**

* Proposals
	+ Option 1: single band + MBR+ inter-band DL CA relaxation factor
	+ Option 2: single band + inter-band DL CA relaxation factor
	+ Option 3: other

**Issue 3.2-4: Beam management**

* Proposals
	+ Option 1: Common Beam Management
	+ Option 2: Separate beam management

### Sub-topic 3-3: LB + HB inter-band CA

**Issue 3.3-1: PSD difference as a capability**

* Proposal: UE capability to distinguish UE’s capability of handling PSD difference
	+ Option 1: Yes
	+ Option 2: No

**Issue 3.3-2: PSD difference**

* Proposals
	+ Option 1: ≥ 25 dB, ≤ 30 dB
	+ Option 2: 6.5 dB

**Issue 3.3-3: EIS Relaxation Framework**

* Proposals
	+ Option 1: single band + MBR + inter-band DL CA relaxation factor
	+ Option 2: single band + inter-band DL CA relaxation factor
	+ Option 3: Other

### Sub-topic 3-4: Split item in WID to separate L+H from L+L/H+H

**Issue 3.4-1:**

* Proposals
	+ Option 1: Treat L+H separately from L+L (or H+H)
	+ Option 2: treat all FR2 inter-band CA as one category

### Sub-topic 3-5: testing considerations for inter-band CA

**Issue 3.5-1: Allow a flexibility of using offset antennas in the FR2 test configuration for inter-band/ blocking measurements and assume it as a system with single AoA.**

* Proposals
	+ Option 1: yes
	+ Option 2: no

**Issue 3.5-2: Allow a use of additional offset antennas for measurement of FR2 RF TRx requirements even with one AoA measurement condition. FFS if there is any needs of additional measurement uncertainty caused by the offset antennas.**

* Proposals
	+ Option 1: yes
	+ Option 2: no

## Companies views’ collection for 1st round

### Open issues

| **Issue** | **Options** | **Company Comments** |
| --- | --- | --- |
| 3.1-1: Quantifying spherical coverage for inter-band CA | spherical coverage for each band determined separately, and common coverage area established | **Qualcomm**: We would like further clarification on common CDF approach. We would like to explain through an example for PC3, in an n257+n260 case. Ignoring MBR or other relaxations for this example, RAN4 seek to establish for common coverage:P(X≥8.0, Y≥11.5) ≥ 0.5, Where:X = sph. coverage of EIRP of n260 (dBm)Y = sph. coverage of EIRP of n257 (dBm)The common CDF approach however captures a different parameter:P(X≤8.0, Y≤11.5) (note sign difference). Hence we would like to go with the common coverage area approach as in WF. **Intel**: Agree on spherical coverage for each band determined separately and common coverage area established. But CR R4-2000116 needs to revise to align the configuration principle.**Huawei**: common spherical coverage range works well for co-located case, while for non-collocated may not much adaptable. For L+H, we are open for not use common CDF, would like to request information on most deployment scenarios for L+H.**SONY**: Option 1(spherical coverage for each band determined separately, and common coverage area established)**Apple**: The definition of common CDF should be clarified. We proposed a compact definition as follows:The common spherical coverage CDF is computed using the joint criterion of {EIS1≤s and EIS2≤s}, such that the resulting function of signal level s is equivalent to the diagonal of the joint empirical CDF P(EIS1≤s1,EIS2≤s2).Note that reversal of the inequality inside the probability function results in the complementary CDF (CCDF) and is not the core issue here.Thus, our preference is Option 2.**NTT DOCOMO, INC**.:We think that the common spherical coverage approach should be useful for a co-located BS scenario and may be also useful for non-colocated scenario. Although the deployment of BSs of LB + HB are non-colocated, there is a possibility that the direction from a UE to both BSs are within the common spherical coverage depending on the position of the UE. |
| Common CDF shall be used for L+L, common CDF shall not be used for L+H |
| 3.2-1: LB + LB, HB + HB PSD difference capability signaling | Yes/No | **Intel**: No**Nokia:** No, would be additional burden to scheduler.**Apple**: Based on the common beam management assumption on the UE, a co-sited deployment of gNBs must also be assumed; therefore, PSD difference capability signaling is not needed. Furthermore, it is not clear what network behavior is expected based on this UE signaling. |
| 3.2-2: LB + LB, HB + HB PSD difference |  ≥ 25 dB, ≤ 30 dB | **R&S:** We share the view from Anritsu on the maximum achievable power imbalance (R4-2000444, Observation 5). These limitation need to be taken into account when defining tests for this feature.**Qualcomm**: We would like to go with the agreement in brackets in WF [2]: “PSD difference ….and [equal] PSD among 28+28 and 39+39 band groups”. This is due to UE limitation, not test system or deployment.**Intel**: 0dB**Huawei**: depends on whether 2 bands can be collocated deployed. For non-collocated case, ≥ 25 dB, ≤ 30 dB is expected.**SONY**: 0 dB power imbalance**Apple**: Based on the common beam management assumption on the UE, a co-sited deployment of gNBs must also be assumed; therefore, PSD difference shall be 0 dB. |
|  6.5dB |
|  0 dB |
| 3.2-3: LB + LB, HB + HB EIS relaxation framework | single band + MBR+ inter-band DL CA relaxation factor | **Qualcomm**: delta R IB (inter-band) should be the only additional relaxation compared to single-band operation. Our preference is not to create a new relaxation for single band operation just because UE supports inter-band CA.**Huawei**: option1, for both peak and spherical coverage**MediaTek**: 1. We prefer “single band + MBR+ inter-band DL CA relaxation factor” framework, because the framework leverages existed MBR discussion result to save discussion time for antenna roll-off part.

Moreover, different UE can support different non-CA operation band quantity with different specific inter-band DL CA. It means that even if these UE models support same inter-band DL CA, the expected performance difference compared to single-band UE would be still different due to different antenna roll-off loss for different total supported bands.(2) About the name of “inter-band DL CA relaxation factor”, we are okay to use other name. Our intention is to make the framework be clearer firstly, because it is helpful to converge discussions on inter-band DL CA relaxation factor “value”. (# whether the “value” include antenna roll-off loss or not.)**Nokia:** We think that single band + MBR+ inter-band DL CA relaxation is too complicated and also note that MBR scheme is under discussion. Single band + inter-band DL CA relaxation factor seems reasonable approach.**Apple**: we observe an impact on REFSENS (peak EIS), as described in 0017. We observe a further impact on spherical coverage EIS due to wideband beam degradation, as described in 0018. Both factors shall be captured in the inter-band EIS requirements for 28+28/39+39 combinations |
| single band + inter-band DL CA relaxation factor |
| other |
| 3.2-4: LB + LB, HB + HB Beam Management | Same | **Qualcomm**: With the agreements on inter-band testing (single AoA), same beam management should be assumed for the RF requirements.**Huawei**: testability limitation shall not be the bottleneck of UE implementation and behavior in real network. It depends on deployment case, for non-collocated independent shall be assumed. Additionally, there is no contradiction, Independent BM can also support single AOA.**MediaTek**: We support “Same” beam management.**SONY**: same beam management shall be assumed for LB+LB and HB+HB.**Apple**: RAN4 shall adopt the common beam management assumption on the UE. |
| Independent |
| 3.3-1: LB + HB PSD difference capability signaling | Yes/No | **Intel**: No**Huawei**: No capability but may with PSD difference. . We don’t recommend to introduce UE capability, it is mandatory for UE if UE can support inter-band CA. we don’t have such capability in FR1 and UE work well.**Nokia:** No. Network cannot control PSD.**Apple**: It is not clear what network behavior is expected based on this UE signaling**NTT DOCOMO, INC**.: Although we show a capability signaling approach as an option, we prefer not to introduce capability if we confirm feasibility of high PSD difference.**Qualcomm**: We have an agreement that requirements are valid only at “moderate” PSD difference. What happens in field operation in then up to implementation. This is same with LTE. RAN4 should define minimum requirements and every UE should meet those thus capability is not needed. |
| 3.3-2: LB + HB PSD difference |  ≥ 25 dB, ≤ 30 dB | **Anritsu**: Withdraw proposal 1 in R4-2000444. But would like to note that there might be a feasibility issue with the achievable PSD imbalance by test equipment.**R&S:** We share the view from Anritsu on the maximum achievable power imbalance (R4-2000444, Observation 5).**Qualcomm**: We can compromise to 7.5 dB for EIS conditions and higher SNR conditions need to be discussed separately, possibly in BB agenda. We have an agreement that requirements are valid only at “moderate” PSD difference. 30 dB is not moderate. There is no need to agree a specific number but we have provided a way to define RF requirements that avoid difficult situations. This is same approach as LTE. **Intel**: ≥ 25 dB, ≤ 30 dB**Huawei**: should not have limitation when defining RF requirement, since we already agree on TAE keep 3us. We need to have a test case to verify the PSD difference issue. From network implementation perspective, we can see ≥ 25 dB, ≤ 30 dB PSD is possible. We don’t recommend to introduce UE capability, it is mandatory for UE if UE can support inter-band CA. we don’t have such capability in FR1 and UE work well.**Nokia**: 6.5dB looks insufficient even in collocated deployment so there should be no such limit in core requirement. The conformance test configuration can be based on test limitation.**Apple**: Due to differences in radiated sensitivity performance between LB and HB, the UE baseband will operate under unequal PSD conditions in the RF test setup. RAN4 should further study this effect before considering additional differences in the emulated signals.**NTT DOCOMO, INC**.: We would like to take option 1. Based on R4-2000395, we understand it would be possible to handle 30dB PSD difference using LPF in HB Rx and HPF in LB Rx. |
|  6.5dB |
| 3.3-3: LB + HB EIS relaxation framework | single band + MBR+ inter-band DL CA relaxation factor | **Qualcomm**: delta R IB (inter-band) should be only relaxation because of inter-band CA operation. Our preference is not to add relaxation to single band operation just because UE supports inter-band CA. Applying MBR framework to single band requirement as normally for single band operation is our view and when UE is configured and activated for inter-band CA, then additional delta R IB relaxation is applied. If only single band and inter band relaxation is applied, requirement for UE may be more stringent in inter-band CA than in single band operation (because of MBR applies in single band)**Intel**: Single band + MBR+ inter-band DL CA relaxation factor**Huawei**: prefer single band + MBR+ inter-band DL CA relaxation factor, since MBR and inter-band DL CA relaxation factor do not come from the same issue. For issue whether apply to single band, need further evaluation. If it is not applied for single band, it may need some adjustment when condition is changed, it actually depends on the RF architecture used for inter-band CA.**MediaTek**: Same comment no matter LB+LB, HB+HB or LB+HB:1. We prefer “single band + MBR+ inter-band DL CA relaxation factor” framework, because the framework leverages existed MBR discussion result to save discussion time for antenna roll-off part.

Moreover, different UE can support different non-CA operation band quantity with different specific inter-band DL CA. It means that even if these UE models support same inter-band DL CA, the expected performance difference compared to single-band UE would be still different due to different antenna roll-off loss for different total supported bands.(2) About the name of “inter-band DL CA relaxation factor”, we are okay to use other name. Our intention is to make the framework be clearer firstly, because it is helpful to converge discussions on inter-band DL CA relaxation factor “value”. (# whether the “value” include antenna roll-off loss or not.)**SONY**: single band + MBR+ inter-band DL CA relaxation factor. We also proposed 2 dB relaxation for each band to meet 50% common spherical coverage enhancement, but this number does not take into account any potential receiver degradation due to PSD difference.**Nokia**: Single band + inter-band DL CA relaxation factor seems reasonable approach.**Apple**: The definition of common CDF should be first clarified |
| single band + inter-band DL CA relaxation factor |
| other |
| 3.4-1: separate L+H from L+L/H+H in WID | Yes/No | **Intel**: Yes**SONY**: Yes.**Nokia:** Yes, option 1. There is most interest to L-H from operators hence with this modification to WID L-H work can proceed with different time scale compared to L-L and H-H.**Apple**: We don’t see the need to revise the WID, since all of these options are in the scope of inter-band carrier aggregation in FR2. However, the specification shall consider differences in requirements based on applicability to 28+28/39+39 and 28+39 combinations.**Qualcomm**: Apple comment is internally contradictory since they acknowledge the different treatment and requirements of L+L and L+H and WID change would allow separate treatment of these requirements. In order to complete the work in the next meeting we will need proposals for band configurations. Could Apple bring band configuration requests for the L+L and H+H directly to the next plenary (RAN#87) with co-signers since none were requested within the RAN4 deadline? And Note, 28+28 inter-band CA is not meaningful since n257 covers n261 completely and there is only one band in 39 GHz domain so 39+39 combination is not even possible now. |
| 3.5-1: allow offset antennas as equivalent to single AoA for IBB  | Yes/No | **R&S:** The requirements have been defined under the assumption that DL signal and blocker are coming from the same direction. Allowing offset antennas might make it easier for DUTs to pass the test since Ues will orientate their beam pattern towards the DL. The UE will then likely see the blocker with less antenna gain leading to incorrect results. Also current test systems have already been designed according to the existing minimum requirements. Introducing offset antennas would lead to higher measurement uncertainties.**Qualcomm**: This Ran5 facing question should not delay introduction of core requirements**Huawei**: IBB issue may need to discuss in enhanced test SI or Rel-15.**Anritsu**: We still believe that we can optimize the antenna arrangement and reduce the decrease of power from the offset antenna more than the case we combine all the DL signals from SS. Also we think that we should try to keep a scalability of test system as much as possible yet. We should also try to compare the system from multiple viewpoints, e.g. total MU values b/w the system which combines all the DL signals and the system with offset antennas, future scalability of the system configuration, total cost to cover multiple test cases, etc. |
| 3.5-2: allow offset antennas for TRx requirements | Yes/No | **R&S:** In our understanding offset antennas are not necessary for inter-band CA of 28 + 39 GHz bands. This can be realized without offset antennas in the test system, while at the same time fulfilling existing Rel-15 requirements and uncertainties. As shown by Anritsu in R4-2000446 introducing offset antennas leads to higher IL in some paths which would reduce the available dynamic range. Also we expect an impact on the quality of the quiet zone (among other effects) when using antennas that are offset from the focal point of the system. This would in our understanding lead to higher MU and worse performance than single antenna systems.**Qualcomm**: This Ran5 facing question should not delay introduction of core requirements**Huawei**: Firstly, we think it is in the range of this WI as agreed in the WF. Would like to clarify that whether there is other test method to generating 2 DL signals with single AOA simultaneously? According to R4-2000445, we can see it is not possible. We would like hear the comments from TE vendors. If it is not possible, we would like to clarify that how much angle difference reached Ues on these 2 DL signals with antenna offset method. I mean, we may need to initiate the 2AOA test environment discussion for inter-band CA in RAN4. |

## 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.*

| **Issue** | **Status Summary** | *Recommendations for 2nd round:* |
| --- | --- | --- |
| 3.1-1: Quantifying spherical coverage for inter-band CA**Option #1:**spherical coverage for each band determined separately, and common coverage area established**Option #2:**common CDF shall be used for L+L, common CDF shall not be used for L+H | **Option #1:** 4 companies (Qualcomm, Intel, Sony, NTT Docomo)**Option #2:** 1 company (Apple)1 company (Huawei) shared further views, and asked about likely deployment scenario for L+H (co-located vs non) | Please use WF [2] as initial condition for this discussion. *Defining EIS spherical coverage requirement for inter-band CA.** *The UE shall meet the EIS spherical coverage requirement simultaneously among bands, the common EIS spherical coverage range between the two bands shall be 50% for power class 3 UE.*
* *Rel-15 EIS spherical coverage requirement will be taken as baseline assuming that the relaxation for 50%-tile point for power class 3 UE is introduced. The relaxation framework and value are FFS. Relaxation value cannot be 0.*

[2] talks about a common spherical coverage ‘range’, derived from the spherical coverage requirements in Rel-15, which is per-band. It does not talk about a common or joint CDF. **Option #2 is outside WF. Continue discussion if option #1 can be confirmed** |
| 3.2-1: LB + LB, HB + HB PSD difference capability signaling**Yes/No** | **Yes:** No support**No:** 3 companies (Intel, Nokia, Apple**)**  | **Tentative agreement: No capability signaling for DL PSD difference for L+L and H+H case**  |
| 3.2-2: LB + LB, HB + HB PSD difference**Option #1:** ≥ 25 dB, ≤ 30 dB**Option #2:** 6.5dB**Option #3:** 0 dB | **Option #1:** 1 company (Huawei, for non-colocated case)**Option #2:** No support**Option #3:** 4 companies (Qualcomm, Intel, Sony, Apple)**Other concern: (R&S, Anritsu):** Concern on the maximum achievable power imbalance (R4-2000444, Observation 5). | By agreement [3], all RF testing must be performed using single AoA, pending testability solution*Spherical coverage requirements for inter-band CA are tested from single AoA for Rel-16 ….*Would company supporting option #1 please share view on PSD difference for co-located case?  |
| 3.2-3: LB + LB, HB + HB EIS relaxation framework**Option #1:**single band + MBR+ inter-band DL CA relaxation factor**Option #2:**single band + inter-band DL CA relaxation factor |  | (merged with 3.3-3) due to similarity |
| 3.2-4: LB + LB, HB + HB Beam Management**Option #1:** Same**Option #2:** Independent | **Option #1:** 4 companies (Qualcomm, Sony, MediaTek, Apple)**Option #2:** 1 company (Huawei) | Moderator: By agreement in [3], all RF testing must be performed using single AoA, pending testability solution*Spherical coverage requirements for inter-band CA are tested from single AoA for Rel-16 ….*Would company supporting option #2 please share view if BM is independent or same across 2 bands if the the gNBs for the 2 bands are co-located? It appears their concern “testability limitation shall not be the bottleneck of UE implementation and behavior in real network” is addressed because single AoA testing does not preclude independent BM |
| 3.3-1: LB + HB PSD difference capability signaling**Yes/No** | **Yes:** 1 company (NTTDocomo will withdraw support if PSD difference is high enough)**No:** 5 companies (Intel, Nokia, Huawei, Apple, Qualcomm) | Moderator: Can we confirm scope of PSD difference discussion:1. section 7.3A only, not 7.4A, 7.5A, 7.6A ?
2. all 7.xA sections
3. Other?
 |
| 3.3-2: LB + HB PSD difference**Option #1:** ≥ 25 dB, ≤ 30 dB**Option #2:** 6.5dB | **Option #1:** 3 companies (Intel, Huawei, NTTDocomo)**Option #2:** 1 company (Qualcomm)**Other:** 2 companies (Anritsu, R+S) have voiced concern about TE ability to support high PSD **Other companies (Nokia**, Apple) have shared further views  | (Continue Discussion) |
| 3.3-3 and 3.2-3: EIS relaxation framework for both, LL/HH and LHOption #1:single band + MBR+ inter-band DL CA relaxation factorOption #2:single band + inter-band DL CA relaxation factor | **Option #1:** 6 companies (Qualcomm, Intel, Huawei, MediaTek, Sony, Apple)**Option #2:** 1 company (Nokia) | Moderator: It appears that in option #2, the intent is to reduce spec. complexity by merging into one parameter, the relaxation due to UE support of multiple bands, and the relaxation due to simultaneous operation in multiple bands. If this is common understanding, it appears that both options are equivalent, but option #2 has more moving parts and more difficult to maintain due to ‘folding in’ MBR framework. **If common understanding, can tentative agreement be option #1?** |
| 3.4-1: separate L+H from L+L/H+H in WIDYes/No | **Yes**: 4 Companies (Intel, Sony, Nokia, Qualcomm)**No**: 1 company (Apple). | Moderator: There appears to be consensus that the considerations will be different between LL/HH and LH scenarios. Is there objection to independent conclusion of L+L/H+H and L+H objectives? |
| 3.5-1: allow offset antennas as equivalent to single AoA for IBB ?Yes/No  | **R&S:** The requirements have been defined under the assumption that DL signal and blocker are coming from the same direction. Allowing offset antennas might make it easier for DUTs to pass the test since Ues will orientate their beam pattern towards the DL. The UE will then likely see the blocker with less antenna gain leading to incorrect results. Also current test systems have already been designed according to the existing minimum requirements. Introducing offset antennas would lead to higher measurement uncertainties.**Qualcomm**: This Ran5 facing question should not delay introduction of core requirements**Huawei**: IBB issue may need to discuss in enhanced test SI or Rel-15.**Anritsu**: We still believe that we can optimize the antenna arrangement and reduce the decrease of power from the offset antenna more than the case we combine all the DL signals from SS. Also we think that we should try to keep a scalability of test system as much as possible yet. We should also try to compare the system from multiple viewpoints, e.g. total MU values b/w the system which combines all the DL signals and the system with offset antennas, future scalability of the system configuration, total cost to cover multiple test cases, etc. | (Continue Discussion) |
| 3.5-2: allow offset antennas for TRx requirements?Yes/No | **R&S:** In our understanding offset antennas are not necessary for inter-band CA of 28 + 39 GHz bands. This can be realized without offset antennas in the test system, while at the same time fulfilling existing Rel-15 requirements and uncertainties. As shown by Anritsu in R4-2000446 introducing offset antennas leads to higher IL in some paths which would reduce the available dynamic range. Also we expect an impact on the quality of the quiet zone (among other effects) when using antennas that are offset from the focal point of the system. This would in our understanding lead to higher MU and worse performance than single antenna systems.**Qualcomm**: This Ran5 facing question should not delay introduction of core requirements**Huawei**: Firstly, we think it is in the range of this WI as agreed in the WF. Would like to clarify that whether there is other test method to generating 2 DL signals with single AOA simultaneously? According to R4-2000445, we can see it is not possible. We would like hear the comments from TE vendors. If it is not possible, we would like to clarify that how much angle difference reached Ues on these 2 DL signals with antenna offset method. I mean, we may need to initiate the 2AOA test environment discussion for inter-band CA in RAN4. | (Continue Discussion) |

*Suggestion on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title**  | **Assigned Company,****WF or LS lead** |
| R4-2002825 | WF on Inter-band DL CA | Apple |

## Discussion on 2nd round (if applicable)

| **Issue** | **Status Summary** | **2nd round Discussion:** |
| --- | --- | --- |
| 3.1-1: Quantifying spherical coverage for inter-band CA**Option #1:**spherical coverage for each band determined separately, and common coverage area established**Option #2:**common CDF shall be used for L+L, common CDF shall not be used for L+H | **Option #1:** 4 companies (Qualcomm, Intel, Sony, NTT Docomo)**Option #2:** 1 company (Apple)1 company (Huawei) shared further views, and asked about likely deployment scenario for L+H (co-located vs non) | Please use WF [2] as initial condition for this discussion. *Defining EIS spherical coverage requirement for inter-band CA.** *The UE shall meet the EIS spherical coverage requirement simultaneously among bands, the common EIS spherical coverage range between the two bands shall be 50% for power class 3 UE.*
* *Rel-15 EIS spherical coverage requirement will be taken as baseline assuming that the relaxation for 50%-tile point for power class 3 UE is introduced. The relaxation framework and value are FFS. Relaxation value cannot be 0.*

[2] talks about a common spherical coverage ‘range’, derived from the spherical coverage requirements in Rel-15, which is per-band. It does not talk about a common or joint CDF. **Option #2 is outside WF. Continue discussion if option #1 can be confirmed** |
| 3.2-1: LB + LB, HB + HB PSD difference capability signaling**Yes/No** | **Yes:** No support**No:** 3 companies (Intel, Nokia, Apple**)**  | **Tentative agreement: No capability signaling for DL PSD difference for L+L and H+H case**  |
| 3.2-2: LB + LB, HB + HB PSD difference**Option #1:** ≥ 25 dB, ≤ 30 dB**Option #2:** 6.5dB**Option #3:** 0 dB | **Option #1:** 1 company (Huawei, for non-colocated case)**Option #2:** No support**Option #3:** 4 companies (Qualcomm, Intel, Sony, Apple)**Other concern: (R&S, Anritsu):** Concern on the maximum achievable power imbalance (R4-2000444, Observation 5). | By agreement [3], all RF testing must be performed using single AoA, pending testability solution*Spherical coverage requirements for inter-band CA are tested from single AoA for Rel-16 ….*Would company supporting option #1 please share view on PSD difference for co-located case?  |
| 3.2-4: LB + LB, HB + HB Beam Management**Option #1:** Same**Option #2:** Independent | **Option #1:** 4 companies (Qualcomm, Sony, MediaTek, Apple)**Option #2:** 1 company (Huawei) | Moderator: By agreement in [3], all RF testing must be performed using single AoA, pending testability solution*Spherical coverage requirements for inter-band CA are tested from single AoA for Rel-16 ….*Would company supporting option #2 please share view if BM is independent or same across 2 bands if the the gNBs for the 2 bands are co-located? It appears their concern “testability limitation shall not be the bottleneck of UE implementation and behavior in real network” is addressed because single AoA testing does not preclude independent BM |
| 3.3-1: LB + HB PSD difference capability signaling**Yes/No** | **Yes:** 1 company (NTTDocomo will withdraw support if PSD difference is high enough)**No:** 5 companies (Intel, Nokia, Huawei, Apple, Qualcomm) | Moderator: Can we confirm scope of PSD difference discussion:1. section 7.3A only, not 7.4A, 7.5A, 7.6A ?
2. all 7.xA sections
3. Other?

[Intel]: Since PSD difference is a OOB requirements, should be 7.6A only |
| 3.3-2: LB + HB PSD difference**Option #1:** ≥ 25 dB, ≤ 30 dB**Option #2:** 6.5dB | **Option #1:** 3 companies (Intel, Huawei, NTTDocomo)**Option #2:** 1 company (Qualcomm)**Other:** 2 companies (Anritsu, R+S) have voiced concern about TE ability to support high PSD **Other companies (Nokia**, Apple) have shared further views  | (Continue Discussion)[Intel] 6.5dB is not correct. Even considering existing IBB, it should be better than 20.5dB in n260 and 21.5dB in n257/258/261. Note in IBB, Pinterferer is defined as aggregated power + 20.5dB for n260 and aggregated power + 21.5dB for n257/258/261. Aggregated power refers to total wanted signal power of CA. |
| 3.3-3 and 3.2-3: EIS relaxation framework for both, LL/HH and LHOption #1:single band + MBR+ inter-band DL CA relaxation factorOption #2:single band + inter-band DL CA relaxation factor | **Option #1:** 6 companies (Qualcomm, Intel, Huawei, MediaTek, Sony, Apple)**Option #2:** 1 company (Nokia) | Moderator: It appears that in option #2, the intent is to reduce spec. complexity by merging into one parameter, the relaxation due to UE support of multiple bands, and the relaxation due to simultaneous operation in multiple bands. If this is common understanding, it appears that both options are equivalent, but option #2 has more moving parts and more difficult to maintain due to ‘folding in’ MBR framework. **If common understanding, can tentative agreement be option #1?** |
| 3.4-1: separate L+H from L+L/H+H in WIDYes/No | **Yes**: 4 Companies (Intel, Sony, Nokia, Qualcomm)**No**: 1 company (Apple). | Moderator: There appears to be consensus that the considerations will be different between LL/HH and LH scenarios. Is there objection to independent conclusion of L+L/H+H and L+H objectives? |
| 3.5-1: allow offset antennas as equivalent to single AoA for IBB ?Yes/No  | **R&S:** The requirements have been defined under the assumption that DL signal and blocker are coming from the same direction. Allowing offset antennas might make it easier for DUTs to pass the test since Ues will orientate their beam pattern towards the DL. The UE will then likely see the blocker with less antenna gain leading to incorrect results. Also current test systems have already been designed according to the existing minimum requirements. Introducing offset antennas would lead to higher measurement uncertainties.**Qualcomm**: This Ran5 facing question should not delay introduction of core requirements**Huawei**: IBB issue may need to discuss in enhanced test SI or Rel-15.**Anritsu**: We still believe that we can optimize the antenna arrangement and reduce the decrease of power from the offset antenna more than the case we combine all the DL signals from SS. Also we think that we should try to keep a scalability of test system as much as possible yet. We should also try to compare the system from multiple viewpoints, e.g. total MU values b/w the system which combines all the DL signals and the system with offset antennas, future scalability of the system configuration, total cost to cover multiple test cases, etc. | (Continue Discussion) |
| 3.5-2: allow offset antennas for TRx requirements?Yes/No | **R&S:** In our understanding offset antennas are not necessary for inter-band CA of 28 + 39 GHz bands. This can be realized without offset antennas in the test system, while at the same time fulfilling existing Rel-15 requirements and uncertainties. As shown by Anritsu in R4-2000446 introducing offset antennas leads to higher IL in some paths which would reduce the available dynamic range. Also we expect an impact on the quality of the quiet zone (among other effects) when using antennas that are offset from the focal point of the system. This would in our understanding lead to higher MU and worse performance than single antenna systems.**Qualcomm**: This Ran5 facing question should not delay introduction of core requirements**Huawei**: Firstly, we think it is in the range of this WI as agreed in the WF. Would like to clarify that whether there is other test method to generating 2 DL signals with single AOA simultaneously? According to R4-2000445, we can see it is not possible. We would like hear the comments from TE vendors. If it is not possible, we would like to clarify that how much angle difference reached Ues on these 2 DL signals with antenna offset method. I mean, we may need to initiate the 2AOA test environment discussion for inter-band CA in RAN4. | **Anritsu:**To Huawei’s question in the 1st round>Would like to clarify that whether there is other test method to generating 2 DL signals with single AOA simultaneously?-> We would not say it is impossible. But to achieve the simultaneous 2 DL signal transmission from single AoA (also with one blocker port), we assume that we need to equip a customized high gain power amplifier(s) in the TE which requires impractical costs. >we would like to clarify that how much angle difference reached UEs on these 2 DL signals with antenna offset method. -> It depends on the test system design, both antenna arrangement and reflector (e.g. design of size, roll edge). As written in our paper (R4-2000446), we expect approximately 2 to 4 degrees are the range of the offset angle.**Qualcomm:** Are comments for 28+39 scalable for other combinations, say 24+43?**R&S:** As a response to Huawei**,** for inter-band CA combinations 28 + 28, 39+39 and 28+39, we think offset antennas are not necessary. We already shared this view at the last RAN4 meeting in R4-1913253. In our understanding, these CA combinations can be tested with signals coming from a single antenna, while at the same time the system can fulfill the single carrier parameters agreed upon by RAN5 for Rel-15.To Qualcomm: Yes, our comments above are applicable for inter-band combinations between currently defined FR2 bands (n257, n258, n259, n260, n261) covering the range from 24 – 43 GHz. |

## 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”* |

# References

[1] R4-1916021, “WF on intra-band NC DL CA”, Qualcomm, RAN4#93, Reno, NV, USA

[2] R4-1916024, “WF on FR2 inter-band DL CA”, Nokia, RAN4 #93, Reno, NV, USA

[3] R4-1913054, “WF on FR2 inter-band DL CA”, Sony, RAN4 #92-Bis, Chongqing, China

# Tracking

|  |  |
| --- | --- |
| Version | Files Incorporated |
| 0 | Initial, based on R4-2002695 |
| 1 | R4-2002695\_AnritsuTopicGrp22\_Rnd2\_v0\_QC\_1\_Mar2 |
|  |  |
|  |  |
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