**3GPP TSG-RAN WG4 Meeting #112 R4-2412827**

**Maastricht, Netherlands, 19 – 23 August, 2024**

**Agenda item:** 8.6.4

**Source:** Moderator (Mediatek Inc.)

**Title:** Topic summary for [112][122] FS\_NR\_FR1\_DL\_Frag\_Carrier

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion (e.g. list of treated agenda items) and provide some guidelines for email discussion if necessary.*

Thread [125] includes following topics:

1. Topic #1: Workplan
2. Topic #2: Methods for reducing the number of UE Rx chains
3. Topic #3: Impacts on UE RF requirements and DL performance

# Topic #1: Workplan

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

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** | **T-doc name** | **Company** | **Proposals / Observations** |
| [**R4-2411554**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411554.zip) | Work plan for fragment carriers study | MediaTek Inc. | * *Work plan for* *NR FR1 DL fragmented carriers* |

## Open issues summary

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

### Sub-topic 1-1: Workplan for Rel-19 NR FR1 DL fragmented carriers

Workplan in [**R4-2405486**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405486.zip)

* Proposals

|  |  |
| --- | --- |
| **Meeting** | **Rel-19 NR FR1 DL fragmented carriers** |
| #112 | 1. Initial discussion on clarification on the SI scope and alignment of understanding of scope for the objectives. If needed, SI can be clarified and revised in next RAN meeting 2. Initial discussion on the equal PSD configuration applicability, architecture assumption and get consensus on the way forward 3. Initial discussion on reducing the number of UE Rx chains   - Initial discussion on example band for study and the example band selection  - Evaluation on the possible requirements adjustment/relaxation  - The ability to semi-statically switch hardware resources  - Means for a UE to inform the network of appropriate CA configuration it can support   1. Initial study on reasonable level for the power spectral density difference between carriers of co-located adjacent channel operators |
| #112bis | 1. Continue discussion on method of reducing the number of UE Rx chains   - Evaluation on the possible requirements adjustment/relaxation  - The ability to semi-statically switch hardware resources  - Means for a UE to inform the network of appropriate CA configuration it can support   1. Continue discussion on reasonable level for the power spectral density difference between carriers of co-located adjacent channel operators |
| #113 | 1. Continue discussion on method of reducing the number of UE Rx chains   - Evaluation on the possible requirements adjustment/relaxation  - The ability to semi-statically switch hardware resources  - Means for a UE to inform the network of appropriate CA configuration it can support   1. Continue discussion on reasonable level for the power spectral density difference between carriers of co-located adjacent channel operator 2. Initial discussion on whether and how to apply the conclusions to intra-band component of inter-band CA |
| #114 | 1. Continue discussion on method of reducing the number of UE Rx chains and conclude if possible   - Evaluation on the possible requirements adjustment/relaxation  - The ability to semi-statically switch hardware resources  - Means for a UE to inform the network of appropriate CA configuration it can support   1. Continue discussion on reasonable level for the power spectral density difference between carriers of co-located adjacent channel operators and conclude if possible 2. Continue discussion on whether and how to apply the conclusions to intra-band component of inter-band CA |
| #114bis | Continue discussion on remaining issues and consolidate big TR |
| #115 | Finalize the big TR for NR FR1 DL fragment carriers study |

* Recommended WF
  + Approve the workplan.

# Topic #2: Methods for reducing the number of UE Rx chains

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

NOTE 1: No RAN1 impact is foreseen

NOTE 2: RAN2 work, if necessary, will be triggered by RAN4 LS

NOTE 3: This study starts from single DL band. Sharing RF chain is not considered among inter-band DL carriers.

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** | **T-doc name** | **Company** | **Proposals / Observations** |
| [**R4-2411310**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411310.zip) | Views on UE RF architecture and NW deployment assumption for fragmented carriers | Samsung, TELUS, Bell mobility | （SID clarification）  ***Proposal 1: Align the understanding of current SID, the scope should be those bands whose frequency span is within 100MHz, which includes all FDD bands and some TDD bands.***  ***Proposal 2: Prioritize FDD bands.***  ***Proposal 3: Recommend n7, n25, n26 with 2NC CA as example combos.***  （UE RF architecture）  ***Observation 1: According to TR 36.823, it seems the Rx requirements in current spec are specified based on “partially shared architecture”***  ***Observation 2: From what we know the popular implementation for pure intra-band DL CA without MIMO/Rx diversity is “fully separated architecture”, with the existing requirements being complied with. One obvious advantage for “fully separated architecture” is that it can process two separate carriers located arbitrarily within a frequency band. One disadvantage is that it supports fewer NC CCs.***  ***Observation 3: The performance for “partially shared architecture” and “fully separated architecture” are comparable, and the spec is implementation agnostic.***  ***Proposal 4: For intra-band DL NC CA, RAN4 to confirm that current spec accommodate both “partially shared architecture” and “fully separated architecture”.***  ***Proposal 5: For fragmented carriers SI, only the “fully shared architecture” needs to be studied.***  (PSD difference consideration with NW deployment assumption)  ***Observation 4: It is difficult to predict the power level difference/PSD difference between two co-location operators given the EIRP and CBW of gNBs for transmission could be different.***  ***Proposal 6: Prioritize the “co-location” deployment (meaning only location is shared, but not infrastructure).***  ***Proposal 7: For evaluation purpose and for simplicity, assume the two gNBs of two co-location operators are both transmitting at maximal allowed power level.***  ***Proposal 8: Further, in the context of the Canadian regulation, for n7/n25/n66, equal PSD between two co-location operators could be assumed for evaluation purpose, as the starting point.*** |
| [**R4-2411404**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411404.zip) | On methods for reducing the number of UE Rx chains for fragmented carriers | Apple | **Prerequisite conditions**  ***Proposal 1:******To allow the UE to support the two non-contiguous CCs with common/shared RF chains instead of separate RF chains, the blocker power level in the gap needs to be at an appropriate level that the UE can handle with common RF chain.***  ***Proposal 2:*** ***The impact of UE switching between common RF chain and separate RF chains, including potential interruption, should be studied. If there is RRM impact, RAN4 should consider it.***  **Signaling aspects**  ***Proposal 3: Between the following two options, Option 1 is preferred.***  ***• Option 1: To trigger the RAN2 discussion at this meeting. Therefore, the RAN4 discussion on RF requirements and RAN2 discussion on signaling can progress in parallel***  ***• Option 2: Wait until RAN4 has concluded the RF requirement impact analysis including the blocker power level*** |
| [**R4-2411555**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411555.zip) | Discussion on methods for reducing the number of UE Rx chains | MediaTek Inc. | **Scope of study**  ***Proposal 1: All FDD and SDL bands are applicable for the study. TDD bands n41, n46, n48, n77, n78, n79, n90, n96, n102 and n104 are not applicable for the study.***  **Methods to reduce number of UE Rx chains**  **Observation 1: The existing DL NCCA requirements are based on partially-shared Rx architecture**  ***Proposal 2: Fully-shared Rx chain will be considered for the method to reduce number of Rx chains. It does not preclude using existing partially-shared Rx chain architecture or fully-separated Rx chain for new designed UE if capable.*** |
| [**R4-2411691**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411691.zip) | On general aspects of fragmented carriers | Huawei, HiSilicon | **Reference RF architecture**  **Observation 1: The current RF receiving requirements in TS 38.101-1 for non-contiguous CA are based on the partially shared architecture. i.e. the antenna and LNA are shared by both carriers.**  **Observation 2: Comparing with partially shared or separated architecture, the fully shared architecture could handle the non-contiguous CCs with less Rx chain, or provide additional DL MIMO layer capability with the same number of Rx chains.**  **Observation 3: The RF receiving performance might be degraded with the fully shared architecture.**  **Proposal 1: Current study item focuses on the fully shared architecture to identify what the major impacts on the RF requirements are, and how much the impacts could be.**  **Inter-operator collocated scenario**  **Observation 4: Regarding inter-operator deployment scenario, it’s not clear whether the SI objective is limited to shared RRU case, or separate RRU case is also included.**  **Proposal 2:** **For inter-operator deployment scenario, both shared RRU case and separate RRU case are considered.** |
| [**R4-2412087**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412087.zip) | Discussion on methods for reducing the number of UE RX chains | vivo | **Observation 1:** The sharing of LO, filters and some other devices would introduce some new interference and degradation of DL performance compared to separate state.  **Proposal 1:** The “shared RX chain” should be clarified clearly that which part of the hardware resources would be switched to a shared state compared to the current technology.  **Observation 2:** Considering the need of shared RX chain and the possibility of aggregating more CCs, the demand for better-performing devices should be higher than before, which should be considered as well.  **Observation 3:** Before fully studying the specific impact on DL performance, the level of RX chain sharing should not be expanded to the entire frequency band.  **Observation 4:** The power of the in-gap signal of the adjacent channel operator should be controlled to a certain level, or a relative low level compared to the two target non-contiguous CCs, otherwise the RX chain could not be shared between the two sub-blocks.  **Proposal 2:** The fourth sub-bullet in the SID should be simplified to “Determine a reasonable upper level of the power spectral density difference of the in-gap signal compared to the two non-contiguous CCs”.  **Proposal 3:** The inter-operator co-located scenario should be clarified: In the same band, whether the power difference transmitted from different operators in the co-located BS is very small.  **Observation 5:** If only the power difference transmitted from different operators could be guaranteed at a relatively small level, then the sharing of the RX chains should be based on the premise that the BW of the in-gap signal should not be narrower than a certain range.  **Proposal 4:** The new CA configuration supported only by adjusted RF requirements could be reported to the NW together with other default supported CA configuration. |
| [**R4-2412274**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412274.zip) | Discussion on methods for reducing the number of UE RX chains | Spreadtrum Communications | ***UE architectures assumption***  **Proposal 1:** **UE architectures assumption is needed to be studied further.**  **Proposal 2:** **Shared LNA or shared LNA and shared LO architecture assumption could be a starting point for UE architectures assumption.**  ***Methods for reducing the number of UE Rx chains***  **Observation 1: If inter-operator co-ordination is practical, shared RF chain for non-contiguous 2cc is feasible.**  **Proposal 3:** **Whether inter-operator co-ordination is feasible should be further studied.**  **Proposal 4:** **Noise and interference measurement of gap to select proper PRBs could be considered.**  **Proposal 5:** **gNB trigger UE to measure gap could be considered.** |
| [**R4-2412278**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412278.zip) | Operator’s initial views on FR1 fragmented carriers study | CHTTL | ***Initial overview view on the fragment carrier studies***  **Proposal 1:** **Clarify the goal of the fragmented carrier study is to study the method to enable support of DL non-contiguous 2CC in a shared RF chain, i.e. with single RF chain with single antenna per DL MIMO layer support.**  **Proposal 2:** **RAN4 to analysis the main obstacles to support two non-contiguous FR1 CCs in a shared RF chain, including (but not limited to) the following aspects:  1. Any additional restriction on the total aggregated channel span on each sub-regions FR1-a (600-1000MHz), FR1-b (1400-2200MHz), FR1-c (2300-2700MHz).  2. Any restriction on the CC arrangement (including BW & gap difference) of the two non-contiguous CCs.  3. Acceptable received power difference of two non-contiguous CCs.  4. Acceptable interference level between the gap of the two non-contiguous CCs.**  ***RF image issues***  **Observation 1: When receiving two NC carriers with a shared RF chain, there might be image issues from another CC or from another signal in the middle gaps of the 2CCs.**  **Observation 2: In LTE specification, the minimum receiver image rejection requirement for intra-band contiguous CA is set as 25dB.**  **Observation 3: The image rejection ratio could be higher than 30dB with a smaller amplitude mismatch (~<3%) and smaller phase error (~<3°).**  **Proposal 3: RAN4 to confirm it is feasible to receive two non-contiguous CCs in a shared RF chains with the assumption that power spectral density imbalance between any of the CC and also the signal in the gap are within 6dB.  - FFS on assuming higher PSD for the signal in the gap of 2CC.**  **Proposal 4: RAN4 to study whether a better image rejection ratio 30dB can be assumed for the studied FC NC receiver.**  ***Inter-operator co-located scenarios***  **Proposal 5:** **RAN4 to analysis what level of interference can be assumed in the middle of the two DL NC CCs in the inter-operator co-located BS scenarios.**  **- The mast sharing and site sharing are considered as the inter-operator co-located BS scenarios**  **- Whether the small cell/ hotspot deployment needs to be considered can be further discussed.**  ***Initial views on potential impacted RF requirement***  **Observation 4: It seems that the current requirement of ΔRIBNC could be re-used for shared RF chain architecture targeted in this FC study.**  **Proposal 6:** **The current in-gap ACS and in-gap in-band blocking requirements might need to be adjusted for the UE using shared RF chain supporting non-contiguous CA.** |
| [**R4-2413031**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2413031.zip) | On architecture options for fragmented spectrum reception | Skyworks Solutions Inc. | ***Study item description inputs***  **Observations:**   * **In the first statement, it is unclear what is meant by RF chains as it could be interpreted as antenna and LNA RF paths which can already share multiple DL CCs today.** * **It seems that Rx chain sharing is the goal by receiving multiple CCs par analog BB and/or Digital BB paths.** * **If the PSD imbalance of 6dB between the co-located CCs is captured, it is unclear if other channels in the gap or the edges of the CCs are collocated and thus which blocking levels may be suffered in-gap and on the side adjacent channels.** * **It would be useful to have an example scenario/band.**   **Proposal:**   * **The SID should better clarify what is understood by RF chains and Rx chains, as it is our understanding that within the same band both the antenna and the LNA is already shared between non-contiguous CCs.** * **The power of adjacent channels in-gap and on the sides should be clarified for this fragmented carrier scenario.** * **An example scenario should be added in the SID to have a more concrete case to study.**   ***Architectures to reduce the number of UE Rx chains***  **Proposal:** **In a similar way as specified for overlapping band non-collocated CA scenario, RAN4 studies the possibility of supporting only 2Rx in the 4Rx band in order to free up more receive paths to support more DL bands and/or CCs:**   * **This may already be supported by current architecture.** * **The network may configure in a semi-static way the number of Rx per band to trade some of the 4Rx receive path to higher number of DL bands and/or CCs.**   **Proposal on architecture options:** **RAN4 studies different architectures where:**   * **A single analog BB chain is used to receive two non-contiguous CCs within a wide analog filter:**   + **Blocker requirement may need to be revisited separately for in-gap blockers and adjacent side blockers.**   + **Specific issues may need to be addressed when a blocker falls on the shared DL LO frequency.** * **Additionally, study:**   + **A separate digital BB path per CC/cluster is used allowing good blocker and ACS performance.**   + **A shared digital BB path for both CCs/clusters with its potential ACS limitations**     - **Single FFT may be used if the CCs are SCS aligned.** * **Maximum received BW separation for two CCs/clusters in one RX path is 50MHz for 15kHz CCs and 100MHz for 30kHz CCs.** |
| [**R4-2413270**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2413270.zip) | Discussion on UE Rx chains of Fragmented Carriers | Ericsson | ***Scenarios for fragmented spectrum study***  [**Observation 1** **Supported band combinations with a reduced number of Rx chains, and consequently reduced selectivity performance, would have to be advertised with modified UE band-combination capabilities. There is nothing to prevent a UE vendor from advertising BCs with reduced interference rejection capability even for band combinations where the number of Rx chains is not a problem, which implies degraded selectivity in general as support of any BC is always optional.**](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.2\R4-2413270%20UE%20Rx%20Chains%20of%20Fragmented%20Carriers.docx#_Toc173913491)  ***Co-located conditions in practical deployment***  [**Observation 2** **The collocation deployment scenario should meet the conditions outlined in MRTD as specified in TS38.133 clause 7.6.4 and the power spectra density imbalance specified in TS38.101.**](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.2\R4-2413270%20UE%20Rx%20Chains%20of%20Fragmented%20Carriers.docx#_Toc173913492) |
| [**R4-2413339**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2413339.zip) | Discussion on methods for reducing the number of UE Rx chains for Fragmented Carriers | Nokia | ***2.1 Fragmented Carriers and their relation to the number of UE Rx chains***  **Observation 1: Fragmented carriers are in some sense similar to non-contiguous carrier aggregation which is already specified for intra-band carrier aggregation in TS 38.101-1.**  **Observation 2: It is not always clear within RAN4 what it meant by “Rx Chain”, “Rx path” or “Rx Branch”.**  **Observation 3: A single Rx chain for a 2Rx UE consists of one main Rx and one diversity Rx branch according to previously shared understandings from UE vendors.**  **Proposal 1: For a 2Rx UE, the common RAN4 understanding is that a single Rx chain consists of one main Rx branch and one diversity Rx branch.**  **Proposal 2: For a 4Rx UE, the common RAN4 understanding is that a single Rx chain consists of one main Rx branch and three diversity Rx branches.**  **Observation 4: For the current UE implementation, a separate UE RF chain per fragmented carrier is assumed.**  ***2.2 Types of UE receiver architectures for reducing the number of Rx chains for fragmented carriers***  **Observation 5: Type 1 UE receiver does not have the ability to suppress/attenuate in-gap interference via analogue filtering.**  **Observation 6: Even though there may be a possibility to suppress some of the in-gap interference in the digital domain, the objective of the SI is to free up Rx resources hence the focus is on the analog Rx chains.**  **Observation 7: For the case that the UE uses a single Rx chain for the reception of the two fragmented carriers in the presence of an in-gap interferer, a new set of requirements must capture the conditions and the relaxation.**  **Observation 8: A new set of requirements shall apply for a Type 2 implementations when the UE uses a single Rx chain for the reception of the fragmented carries.**  **Observation 9: For type 3 implementations the same new set of requirements as for type 2 implementations can apply.**  **Proposal 3:** **RAN4 shall focus on Type 2 (Internal Rx path split) and Type 3 (External Rx path split) implementations when discussion reducing the number of Rx chains for fragmented carriers.**  ***2.3 Use of “extra” Rx chain after reducing the number of Rx chains for fragmented carriers***  **Observation 10: A motivation for the SI is to “free up” Rx chains as these can then be used for additional CCs in a higher order inter/intra-band combination.**  **Observation 11: There are multiple limiting factors to the availability of Rx chains and thereby possible number of DL CCs. A solution for fragmented carriers may depend on the specific combinations of bands.**  **Proposal 4:** **RAN4 shall focus on the fundamental issue of fragmented spectrum and solutions to reduce the needed Rx chains to receive these. However, the end goal of higher order inter/intra-band combinations shall be considered as a part of any solution.**  ***2.4 Scheduling of the fragmented carriers within a single Rx chain***  **Observation 12: Current DL non-contiguous intra-band carrier aggregation consists of at least two and up to four component carriers (CCs).**  **Observation 13: The SID limits the scope to two non-contiguous CCs within a CA combination.**  **Proposal 5:** **RAN4 shall** **discuss whether each fragment is treated as an individual CC or a single CC can cover the fragments.**  **Observation 14: RAN4 can also consider solutions for fragmented spectrum with more than two spectrum fragments.**  **2.5 Duplex modes for fragmented carrier operation**  **Observation 15: The SID does not explicitly mention whether both FDD and TDD bands are under consideration for fragmented carrier operation.**  **Proposal 6:** **RAN4 shall clarify whether a solution for fragmented carriers is to be** **applicable for both TDD and FDD bands, only to FDD, or whether there can be separate solutions for TDD and FDD fragmented carriers.** |

## Open issues summary

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

### Sub-topic 2-1:Study scope clarification

*Sub-topic description*

*Open issues and candidate options before meeting:*

#### **Issue 2-1-1: Applicability and clarification on the scope**

* Proposal 1 (Samsung, Bell mobility, TELUS)
* ***Proposal 1:*** ***Align the understanding of current SID, the scope should be those bands whose frequency span is within 100MHz, which includes all FDD bands and some TDD bands.***
* Proposal 2 (MediaTek)
* ***Proposal: All FDD and SDL bands are applicable for the study.*** ***TDD bands n41, n46, n48, n77, n78, n79, n90, n96, n102 and n104 are not applicable for the study.***
* Proposal 3 (CHTTL)
* ***Clarify*** ***the goal of the fragmented carrier study is to study the method to enable support of DL non-contiguous 2CC in a shared RF chain, i.e. with single RF chain with single antenna per DL MIMO layer support***
* ***RAN4 to analysis the main obstacles to support two non-contiguous FR1 CCs in a shared RF chain, including (but not limited to) the following aspects:  
   1. Any additional restriction on the total aggregated channel span on each sub-regions FR1-a (600-1000MHz), FR1-b (1400-2200MHz), FR1-c (2300-2700MHz).  
   2. Any restriction on the CC arrangement (including BW & gap difference) of the two non-contiguous CCs.  
   3. Acceptable received power difference of two non-contiguous CCs.  
   4. Acceptable interference level between the gap of the two non-contiguous CCs***
* Proposal 4 (Nokia)
* ***RAN4 shall discuss*** ***whether each fragment is treated as an individual CC or a single CC can cover the fragments***
* ***RAN4 shall focus on the fundamental issue of fragmented spectrum and solutions to reduce the needed Rx chains to receive these. However,*** ***the end goal of higher order inter/intra-band combinations shall be considered as a part of any solution***
* ***RAN4 shall clarify whether a solution for fragmented carriers is to be applicable for both TDD and FDD bands, only to FDD, or whether there can be separate solutions for TDD and FDD fragmented carriers***
* Proposal 5 (CATT, from R4-2411114)
* ***RAN4 to clarify that the reception of*** ***the two non-contiguous CCs is still under the current DL non-contiguous CA framework, i.e., the two non-contiguous belong to two different cells, but received by a shared Rx chain, although some RF requirements may be impacted by this enhancement.***
* Proposal 6(ZTE, from [R4-2411886](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411886.zip))
* ***Both TDD and FDD intra-band DL contiguous CA should be included***
* Recommended WF
  + RAN4 discuss if the goal clarification and the sub-bullets are agreeable:
    - The goal of the DL fragmented carrier study is to study the method to enable support of DL non-contiguous 2CC in a shared Rx chain
    - The two non-contiguous CCs is still under the current DL non-contiguous CA framework
      * Further discuss whether each fragment is treated as an individual CC or a single CC can cover the fragments
    - The end goal of higher order inter/intra-band combinations shall be considered as a part of any solution
  + RAN4 discuss common understanding of current SID scope, whether the bullets below are agreeable
    - The scope should be those bands whose frequency span is within 100MHz, which includes all FDD/SDL bands and some TDD bands with frequency span ≤ 100 MHz.
    - TDD bands n41, n46, n48, n77, n78, n79, n90, n96, n102 and n104 are not applicable for the study

Apple: The sub-bullet “ an individual CC or a single CC can cover the fragments”, if a single CC can cover fragments, then it is beyond 5G support.

Ericsson: we think that should be separate CC. A single CC is another concept.

Samsung: we share the same view as Apple and Ericsson.

CATT: This sub-bullet should be removed.

Nokia: We are OK to we can come with term that individual CCs will be considered for fragmented DL. For TDD bands, we need more discussion. We are not ready to preclude those bands from SI.

T-Mobile USA: we share the similar view as Nokia. We need consider n41. We are fine to limit the maximum span of frequency to 100MHz.

ZTE: Band 39 and other band also meet the criterion </=100MHz. Should we consider SDL band?

Samsung: Regarding to SID, we share the similar view ZTE that range of frequency is less than 100MHz. I wonder if n41 is allocated to two operators.

T-Mobile USA: we have all 194MHz in some place and we have multiple blocks in other places.

Huawei: To sub-bullet of individual CC and single CC, since RAN1 will be impacted, we can go with the individual CCs. Any features introduced before Rel-19 are not precluded. To 100MHz, we share the similar view as Samsung. The study should focus on single band not larger than 100MHz.

Vivo: Regarding 100Mhz limitation, it might be some unclear part. For single DL band with frequency span less than 100MHz, some think the band should be less than 100MHz while others think it is the span of two blocks.

OPPO: We share the view as Vivo. The band can be larger than 100MHz. But the CCs should be within the 100MHz.

Nokia: Indeed the limitation is that the fragments should be within 100MHz. We need clarify it. We still have the limit to treat the frequency separated more than 100MHz.

AT&T: It is better to say fragments is fully contained within 100MHz.

CATT: The original meaning is not that band should be within 100MHz.

Samsung: we can accept the comments from Nokia and AT&T.

Huawei: for fragmented bands, the study method and performance impact are quite similar to the band within 100MHz and fragmented carriers within 100MHz. We can start with the band within 100MHz and then extend it to the larger band.

Nokia: Some places the larger band will be used. The main limitation is the impact to UE. What features do you mean?

Huawei: all the features introduced by previous releases.

Agreement:

* The goal of the DL fragmented carrier study is to study the method to enable support of DL non-contiguous 2CC by using a single Rx RF chain
  + The two non-contiguous CCs is still under the current DL non-contiguous CA framework
    - Each fragment is treated as an individual CC
  + The study should be future-proof for the higher order inter/intra-band combinations or additional CC(s) within the same band with fragments within 100MHz.
  + Any features introduced before Rel-19 are not precluded.
  + [The scope should be those bands, where the fragments are fully confined within 100MHz, which includes all FDD/SDL bands and TDD bands
    - Consider n2/n25, n3, n7, n66, n41, n39 as the example bands.
      * Provide the details related to gap between fragmented DL blocks]

#### **Issue 2-1-2: Reference architecture**

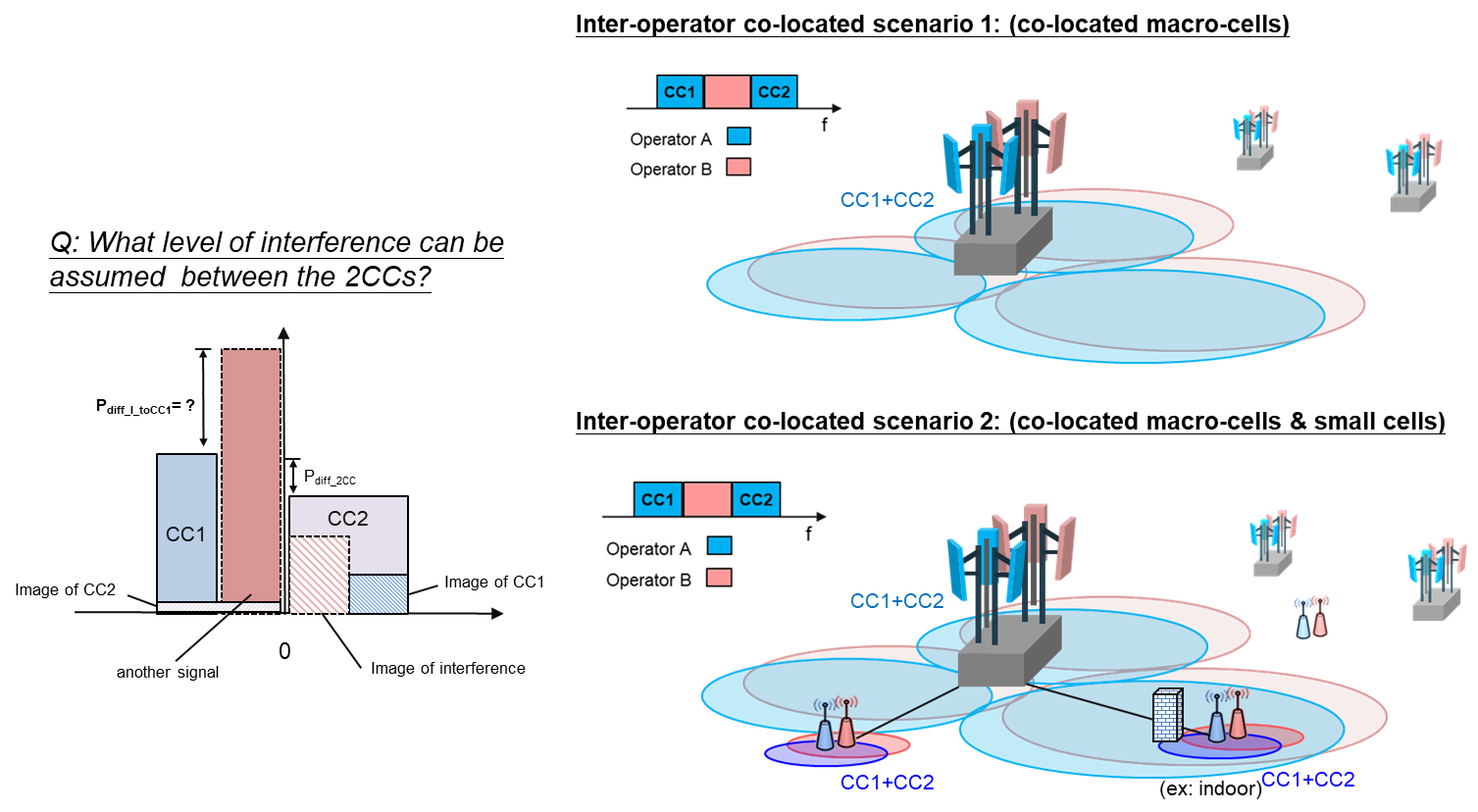
* Proposal 1 (Samsung, Bell mobility, TELUS, MediaTek, Huawei)
* ***For fragmented carriers SI,*** ***only the “fully shared Rx chain architecture” needs to be studied .***
* Proposal 2 (Spreadtrum)
* ***Shared LNA or shared LNA and shared LO architecture assumption could be a starting point for UE architectures assumption.***
* Proposal 3 (Skyworks)
* ***In a similar way as specified for overlapping band non-collocated CA scenario,*** ***RAN4 studies the possibility of supporting only 2Rx in the 4Rx band in order to free up more receive paths to support more DL bands and/or CCs***
* ***RAN4 studies different architectures, i.e., shared/separated BB path***
* Proposal 4 (Nokia)
* ***For a*** ***2Rx UE, the common RAN4 understanding is that*** ***a single Rx chain consists of one main Rx branch and one diversity Rx branch.***
* ***For a 4Rx UE, the common RAN4 understanding is that*** ***a single Rx chain consists of one main Rx branch and three diversity Rx branches.***
* ***RAN4 shall focus on Type 2 (Internal Rx path split) and Type 3 (External Rx path split) implementations when discussion reducing the number of Rx chains for fragmented carriers***
* Proposal 5 (vivo)
* ***The “shared RX chain” should be clarified clearly that which part of the hardware resources would be switched to a shared state compared to the current technology***
* Proposal 6 (Apple, from R4-2411405)
* ***It is proposed to clarify that the UE architecture that has a common eLNA followed by separate RF chains is considered one of separate RF chains***
* Recommended WF
  + The existing requirements for DL NCCA was specified based on partially-shared Rx chain according to TR36.823.
    - It is RAN4 common understanding that for 2Rx UE, a single Rx chain consists of one main Rx branch and one diversity Rx branch. For 4Rx UE, a single Rx chain consists of one main Rx branch and three diversity Rx branches.
  + FFS on following options for reducing number of Rx chains for DL non-contiguous CCs:
    - Option 1: Only the “fully shared Rx chain architecture” needs to be studied
    - Option 2: RAN4 also studies the possibility of supporting only 2Rx in the 4Rx band
    - Other options are not precluded

#### **Issue 2-1-3: Example band consideration**

* Proposal 1 (Skyworks)
* ***Proposal: An example scenario should be added in the SID to have a more concrete case to study.***
* Proposal 2 (Samsung, Bell mobility, TELUS)
* ***Proposal:*** ***Prioritize FDD bands. Recommend n7, n25, n26 with 2NC CA as example combos***
* Proposal 3 (Huawei, from R4-2411692)
* ***RAN4 to decide the example bands for studying the RF requirements of fully shared RF architecture from bands n1, n7, n25, n26 and n66***
* Recommended WF
  + Suggest RAN4 discuss on which option can be agreeable:
    - Option 1: Prioritize FDD bands. Recommend n7, n25, n26 with 2NC CA as example combos
    - Option 2: RAN4 to decide the example bands for studying the RF requirements of fully shared RF architecture from bands n1, n7, n25, n26 and n66

#### **Issue 2-1-4: Study on** **power spectral density difference between carriers of co-located adjacent channel operators**

* Proposal 1 (Samsung, Bell mobility, TELUS, MediaTek)
* ***Proposal 1:*** ***Prioritize the “co-location” deployment (meaning only location is shared, but not infrastructure).***
* ***Proposal 2:*** ***For evaluation purpose and for simplicity,*** ***assume the two gNBs of two co-location operators are both transmitting at maximal allowed power level.***
* ***Proposal 3: Further, in the context of the Canadian regulation, for n7/n25/n66,*** ***equal PSD between two co-location operators could be assumed for evaluation purpose, as the starting point..***
* Proposal 2 (vivo)
* ***The inter-operator co-located scenario should be clarified: In the same band, whether the power difference transmitted from different operators in the co-located BS is very small.***
* Proposal 3 (Huawei)
* ***For inter-operator deployment scenario, both shared RRU case and separate RRU case are considered.***
* Proposal 4 (Spreadtrum)
* ***Whether inter-operator co-ordination is feasible should be further studied.***
* Proposal 5 (CHTTL)
* ***RAN4 to analysis what level of interference can be assumed in the middle of the two DL NC CCs in the inter-operator co-located BS scenarios.***
* ***- The mast sharing and site sharing are considered as the inter-operator co-located BS scenarios***

***- Whether the small cell/ hotspot deployment needs to be considered can be further discussed.***

* Recommended WF

RAN4 discuss which option for study on power spectral density difference between carriers of co-located adjacent channel operators is agreeable:

* + Option 1: Prioritize the “co-location” deployment (meaning only location is shared, but not infrastructure)
    - For evaluation purpose and for simplicity, assume the two gNBs of two co-location operators are both transmitting at maximal allowed power level
    - equal PSD between two co-location operators could be assumed for evaluation purpose, as the starting point
  + Option 2: For inter-operator deployment scenario, both shared RRU case and separate RRU case are considered

FFS on whether inter-operator co-ordination is feasible.

#### **Issue 2-1-5: Prerequisite conditions**

* Proposal 1 (Apple)
* ***The blocker power level in the gap needs to be at an appropriate level that the UE can handle with common RF chain.***
* Proposal 2 (Spreadtrum)
* ***Noise and interference measurement of gap to select proper PRBs could be considered.***
* Proposal 3 (CHTTL)
* ***RAN4 to confirm it is feasible to receive two non-contiguous CCs in a shared RF chains with the assumption that power spectral density imbalance between any of the CC and also the signal in the gap are within 6dB.  
   - FFS on assuming higher PSD for the signal in the gap of 2CC.***
* ***RAN4 to study whether a better image rejection ratio 30dB can be assumed for the studied FC NC receiver.***
* ***The current in-gap ACS and in-gap in-band blocking requirements might need to be adjusted for the UE using shared RF chain supporting non-contiguous CA***
* ***RAN4 to analysis what level of interference can be assumed in the middle of the two DL NC CCs in the inter-operator co-located BS scenarios.***
* Proposal 5 (vivo)
* ***The fourth sub-bullet in the SID should be simplified to “Determine a reasonable upper level of the power spectral density difference of the in-gap signal compared to the two non-contiguous CCs”***
* Recommended WF
  + Moderator suggest to discuss the proposals in topic 3.

#### **Issue 2-1-6: Others**

* Proposal 1 (Apple)
* ***The impact of UE switching between common RF chain and separate RF chains, including potential interruption, should be studied. If there is RRM impact, RAN4 should consider it.***
* Proposal 2 (vivo)
* ***The new CA configuration supported only by adjusted RF requirements could be reported to the NW together with other default supported CA configuration.***
* Proposal 3 (Spreadtrum)
* ***gNB trigger UE to measure gap could be considered.***
* Recommended WF
  + FFS

# Topic #3: Impacts on UE RF requirements and DL performance

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

NOTE 1: No RAN1 impact is foreseen

NOTE 2: RAN2 work, if necessary, will be triggered by RAN4 LS

NOTE 3: This study starts from single DL band. Sharing RF chain is not considered among inter-band DL carriers.

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** | **T-doc name** | **Company** | **Proposals / Observations** |
| **[R4-2411114](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411114.zip)** | Discussion on impacts on UE RF requirements and DL performance for fragmented carriers | CATT | ***Clarification on the work scope***  **Proposal 1: RAN4 to clarify the exact meaning of inter-operator collocated scenario and update the SID accordingly to facilitate the study.**  **Proposal 2:** **RAN4 to clarify that the reception of the two non-contiguous CCs is still under the current DL non-contiguous CA framework, i.e., the two non-contiguous belong to two different cells, but received by a shared Rx chain, although some RF requirements may be impacted by this enhancement.**  **Proposal 3:** **At this stage RAN4 does not take** **DL MIMO into account.**  **Proposal 4: RAN4 to clarify the intended uplink configuration in this study.**  **Proposal 5: The answers to the following questions from proponents are needed:**   * **Question 1: According to the original intention, some clarification is required on the DL frequency span, i.e., DL frequency span≤100MHz is only for SCS 30kHz, and ≤ 50MHz for SCS 15kHz?** * **Question 2: Is there any regulation that could guarantee the subcarrier grid alignment among all operators in a single band with 100kHz channel raster?** |
| [**R4-2411311**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411311.zip) | Views on UE RF requirements for fragmented carriers | Samsung, TELUS, Bell mobility | **2.1 UE RF requirements**  ***Observation 1: It is anticipated that the performance for “fully shared architecture” would be degraded compared with the existing requirements.***  **ΔRIBNC**  ***Proposal 1:*** ***For selected example combos, the configuration defined in Table 7.3A.2.2-1 and Table 7.3A.2.2-2 of TS 38.101-1 could be reused for performance evaluation, forΔRIBNC.***  ***Observation 2: ForΔRIBNC, the interference attenuation from Pcell UL to Scell DL is mainly provided by duplexer gap, thus it is expected that the performance of “fully shared architecture” would be similar to the existing requirements.***  **ACS/IBB/NBB**  ***Proposal 2: For the evaluation of ACS/In-band blocking/Narrow-band blocking, the UL configuration are in accordance with Table 7.3A.2.2-1 of TS 38.101-1.***  ***Proposal 3:*** ***In-gap ACS, in-gap IBB and in-gap NBB requirements for “fully shared architecture” need to be re-evaluated because of the poor interference rejection capability of analog filter (before ADC) and digital filter.***  ***Proposal 4：FFS whether out-of-gap ACS/IBB/NBB requirements need to be relaxed.***  **Wide band intermodulation**  ***Observation 3：It is anticipated the performance would not be degraded with “fully shared architecture”, for wide band intermodulation.***  **OOB blocking/Spurious response**  ***Proposal 5:*** ***Out-of-band blocking and spurious response do not need requirement adjustment as they are tested with the interferer falling more than 15 MHz above or below the band and the attenuation is mainly provided by per band duplexer/filter.***  **Signalling design**  ***Proposal 6:*** ***Put off the signalling related discussions until the UE performance aspects are clear.*** |
| [**R4-2411405**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411405.zip) | On UE RF requirements for fragmented carriers | Apple | **Common RF chain vs. separate RF chains**  ***Proposal 1:*** ***It is proposed to clarify that the UE architecture that has a common eLNA followed by separate RF chains is considered one of separate RF chains.***  **Receiver sensitivity**  ***Proposal 2: ΔRIBNC may need to be updated to reflect the filter rejection reduction of common RF chain compared to separate RF chains for each intra-band non-contiguous CA band combination.***  **ACS**  ***Observation 1: With the loss of any analog BB filter rejection for in-gap ACS requirement and reduced rejections for out-gap ACS requirement, meeting the ACS requirement is much harder and likely to eat into the UE implementation margins. This would justify limiting the PSD difference between blocker and CCs. In other words, the blocker power level in the requirement needs to be adjusted.***  **IBB**  ***Observation 2: With the loss of any analog BB filter rejection for in-gap and reduced rejections for out-gap, meeting the in-band blocking requirement is much harder and likely to eat into the UE implementation margins. Especially, the image of the blocker in Case 2 would cause the most severe interference because of the large power difference between the blocker and wanted signal. Therefore, the blocker power level in the requirement needs to be adjusted.***  **In-Gap**  ***Proposal 3:*** ***It is proposed to set the in-gap blocker PSD to the same as that of the higher PSD CC and limit the gap length.*** |
| [**R4-2411556**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411556.zip) | Discussion on UE RF requirements and DL performance impacts | MediaTek Inc. | ***Discussion on equal PSD assumption***  **Observation 1: For FDD bands, the REFSENS level over different DL CBWs are usually not equal PSD duel to interference from self-band uplink transmission**  **Observation 2: Equal PSD may apply for BS Tx perspective for single band DL transmission non-contiguous carriers**  ***Proposal 1: We propose option 5 : The study starts from existing test configurations***  ***Proposal 2: The evaluation assumptions on UL Tx shall be consistent with previous RAN4 assumptions. For ex:*** ***PC3 PA ACPR=30dB, with MPR=1dB, Full RB allocation. Tx LO leakage and image rejection ratio are 28dBc***  ***Example band consideration for evaluation discussion***  ***Proposal 3: In order to evaluate impacts on UE DL performance for the study, company may select preferred example band to evaluate impacts on UE RF requirements and DL performance***  ***Aspects of impacts on DL Rx requirements***  **Observation 3: Not only SCC is impacted by self-band UL Tx, PCC may also be impacted by it due to channel selection filter would be adjusted to wider total bandwidth in fully-shared Rx chain architecture**  ***Proposal 4:*** ***Impacts on DL performance shall also consider degradation on PCC due to wider channel selection filter*** ***configured under fully-shared Rx chain architecture*** |
| **[R4-2411692](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411692.zip)** | On RF requirements of fragmented carriers | Huawei, HiSilicon | **Proposal 1: RAN4 needs to study the performance of *fully* shared architecture, taking into account that the baseline reference architecture of existing RAN4 requirements is the *partially* shared architecture.**  ***REFSENS***  **Proposal 2:** **With *fully* shared RF architecture, study the degradation of REFSENS on both PCC and SCC caused by the potentially increased noise floor.**  **Proposal 3:** **RAN4 to decide the example bands for studying the RF requirements of fully shared RF architecture from bands n1, n7, n25, n26 and n66.**  ***ACS/IBB***  **Proposal 4:** **With *fully* shared RF architecture, study the degradation of ACS/IBB on both PCC and SCC caused by the potentially increased noise floor.** |
| [**R4-2411886**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411886.zip) | View on Fragmented carrier | ZTE Corporation, Sanechips | **Observation 1. No ΔRIBNC requirements defined for TDD intra-band non-contiguous CA.**  **Observation 2.There is no impact on maximum input level requirements by reducing the number of UE Rx chains.**  **Observation 3. The in-gap Rx requirements should be checked when reducing the Rx chain.**  **Observation 4. For the two DL carrier, each carrier satisfy the ACS/IBB/NBB requirements of the single carrier for in-gap and out-of-gap testing.**  **Observation 5. With the PSD imbalance between two DL carriers up to 6dB, the power imbalance would be larger than 6dB considering the asymmetric carrier channel bandwidth.**  **Proposal 1.** **Both TDD and FDD intra-band DL contiguous CA should be included.**  **Proposal 2.** **Re-evaluated the ΔRIBNC requirements based on the existing test points.**  **Proposal 3. Except in-gap ACS/IBB, the in-gap narrow band blocking should also need to be checked when reducing the Rx chain.**  **Proposal 4: For the in-band gap test of ACS, IBB and NBB requirements, the existing conditions of the Wgap shall be also applied for the shared RF chain.**  **Proposal 5. The existing ACS level should be maintained when reducing the Rx chain number.** |
| [**R4-2412088**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412088.zip) | Discussion on impacts on UE RF requirements and DL performance | vivo | ***ACS and in-band blocking***  **Observation 1: According to the interference of the in-gap signal, ACS and in-band blocking should be relaxed.**  ***Image rejection of the in-gap interference***  **Proposal 1:** **A new requirement should be set to assess the interference suppression of the image of the in-gap signal, and a relatively reasonable level should be considered.**  ***REFSENS***  **Observation 2: The ΔRIBNC should be relaxed in the shared RX chain structure especially when the frequency separation between the UL CC and the DL CC is too narrow.** |
| [**R4-2413271**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2413271.zip) | Discusson on impact on UE RF requirement of fragmented carriers | Ericsson | ***2.1 ACS and In-band blocking***  [Observation 1 Existing ACS and in-band blocking requirements are based on worst-case scenarios for each carrier and apply to various deployment scenarios.](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413271%20impact%20on%20RF%20requirements.docx#_Toc173874809)  [Observation 2 Relaxing ACS and in-band blocking requirements could create compatibility issues with the existing device ecosystem.](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413271%20impact%20on%20RF%20requirements.docx#_Toc173874810)  ***Proposal 1*** ***It’s important to maintain the current ACS and IBB requirements to ensure UE selectivity. The implementation of non-contiguous intra-band carriers with a single Rx chain is up to UE implementation*** |
| [**R4-2413340**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2413340.zip) | Discussion on impacts on UE RF requirements and DL performance for Fragmented Carriers | Nokia | 2.1 Existing requirements  [Observation 1: Fragmented carriers are in some sense similar to non-contiguous intra-band carrier aggregation (NC IB CA) which is already supported by the specification.](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133729)  [*Proposal 1:* *New requirement for fragmented carriers shall be separated from the existing FDD non-contiguous intra-band carrier aggregation ΔRIBNC.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133730)  [Observation 2: Current specification already has a requirement to the UE that it shall fulfil the requirements with an in-gap interferer of up to -25dBm.](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133731)  [Observation 3: Testing of any new requirements for fragmented carriers may need to be addresses within this SI.](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133732)  [Observation 4: A main challenge of non-contiguous intra-band carrier aggregation with a single Rx chain is the additional sources of interference since the single Rx chain has to cover multiple component carriers (CCs) with a potential in-gap interferer.](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133733)  2.2 Requirements for fragmented carriers  [*Proposal 2:* *At least REFSENS and ACS requirements shall be discussed in relation to fragmented carriers in DL.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133734)  [*Observation 5: REFSENS relaxation for fragmented carrier operation can be related to the widening of the total transmission bandwidth.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133735)  [*Proposal 3:* *RAN4 encourage UE vendors to supply information on expected sensitivity degradation related to widening of the transmission bandwidth for fragmented carrier operation.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133736)  [*Observation 6: The current ACS requirements for non-contiguous intra-band carrier aggregation may depend on the presence of analogue filters which are not available for fragmented carrier operation.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133737)  [*Proposal 4:* *RAN4 shall seek input from UE vendors on expected difference in interference attenuation with current implementation and fragmented carrier operation.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133738)  [*Observation 7: It is already given by the SID that a PSD imbalance of up to 6dB between the wanted carriers within the fragmented carriers shall be accepted.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133739)  2.3 PSD imbalance of the fragmented carriers  [*Proposal 5:* *RAN4 shall not consider power imbalance of the wanted carriers further in relation to the SI on fragmented carriers.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133740)  2.4 Expected interference power level  [*Proposal 6: RAN4 shall consider what level of in-gap interference fragmented carrier operation shall be able to tolerate.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133741)  [*Observation 8: RAN4 can consider if the power level of the in-gap interferer shall be used for enabling or disabling fragmented carrier operation.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133742)  [*Proposal 7:* *RAN4 shall discuss expected UE fallback behaviour when an in-gap interferer precludes the UE to operate in fragmented carrier mode.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133743)  2.5 Means for a UE to inform the network of CA configuration it can support with adjusted RF requirements  [*Observation 9: RAN4 specification already have an agreed syntax for indicating non-contiguous parts of a band combination.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133744)  [*Proposal 8:* *RAN4 can consider a new syntax for indicating support of fragmented carrier operation in a CA configuration*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133745)  [*Observation 10: RAN4 needs to further discuss whether to ask RAN2 on input on signalling to support the feature at a later stage of the SI.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133746)  **2.6 DL performance impact**  [*Observation 11: There should be no performance degradation when introducing a new CA configuration type, in this case fragmented carrier operation.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133747)  [*Proposal 9: RAN4 shall discuss what is the basis for Maximum transmission bandwidth and related Minimum guardbands when operating in fragmented carrier mode.*](file:///D:\1_RAN4\112-Maastricht\DL%20fragmented%20carrier%20-%20In%20meeting%20discussion\8.6.3\R4-2413340%20Discussion%20on%20impacts%20on%20UE%20RF%20requirements%20and%20DL%20performance%20for%20Fragmented%20Carriers.docx#_Toc174133748) |

## Open issues summary

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

### Sub-topic 3-1: Impacts on UE RF requirements and DL performance

#### **Issue 3-1-1: Assumptions on test configurations for evaluation**

* Proposal 1 (Samsung, Bell mobility, TELUS, MediaTek)
* ***For selected example combos, the configuration defined in Table 7.3A.2.2-1 and Table 7.3A.2.2-2 of TS 38.101-1 could be reused for performance evaluation, forΔRIBNC, ACS, IBB, NBB***
* Proposal 2 (CATT)
* ***At this stage RAN4 does not take DL MIMO into account***
* Proposal 3 (CHTTL)
* ***RAN4 to study whether a better image rejection ratio 30dB can be assumed for the studied FC NC receiver.***
* Recommended WF

See if RAN4 can agree on the following test configurations:

* + The configuration defined in Table 7.3A.2.2-1 and Table 7.3A.2.2-2 of TS 38.101-1 could be re-used for performance evaluation, forΔRIBNC, ACS, IBB, NBB and In-gap ACS, in-gap IBB and in-gap NBB requirements for selected example combos
    - UE self-band uplink Tx re-use same assumptions for NR PC3 PA i.e., ACPR=30dB, with MPR=1dB, Full RB allocation. Tx LO leakage and image rejection ratio are 28dB
    - At this stage RAN4 does not take DL MIMO into account

#### **Issue 3-1-2: Prerequisite conditions**

* Proposal 1 (CHTTL)
* ***RAN4 to confirm it is feasible to receive two non-contiguous CCs in a shared RF chains with the assumption that power spectral density imbalance between any of the CC and also the signal in the gap are within 6dB.  
   -*** ***FFS on assuming higher PSD for the signal in the gap of 2CC.***
* Proposal 2 (vivo)
* ***The fourth sub-bullet in the SID should be simplified to “Determine a reasonable upper level of the power spectral density difference of the in-gap signal compared to the two non-contiguous CCs”***
* Proposal 3 (ZTE)
* ***The existing ACS level should be maintained when reducing the Rx chain number***
* Proposal 4 (Ericsson)
* ***It’s important to maintain*** ***the current ACS and IBB requirements to ensure UE selectivity***
* Recommended WF

RAN4 discuss whether the proposals below are agreeable

* + Maintain the current ACS and IBB requirements to ensure UE selectivity
  + The fourth sub-bullet in the SID should be simplified to “Determine a reasonable upper level of the power spectral density difference of the in-gap signal compared to the two non-contiguous CCs”
  + RAN4 to confirm it is feasible to receive two non-contiguous CCs in a shared RF chains with the assumption that power spectral density imbalance between any of the CC and also the signal in the gap are within 6dB
    - FFS on assuming higher PSD for the signal in the gap of 2CC

#### **Issue 3-1-3: Requirements for evaluation**

* Proposal 1 (Samsung, Bell mobility, TELUS)
* ***ΔRIBNC, ACS, IBB, NBB******and In-gap ACS, in-gap IBB and in-gap NBB requirements for “fully shared architecture” need to be re-evaluated***
* ***Out-of-band blocking and spurious response do not need requirement adjustment as they are tested with the interferer falling more than 15 MHz above or below the band and the attenuation is mainly provided by per band duplexer/filter***
* Proposal 2 (Apple)
* ***The blocker power level in the gap needs to be at an appropriate level that the UE can handle with common RF chain***
* ***It is proposed to set the in-gap blocker PSD to the same as that of the higher PSD CC and limit the gap length***
* Proposal 3 (MediaTek)
* ***Impacts on DL performance shall also consider degradation on PCC due to wider channel selection filter configured under fully-shared Rx chain architecture***
* Proposal 4 (Huawei)
* ***With fully shared RF architecture, study the degradation of REFSENS on both PCC and SCC caused by the potentially increased noise floor***
* ***With fully shared RF architecture, study the degradation of ACS/IBB on both PCC and SCC caused by the potentially increased noise floor.***
* Proposal 5 (ZTE)
* ***Re-evaluated the ΔRIBNC requirements based on the existing test points.***
* ***Except in-gap ACS/IBB, the in-gap narrow band blocking should also need to be checked when reducing the Rx chain.***
* ***For the in-band gap test of ACS, IBB and NBB requirements, the existing conditions of the Wgap shall be also applied for the shared RF chain.***
* Proposal 6 (Spreadtrum)
* ***Noise and interference measurement of gap to select proper PRBs could be considered.***
* Proposal 7 (vivo)
* ***A new requirement should be set to assess the interference suppression of the image of the in-gap signal, and a relatively reasonable level should be considered.***
* Proposal 8 (Nokia)
* ***At least REFSENS and ACS requirements shall be discussed in relation to fragmented carriers in DL***
* ***New requirement for fragmented carriers shall be separated from the existing FDD non-contiguous intra-band carrier aggregation ΔRIBNC***
  + ***RAN4 encourage UE vendors to supply information on expected sensitivity degradation related to widening of the transmission bandwidth for fragmented carrier operation.***
  + ***RAN4 shall seek input from UE vendors on expected difference in interference attenuation with current implementation and fragmented carrier operation***
* ***RAN4 shall not consider power imbalance of the wanted carriers further in relation to the SI on fragmented carriers***
* ***RAN4 shall discuss what is the basis for Maximum transmission bandwidth and related Minimum guardbands when operating in fragmented carrier mode.***
* Proposal 9 (CHTTL)
* ***It seems that the current requirement of ΔRIBNC could be re-used for shared RF chain architecture targeted in this FC study.***
* ***The current in-gap ACS and in-gap in-band blocking requirements might need to be adjusted for the UE using shared RF chain supporting non-contiguous CA***
* Recommended WF

Companies’ views are diverged but not controversial. Further discuss following bullets see if they can be agreeable as a package

* + Both TDD and FDD intra-band DL contiguous CA should be included
  + ΔRIBNC, ACS, IBB, NBB and In-gap ACS, in-gap IBB, in-gap NBB requirements as well as the minimum guard band sizes for “fully shared architecture”, all need to be re-evaluated
    - Out-of-band blocking and spurious response do not need requirement adjustment
  + With fully shared RF architecture, study the degradation of REFSENS, ACS, IBB and NBB on both PCC and SCC caused by the potentially increased noise floor
  + New requirement for fragmented carriers shall be separated from the existing FDD non-contiguous intra-band carrier aggregation ΔRIBNC

#### **Issue 3-1-4: Means for a UE to inform the network of appropriate CA configuration it can support with adjusted RF requirements**

* Proposal 1 (Samsung, Bell mobility, TELUS)
* ***Put off the signalling related discussions until the UE performance aspects are clear***
* Proposal 2 (Nokia)
* ***RAN4 can consider a new syntax for indicating support of fragmented carrier operation in a CA configuration***
* Recommended WF
  + Suggest proposal 1, put off the signalling related discussions until the UE performance aspects are clear.

#### **Issue 3-1-5: Others**

* Proposal 1 (Nokia)
* ***RAN4 shall discuss expected UE fallback behaviour when an in-gap interferer precludes the UE to operate in fragmented carrier mode***
* Recommended WF
  + For further discussion