**3GPP TSG-RAN WG4 Meeting #109 R4-2318155**

**Chicago, US, November 13 – 17, 2023**

**Agenda item:** 11.4

**Source:** Moderator (Apple)

**Title:** Topic summary for [109][149] NR\_reply\_LS\_UE\_RF

**Document for:** Information

# Introduction

This email thread is focused on the following RF topics under AI 11.

1. LS on the CA Aggregated BW capability signaling by the UE (R2-2311440)
2. Power class related topics
3. Reply LS on power scaling and PHR in 38.213 (R1-2310555)
4. Reply LS on applicability of requirements for RedCap UE

# Topic #1: LS on the CA Aggregated BW capability signaling by the UE (R2-2311440)

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

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318438 | Apple | ***Query 1****: RAN4 input on the aggregated MIMO layer signaling to go along with aggregated BW capability signaling.****RAN4 response to Query 1****: The aggregated MIMO layer signaling is as beneficial as aggregated BW capability in reducing the UE signaling overhead. It can be indicated independently with the aggregated BW capability for the same band combination.****Query 2****: Is the aggregated BW capability signaling for inter-band FR1 CA with BCS5 also applicable to NR-DC cases?****RAN4 response to Query 2****: The aggregated BW capability signaling for inter-band FR1 CA with BCS5 should also apply for NR-DC.****Query 3****: RAN2 seeks RAN4 input on whether the range is adequate and if not, request RAN4 to provide the expected values.* ***RAN4 response to Query 3****: RAN4 considers the ranges proposed by RAN2 are quite adequate and suggests the following updated ranges as an optimization.**SupportedAggBandwidth-r17 ::= CHOICE {* *fr1-r17 ENUMERATED {mhz100, mhz110, mhz120, mhz130, mhz140, mhz150, mhz160, mhz170, mhz180, mhz190, mhz200, mhz220, mhz240, mhz260, mhz280, mhz300, mhz320, mhz340, mhz360, mhz380, mhz400, mhz450, mhz500, mhz600, mhz700, mhz800, spare1},*fr2-r17 *ENUMERATED {mhz300, mhz400, mhz500, mhz600, mhz700, mhz800, mhz900, mhz1000, mhz1100, mhz1200, mhz1300, mhz1400, mhz1500, mhz1600, mhz1700, mhz1800, mhz1900, mhz2000, mhz2100, mhz2200, mhz2300, mhz2400, spare9, spare8, spare7, spare6, spare5, spare4, spare3, spare2, spare1}**}****Query 4****: For FDD-TDD CA band combinations (in FR1), RAN2 would like to ask RAN4 whether it is correct to assume that the application of BW for FDD and TDD are not equivalent. For example, assuming the SCSs are fixed in most deployments to 15kHz for FDD and 30kHz for TDD, and so, whether it is feasible to calculate the effective total aggregated BW by a formula as below:****Total aggregated BW = 2\*FDD BW + 1\*TDD BW******RAN4 response to Query 4****: It is not correct to assume that the application of BW for FDD and TDD are not equivalent, which is also inconsistent with the RAN4 specifications on the aggregated BW definition as the sum of all carrier BW without different weighting factor between FDD and TDD carriers.* |
| R4-2319106 | Apple | ***LS*** |
| R4-2318535 | Nokia, Nokia Shanghai Bell | Q1: RAN2 also discussed on introducing aggregated MIMO layers capability to go along with the aggregated BW capability for the BC. Similar to the new aggregated bandwidth capability, the intention is to allow the UE to report a maximum number of MIMO layers it can support across the carriers for the band combination and the UE is expected to not support more than these, even when the total number of MIMO layers per each carrier can add up to more than this. But there was no consensus in RAN2 on this aggregated MIMO capability. RAN2 seeks RAN4 input on the aggregated MIMO layer signaling to go along with aggregated BW capability signaling. **A1: Additional MIMO layers increase throughput not RF bandwidth. Hence MIMO layers should not be considered when discussing aggregated BW which is purely RF bandwidth parameter.**Q2: RAN2 would like to ask RAN4 if the aggregated BW capability signaling for inter-band FR1 CA with BCS5, is also applicable to NR-DC cases. **A2: Yes it is.**Q3: RAN2 has the below aggregated BW capability signaling range for FR1 and FR2 respectively. RAN2 seeks RAN4 input on whether the range is adequate and if not, request RAN4 to provide the expected values. **A3: Listing out all individual numbers is not flexible for future use, e.g., 3 MHz channel bandwidth has just been added in RAN4 specifications and this is not considered in the list which has only 1 spare value. Needed level of granularity depends also from operator spectrum holdings. Lets assume operator has 135 MHz of bandwidth RAN4 may be asked to define a BCS limited to maximum aggregated bandwidth of 135 MHz.**SupportedAggBandwidth-r17 ::= CHOICE { fr1-r17 ENUMERATED {mhz20, mhz30, mhz35, mhz40, mhz50, mhz60, mhz70, mhz80, mhz90, mhz100, mhz110, mhz120, mhz130, mhz140, mhz150, mhz160, mhz180, mhz200, mhz220, mhz230, mhz250, mhz280, mhz290, mhz300, mhz350, mhz400, mhz450, mhz500, mhz600, mhz700, mhz800, spare1}, fr2-r17 ENUMERATED {mhz200, mhz300, mhz400, mhz500, mhz600, mhz700, mhz800, mhz900, mhz1000, mhz1100, mhz1200, mhz1300, mhz1400, mhz1500, mhz1600, mhz1700, mhz1800, mhz1900, mhz2000, mhz2100, mhz2200, mhz2300, mhz2400, spare9, spare8, spare7, spare6, spare5, spare4, spare3, spare2, spare1}}Q4: For FDD-TDD CA band combinations (in FR1), RAN2 would like to ask RAN4 whether it is correct to assume that the application of BW for FDD and TDD are not equivalent. For example, assuming the SCSs are fixed in most deployments to 15kHz for FDD and 30kHz for TDD, and so, whether it is feasible to calculate the effective total aggregated BW by a formula as below:**Total aggregated BW = 2\*FDD BW + 1\*TDD BW**For example, the UE can signal the support for the total aggregated BW=160MHz, FDD maximum BW=50MHz and TDD maximum BW=100MHz, This means the UE supports the following combinations.* FDD 30MHz + TDD 100MHz (2\*30MHz + 100MHz = 160MHz)
* FDD 40MHz + TDD 80MHz (2\*40MHz + 80MHz = 160MHz)
* FDD 50MHz + TDD 60MHz (2\*50MHz + 60MHz = 160MHz)

But the UE does not support the following.* FDD 50MHz + TDD 80MHz (2\*50MHz + 80MHz = 180MHz > 160MHz)

It should be noted that the SCS is reported in perCC level including 15KHz, 30KHz or 60KHz for FR1, and there may be cases that different SCSs are reported for FDD bands/TDD bands. Therefore, the total aggregated BW is calculated in a different way from the example in the RAN4 LS, RAN2 seeks RAN4 input on above formula.  **A4: RAN2 assumption is wrong. RAN2 seems to think BB processing BW when it counts for FDD both UL and DL. This is not RAN4s thinking/intention on aggregated BW. RAN4s definition for aggregated BW is seen below.****Total DL aggregated BW = FDD DL BW + TDD BW****Total UL aggregated BW = FDD UL BW + TDD BW.** **Total UL and DL BW can be different.** |
| R4-2318536 | Nokia, Nokia Shanghai Bell | **LS**  |
| R4-2318717 | MediaTek |

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| **Q1**: RAN2 also discussed on introducing aggregated MIMO layers capability to go along with the aggregated BW capability for the BC. Similar to the new aggregated bandwidth capability, the intention is to allow the UE to report a maximum number of MIMO layers it can support across the carriers for the band combination and the UE is expected to not support more than these, even when the total number of MIMO layers per each carrier can add up to more than this. But there was no consensus in RAN2 on this aggregated MIMO capability. RAN2 seeks RAN4 input on the aggregated MIMO layer signaling to go along with aggregated BW capability signaling. |

**Answer**: RAN4 identifies neither the corresponding physical resources characterized by the aggregated MIMO layer capability, nor the necessity for this capability, hence RAN4 proposes not to introduce such a capability.

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| **Q2**: RAN2 would like to ask RAN4 if the aggregated BW capability signaling for inter-band FR1 CA with BCS5, is also applicable to NR-DC cases. |

**Answer**: RAN4 confirms that the aggregated BW capability signaling for inter-band FR1 CA with BCS5 is also applicable to NR-DC cases.

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| **Q3**: RAN2 has the below aggregated BW capability signaling range for FR1 and FR2 respectively. RAN2 seeks RAN4 input on whether the range is adequate and if not, request RAN4 to provide the expected values.SupportedAggBandwidth-r17 ::= CHOICE { fr1-r17 ENUMERATED {mhz20, mhz30, mhz35, mhz40, mhz50, mhz60, mhz70, mhz80, mhz90, mhz100, mhz110, mhz120, mhz130, mhz140, mhz150, mhz160, mhz180, mhz200, mhz220, mhz230, mhz250, mhz280, mhz290, mhz300, mhz350, mhz400, mhz450, mhz500, mhz600, mhz700, mhz800, spare1}, fr2-r17 ENUMERATED {mhz200, mhz300, mhz400, mhz500, mhz600, mhz700, mhz800, mhz900, mhz1000, mhz1100, mhz1200, mhz1300, mhz1400, mhz1500, mhz1600, mhz1700, mhz1800, mhz1900, mhz2000, mhz2100, mhz2200, mhz2300, mhz2400, spare9, spare8, spare7, spare6, spare5, spare4, spare3, spare2, spare1}} |

**Answer**: The complete value sets for the aggregated BW capability signaling range should be derived according to the maximum number of simultaneously active CCs across all bands in the band combination, hence, RAN4 needs to discuss and decide at first the maximum number of bands and CCs supported in the inter-band CA for FR1 and FR2 respectively.

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| **Q4**: For FDD-TDD CA band combinations (in FR1), RAN2 would like to ask RAN4 whether it is correct to assume that the application of BW for FDD and TDD are not equivalent. For example, assuming the SCSs are fixed in most deployments to 15kHz for FDD and 30kHz for TDD, and so, whether it is feasible to calculate the effective total aggregated BW by a formula as below:**Total aggregated BW = 2\*FDD BW + 1\*TDD BW**For example, the UE can signal the support for the total aggregated BW=160MHz, FDD maximum BW=50MHz and TDD maximum BW=100MHz, This means the UE supports the following combinations.* FDD 30MHz + TDD 100MHz (2\*30MHz + 100MHz = 160MHz)
* FDD 40MHz + TDD 80MHz (2\*40MHz + 80MHz = 160MHz)
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But the UE does not support the following.* FDD 50MHz + TDD 80MHz (2\*50MHz + 80MHz = 180MHz > 160MHz)

It should be noted that the SCS is reported in perCC level including 15KHz, 30KHz or 60KHz for FR1, and there may be cases that different SCSs are reported for FDD bands/TDD bands. Therefore, the total aggregated BW is calculated in a different way from the example in the RAN4 LS, RAN2 seeks RAN4 input on above formula. |

**Answer**: Since the aggregated BW capability is defined for UL/DL and TDD/FDD respectively, RAN4 does not see the difference of the application of BW for FDD and TDD, and RAN4 does not identify the need of the total aggregated BW indicated in the equation either. |
| R4-2319895  | Huawei, HiSilicon | **Observation 1: The total baseband processing capability can be considered below, but currently there is no standardization for it and leave it for UE implementation.**

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| **Total baseband processing capability =** $\frac{BW\_{1}}{2^{μ1}}×MIMO\\_Layer\_{1}×F(ModulationOrder\_{1})$ **+** $\frac{BW\_{2}}{2^{μ2}}×MIMO\\_Layer\_{2}×F(ModulationOrder\_{2})$ **+** $\frac{BW\_{3}}{2^{μ3}}×MIMO\\_Layer\_{3}×F(ModulationOrder\_{3})$ **+ ……** |

**Observation 2: Based on the current RAN2 capability framework, UE has the maximum flexibility to report the baseband capability for a band combination via a lot of baseband capabilities per CC (MIMO layer, maximum channel bandwidth, SCS and Modulation Order. In addition, network can configure the corresponding baseband parameters without any adjustment or calculations about Total baseband processing capability.** **Observation 3: network inquiry mechanism designed in current RAN2’s specification can be used to reduce the feature lists reported by UE by considering network prior information.****Observation 4: based on some criterions, e.g. minimum fragmentation of network scheduling or maximum peak data rate, UE can only report a few feature lists to meet the demands of network scheduling instead of reporting every possibilities to network.****Observation 5: For most of FR1 UE, maximum 200~300MHz aggregated channel bandwidth can usually be supported. Thus, the capability maximum aggregated channel bandwidth for most FR1 UEs can meet the demands of most operators’ spectrum allocation.****Observation 6: current mechanism (network inquiry mechanism) in the spec can work well without any serious issues and UE has some flexibilities to report the feature lists based on some criterions. From network scheduling perspective, network will only choose some of feature lists based on specific criterions to reduce the complexity of scheduling.****Proposal 1: Based on the observations above, RAN4 can discuss whether to standardize some criterions in order to balance UE feature lists reports and network inquiry/ scheduling complexity instead of asking UE to report every possibilities which will result complex network scheduling.****Proposal 2: To answer Q1 below:****RAN4 has discussed the new proposal/idea “aggregated MIMO layers capability”, but from RF perspective, Tx RF chains or Rx RF chains can not always be shared between different RF bands due to the restriction of RF front end, which is different. In addition, it’s suggested to further clarify how network can use this information “aggregated MIMO layers capability” and the relationship between aggregated channel bandwidth and aggregated MIMO layer. As the UE capability *maxNumberMIMO-LayersPDSCH* is maintained by RAN1, so it’s suggested to check RAN1’s view on new proposal “aggregated MIMO layers capability”.****Proposal 3: To answer Q2 below:****From RAN4 UE RF perspective, the implementation about NR-CA is similar to NR-DC cases. But if NR-DC cases will bring additional RAN2’s impacts between different BS sites, it’s suggested not to extend the scope of this topic.****Proposal 4: To answer Q3 below:****In current specification, it’s mandatory for FR1 UE to support 100MHz channel bandwidth, it’s mandatory for FR2-1 UE to support 200MHz channel bandwidth and it’s mandatory for FR2-2 UE to support 400MHz channel bandwidth. From RAN4 perspective, the expected values should be larger than these mandatory values when UE declare NR-CA.****For FR1, minimum value can be considered as 200MHz and FFS on maximum value. In order to avoid the fragmental market, it’s proposed to consider 100MHz granularity for FR1.****For FR2, FFS about minimum value and maximum value of FR2 aggregated channel bandwidth considering the real implementation. In order to avoid the fragmental market, it’s proposed to consider the granularity larger than 100MHz for FR2.****Proposal 5: To answer Q4 below:****Since some TDD bands are still deployed assuming 15kHz SCS, e.g. band n34, n38, n39, n41 in Japan, and 5MHz for band n40, n41 and n48, assuming fixed 30kHz SCS for TDD bands is incorrect. In addition, it’s unclear what is assumed for SDL bands. In essence, different SCS configurations will result different equivalent channel bandwidth instead of duplex mode.** **If the factors of MIMO layers and modulation order are considered, it’s suggested to considered the following formula to represent the baseband capability:****Total baseband processing capability =** $\frac{BW\_{1}}{2^{μ1}}×MIMO\\_Layer\_{1}×F(ModulationOrder\_{1})$ **+** $\frac{BW\_{2}}{2^{μ2}}×MIMO\\_Layer\_{2}×F(ModulationOrder\_{2})$ **+** $\frac{BW\_{3}}{2^{μ3}}×MIMO\\_Layer\_{3}×F(ModulationOrder\_{3})$ **+ ……****We still need to check with RAN1 whether the factors of MIMO layers and modulation order can be removed or not. If yes, then the effective total aggregated BW by a formula can be expressed below for FR1.****Total aggregated BW = BW\_15kHz + BW\_30kHz / 2 + BW\_60kHz / 4****Proposal 6:** **Based on RAN2’s LS, some RAN1’s impacts are observed. As this topic has been discussed for more than two years between RAN4 and RAN2 without a clear objective and working group impacts, it’s better to discuss how we can move forward.****Option 1: To continue this topic’s discussion in RAN2 and RAN4 without a clear objective.****Option 2: An organized work can be considered from RAN level with some clear objectives.** |
| R4-2319896 | Huawei, HiSilicon | **LS** |
| R4-2319903 | OPPO |  **Question 1)**RAN2 also discussed on introducing aggregated MIMO layers capability to go along with the aggregated BW capability for the BC. Similar to the new aggregated bandwidth capability, the intention is to allow the UE to report a maximum number of MIMO layers it can support across the carriers for the band combination and the UE is expected to not support more than these, even when the total number of MIMO layers per each carrier can add up to more than this. But there was no consensus in RAN2 on this aggregated MIMO capability. RAN2 seeks RAN4 input on the aggregated MIMO layer signaling to go along with aggregated BW capability signaling.**Proposal 1: Reply as following:** The reporting of max aggregated CBW is to indicate that UE is not be able to support all the possible CBW in some band combinations due to the RF and/or baseband limitation with BCS4 or 5. RAN4 didn’t discuss or intended to report the aggregated MIMO capability along with max aggregated CBW capability. It is up to RAN2 decide whether the aggregated MIMO capability is needed.**Question 2)**RAN2 would like to ask RAN4 if the aggregated BW capability signaling for inter-band FR1 CA with BCS5, is also applicable to NR-DC cases.**Proposal 2: Reply as following:** Based on current RAN4 specification, the BCS for dual uplink inter-band carrier aggregation with uplink assigned to two NR bands are applicable to Dual Connectivity which includes BCS5.**Question 4)**For FDD-TDD CA band combinations (in FR1), RAN2 would like to ask RAN4 whether it is correct to assume that the application of BW for FDD and TDD are not equivalent. For example, assuming the SCSs are fixed in most deployments to 15kHz for FDD and 30kHz for TDD, and so, whether it is feasible to calculate the effective total aggregated BW by a formula as below:**Total aggregated BW = 2\*FDD BW + 1\*TDD BW****Proposal 3: Reply as following:** In RAN4 understanding, the total aggregated CBW is the direct SUM of CBW from each band. |
| R4-2320393 | Qualcomm | **Observation 1: Aggregated MIMO layer capability was not suggested in [1] taking into account the simplicity of signaling design.****Proposal 1: RAN4 suggests not to apply the max aggregated BW capability/IEs for NR DC cases.** **Observation 2: The conversion ratio of TDD BW to FDD BW should be included in the UE total aggregated BW capability. Otherwise, the total aggregated BW could not correctly represent UE’s aggregated BW capability.****Proposal 2: The effective total aggregated BW is calculated by the formula: Total aggregated BW = x\*FDD BW + TDD BW, where x is the conversion ratio calculated by x = SCS of TDD band /SCS of FDD band.** |
| Rev. of R4-2320447 | T-Mobile USA | **Observation 1: The new maximum aggregated bandwidth IEs would be useless to at least one chipset company if Total aggregated BW = 2\*FDD BW + 1\*TDD BW was not an option.** **Observation 2: The need for Total aggregated BW = 2\*FDD BW + 1\*TDD BW is due to there being twice as many FDD subcarriers per MHz for FDD with 15 kHz subcarriers as for TDD with 30 kHz subcarriers.** **Observation 3: If a UE’s maximum aggregated bandwidth capability was a function of Total aggregated BW = 2\*FDD BW + 1\*TDD BW and only Total aggregated BW = 1\*FDD BW + 1\*TDD BW could be signalled, then it will not be possible for a UE to accurately indicate its maximum aggregated bandwidth capability.****Observation 4: Although most if not all current implementations use 15 kHz for FDD and 30 kHz for TDD in FR1, it may lead to problems in the future if the signalling assumes that 15 kHz is always the subcarrier spacing for FDD, and 30 kHz is always the subcarrier spacing for TDD in FR1.** **Observation 5: If the capacity total aggregated bandwidth capability was reported as a maximum number of RBs, it would allow for the use of different subcarrier spacing.****Proposal 1: Ask RAN2 to provide an option for a UE to report Total Maximum Aggregated Baseband Capacity as a number of RBs.** **Proposal 2: RAN4 should propose potential values for total aggregated RBs for the new total aggregated RB IE.**  |

*The moderator can suggest a limited number of papers which could be presented.*

## Open issues summary

*Before f2f meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions..*

### Sub-topic 1-1

*Sub-topic description:*

*Open issues and candidate options before f2f meeting:*

**Issue 1-1-1: Answer to Q1: RAN2 seeks RAN4 input on the aggregated MIMO layer signaling to go along with aggregated BW capability signaling.**

* Proposals
	+ Option 1: No need for such a capability
	+ Option 2: Need for such a capability
* Recommended WF
	+ TBD

**Issue 1-1-2: Answer to Q2: Is the aggregated BW capability signaling for inter-band FR1 CA with BCS5 also applicable to NR-DC cases?**

* Proposals
	+ Option 1: Yes
	+ Option 2: No
* Recommended WF
	+ TBD

**Issue 1-1-3: Answer to Q3: RAN2 seeks RAN4 input on whether the range is adequate and if not, request RAN4 to provide the expected values.**

* Proposals
	+ Suggest discussing the following the aspects first
		- Maximum channel bandwidth UE needs to support, i.e., 100MHz for FR1 and 200MHz for FR2-1 and 400MHz for FR2-2
		- Listing out all individual numbers is not flexible for future use, e.g., 3 MHz channel bandwidth has just been added in RAN4 specifications and this is not considered in the list which has only 1 spare value.
		- Needed level of granularity depends also from operator spectrum holdings.
		- RAN4 needs to discuss and decide at first the maximum number of bands and CCs supported in the inter-band CA for FR1 and FR2 respectively.
* Recommended WF
	+ TBD

**Issue 1-1-4: Answer to Q4: Is the aggregated BW capability signaling for inter-band FR1 CA with BCS5 also applicable to NR-DC cases?**

* Proposals
	+ Option 1: It is not correct to assume that the application of BW for FDD and TDD are not equivalent, which is also inconsistent with the RAN4 specifications on the aggregated BW definition as the sum of all carrier BW without different weighting factor between FDD and TDD carriers.
	+ Option 2: We still need to check with RAN1 whether the factors of MIMO layers and modulation order can be removed or not. If yes, then the effective total aggregated BW by a formula can be expressed below for FR1.
		- Total aggregated BW = BW\_15kHz + BW\_30kHz / 2 + BW\_60kHz / 4
	+ The effective total aggregated BW is calculated by the formula: Total aggregated BW = x\*FDD BW + TDD BW, where x is the conversion ratio calculated by x = SCS of TDD band /SCS of FDD band.
	+ If the capacity total aggregated bandwidth capability was reported as a maximum number of RBs, it would allow for the use of different subcarrier spacing.
		- Proposal 1: Ask RAN2 to provide an option for a UE to report Total Maximum Aggregated Baseband Capacity as a number of RBs.
		- Proposal 2: RAN4 should propose potential values for total aggregated RBs for the new total aggregated RB IE.
* Recommended WF
	+ TBD

# Topic #2: Power class related topics

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

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318037 | Nokia, Nokia Shanghai Bell | **Observation 1:** The question has following two aspects.* One is as a feature, whether is *higherPowerLimit-r17* technically applicable to NR-DC or not?
* The other is whether is there *higherPowerLimit-r17* relatedrequirements for NR-DC in TS38.101-1 or not?

**Observation 2:** Observations for the respective aspects.* There is no technical reason to preclude NR-DC from applying *higherPowerLimit-r17* to it.
* On the other hand, there is no *higherPowerLimit-r17* related requirements for NR-DC corresponding to a NOTE 7 in Table 6.2A.1.3-1 for UE maximum output power for Inter-band CA and *higherPowerLimit-r17* related requirements for Configured transmitted power for Inter-band CA in 6.2A.4.1.3 in TS38.101-1.

We propose to simply share the above facts with RAN2. It is up to RAN2 on what to do for TS38.331 and TS38.306 with the consideration of the information.**Proposal:** A reply LS should simply share the above observations without specific actions. |
| R4-2318440 | Apple | ***Observation 1****: The high-power limit feature is also applicable to FR1 inter-band NR DC as the RF characteristics for inter-band NR DC is fundamentally the same as inter-band UL CA for the same band combination.****Observation 2****: Owing to that the FR1 NR CA PC2-equivalent NR DC configuration has not yet been proposed, there is no footing in RAN4 specifications to introduce the high-power limit feature for FR1 inter-band NR DC as of yet.****Proposal 1****: RAN4 can confirm that the high-power limit feature is also applicable to FR1 inter-band NR DC, though the feature has not been formally introduced in RAN4 specifications.****Proposal 2****: It is up to RAN2’s decision on whether to extend the existing IE of higherPowerLimit-r17 to also support FR1 inter-band NR DC in Rel-18 as a forward-looking feature or wait till RAN4’s introduction of FR1 PC2 inter-band NR DC before extending this feature to NR DC.* |
| R4-2319108  | Apple | RAN4 thanks RAN2 for the reply LS on higher power limit capability for inter-band UL DC and the question for clarifying the applicability of the parameter “higherPowerLimit-r17” where RAN2 would like to confirm whether the higher power limit is applicable to NR-DC?RAN4 has discussed the applicability of the parameter “higherPowerLimit-r17” and can confirm that the high-power limit feature is also applicable to FR1 inter-band NR DC, though the feature has not been formally introduced in RAN4 specifications. It is up to RAN2’s decision on whether to extend the existing IE of *higherPowerLimit-r17* to also support FR1 inter-band NR DC in Rel-18 as a forward-looking feature or wait till RAN4’s introduction of FR1 PC2 inter-band NR DC before extending this feature to NR DC.  |
| R4-2318891 | Xiaomi | **Observation 1: According to the current RAN4 spec, the feature higher power limit are only applicable to NR CA and EN-DC cases. The reason is that it was agreed in RAN4, only PC2 with PC2+PC3 PA configuration and PC3 with PC3+PC5 (unlicensed) PA configuration are the supported scenarios for this feature, and currently only NR CA and EN-DC cases have those scenarios.****Observation 2: if the above agreed scenarios (i.e. PC2 with PC2+PC3 PA configuration and PC3 with PC3+PC5 (unlicensed) PA configuration) were introduced for NR CA or NE-DC cases in the future, it seems reasonable that the feature higher power limit could be also applicable.**It is proposed to take above 2 observations into consideration when drafting the reply LS. |
| R4-2318716 | MediaTek | RAN4 thanks RAN2 for the reply LS on higher power limit capability for inter-band UL DC with the clarification question:**Question**: For clarifying the applicability of the parameter “higherPowerLimit-r17”, RAN2 would like to confirm whether the higher power limit is applicable to NR-DC?**Answer**: RAN4 has completed the specification of higher power limit capability for both NR UL inter-band CA and inter-band EN-DC, and without loss of generosity, the higher power limit capability is also applicable to inter-band NR DC for the same band combination supporting inter-band UL CA operation. RAN4 will complete spec works on the higher power limit capability for NR DC in the Rel-17 maintenance. |
| R4-2318960 | vivo | RAN4 thanks RAN2 for the Reply LS on higher power limit capability for inter-band UL DC. RAN4 discussed the question below and would like to provide the answer:**Question**: For clarifying the applicability of the parameter “*higherPowerLimit-r17*”, RAN2 would like to confirm whether the higher power limit is applicable to NR-DC?**Answer:** The higher limit is not applicable to NR-DC from RAN4’s perspective at least in Rel-17 and Rel-18. The corresponding requirements were defined for inter band UL CA and inter band UL EN-DC, and no requirements defined for NR-DC. |
| R4-2319407 | Samsung | RAN4 respectfully thanks RAN2 for the LS on higher power limit capability for inter-band UL DC in R2-2311441. RAN4 discussed the following question raised in the LS, and have the following answer based on the group’s common understanding on this topic:* **Question**: For clarifying the applicability of the parameter “higherPowerLimit-r17”, RAN2 would like to confirm whether the higher power limit is applicable to NR-DC?
* **Answer:** RAN4 confirms that higher power limit capability is not applicable to NR-DC.
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| R4-2319440 | Ericsson | **Proposal 1: RAN4 should reconsider if extending the higher-power limit to NSA band combination is required given that the *powerClass* can be extended. This to avoid further ambiguity in UE power capability signalling for supported band combinations.** |
| R4-2319901 | OPPO | **Question**: For clarifying the applicability of the parameter “*higherPowerLimit-r17*”, RAN2 would like to confirm whether the higher power limit is applicable to NR-DC?**Proposal 1: Reply as below:** RAN4 spec doesn’t support the *higherpowerlimit* feature in NR-DC up to now. |
| R4-2318038 | Nokia, Nokia Shanghai Bell | **Observation 1**: For NR inter band UL CA including intra band contiguous UL CA, the power class capability to be referred to is still under discussion, e.g., possible candidates could be ue-PowerClass, powerClass for one of the fallback band combinations, etc.. **Observation 2**: The LS is about *ue-PowerClassPerBandPerBC-r17*. Hence, it is not essential to include the power class interpretation for intra band CA part within the NR inter-band UL CA in the reply LS in case *ue-PowerClassPerBandPerBC-r17* is absent. **Observation 3**: if *ue-PowerClassPerBandPerBC-r17* is indicated, maximum Tx power over the carrier(s) in the respective bands is determined by min {*ue-PowerClassPerBandPerBC-r17*, *powerClass or powerClass-v1610* for NR inter-band UL CA}.**Proposal 1**: In case RAN4 cannot reach a consensus on which power class parameter should be referred to for knowing the achievable highest power for intra band contiguous UL CA part within an NR inter-band UL CA, RAN4 should include power class interpretation for only the case that *ue-PowerClassPerBandPerBC-r17* is present and finish the LS reply to RAN2, while RAN4 keeps discussing the remaining issue in RAN4. **Proposal 2:** Consider following changes to [2] in the LS reply to RAN2. Note that specific reasons of the changes can be seen in Section 2.1. *ue-PowerClassPerBandPerBC-r17* is applicable to only NR inter-band UL CA, i.e., when there is uplink configured in two different operating bands. Each uplink band contains only single UL CC or intra-band contiguous UL CA. The R4 16-8 is not applicable to MR-DC BCs.
2. *ue-PowerClassPerBandPerBC-r17* indicates the power class over the carrier(s) for each individual band within a given band combination that a UE supports, while *powerClass* or *powerClass-v1610* indicates the power class for the NR inter-band UL CA.
3. *ue-PowerClassPerBandPerBC-r17* if indicated for a band shall determine the power class over the carriers of this constituent band of a band combination ~~(It is not expected that the power class indicated in this field would be higher than the power class of the band combination)~~, ~~otherwise~~ i.e., the applicable power class over the carrier for the individual bands within the NR inter-band UL CA is determined as min {*power class in ue-PowerClassPerBandPerBC-r17*, *powerClass or powerClass-v1610* for the *NR inter-band ULCA*
4. *ue-PowerClassPerBandPerBC-r17* does not modify *powerClass/powerClass-v1610* for a band combination and conversely. ~~The capability definition of~~ *~~powerClass/powerClass-v1610~~* ~~requires update to include~~ *~~ue-PowerClassPerBandPerBC-r17~~*.
 |
| R4-2318439 | Apple | ***Observation 1****: There is a fuzzy boundary as whether the “per band” and “per band combination” applicability is for UL configuration only, or it also includes the DL configuration, so is for intra-band combination.****Observation 2****: The power class applicability for both intra-band combination and single UL with DL only inter-band combination shall be “per band combination”, despite technically they may have the same power class as single band in most cases.****Observation 3****: For intra-band contiguous UL CA and single CC UL with DL only intra-band contiguous CA (fallback of contiguous UL CA), the current signaling design does not allow to indicate different power classes between the two.****Proposal****: RAN4 to take the above answers to RAN2 questions into consideration when drafting the reply LS to RAN2.* |
| R4-2319107 | Apple | RAN4 thanks RAN2 for the LS regarding the per band per band combination power class capability (IE: *ue-PowerClassPerBandPerBC-r17*) introduced in Rel-17 indexed as 16-8 in RAN4 feature list and the questions on its applicability and relation to the existing power class capabilities.RAN4 has discussed the questions from RAN2 and would like to provide our responses as below:***Question 1****: Whether R4 16-8 is applicable to only inter-band CA?****RAN4 answer to question 1****: ue-PowerClassPerBandPerBC-r17 capability (R4 16-8) is only applicable to FR1 inter-band UL CA and NR DC.****Question 2****: What is the interaction between R4 16-8 and the existing power class capabilities (i.e. ue-PowerClass/ue-PowerClass-v1610/ue-PowerClass-1700, powerClassNRPart-r16 (if R4 16-8 is also applicable to the cases other than inter-band CA) and powerClass/powerClass-v1610)?* ***RAN4 answer to question 2****: The relation of ue-PowerClassPerBandPerBC-r17 to other existing power classes can be summarized as below:*1. *The functionality is the same as powerClassNRPart-r16 except that ue-PowerClassPerBandPerBC-r17 is used for FR1 inter-band UL CA or DC, while powerClassNRPart-r16 is used for FR1 inter-band MR-DC.*
2. *ue-PowerClassPerBandPerBC-r17 only needs to be indicated when it is different from ue-PowerClass /ue-PowerClass-v1610/ue-PowerClass-1700.*
3. *ue-PowerClassPerBandPerBC-r17 shall not exceed the maximum output power level of its parent inter-band UL combination power class powerClass/powerClass-v1610 when both UL bands are configured.*
4. *ue-PowerClassPerBandPerBC-r17 is applicable for both single CC UL and intra-band contiguous UL CA*
 |
| R4-2319409 | Samsung | In RAN4#106 meeting, RAN4 replied RAN2’s LS on the received clarification questions for the interaction between *ue-PowerClassPerBandPerBC-r17* (R4 16-8) and other existing different power class parameters. After extended discussion during subsequent meetings, RAN4 would like to have following further clarification with RAN2.1. *ue-PowerClassPerBandPerBC-r17* is applicable to only NR inter-band UL CA, i.e. when there is uplink configured in two different operating bands. Each uplink band contains only single UL CC or intra-band contiguous UL CA.
2. *ue-PowerClassPerBandPerBC-r17* indicates the power class that a UE supports for each individual band within a given band combination, while *powerClass*/*powerClass-v1610* indicates the power class for this band combination.
3. *ue-PowerClassPerBandPerBC-r17* if indicated for a band shall determine the power class of this constituent band of a band combination (It is not expected that the power class indicated in this field would be higher than the power class of the band combination), otherwise *ue-PowerClass*/*ue-PowerClass-v1610*/*ue-PowerClass-v1700* applies.
4. *ue-PowerClassPerBandPerBC-r17* does not modify *powerClass/powerClass-v1610* for a band combination and conversely. The capability definition of *powerClass/powerClass-v1610* requires update to include *ue-PowerClassPerBandPerBC-r17,* i.e., if the power class indicated by *powerClass/powerClass-v1610* is higher than the power class that the UE supports on the individual bands of this band combination (*ue-PowerClassPerBandPerBC-r17* if indicated or *ue-PowerClass* in *BandNR otherwise*), the latter determines maximum TX power available in each band.
 |
| R4-2319439 | Ericsson | At RAN4#106, RAN4 provided a reply to the RAN2 LS in R2-2211023 on the interaction between the *ue-PowerClassPerBandPerBC-r17* (R4 16-8) and other existing power class capabilities in R4-2303630/R2-2302435. Following discussions during subsequent RAN4 meetings, RAN4 would like to clarify further that:1. The R4 16-8 is only applicable to UL CA band combinations (BCs) with an inter-band part and each intra-band part configured with a single CC or intra-band contiguous UL CA and without UL-MIMO.

The R4 16-8 is not applicable to MR-DC BCs.1. Only if present for a band of an applicable BC, the *ue-PowerClassPerBandPerBC-r17* indicates the power class supported in the band and then replaces the power class indicated by *ue-PowerClass/ue-PowerClass-v1610/ue-PowerClass-1700* (all if more than one of these values are included) for the said band.
2. If the power class for the band combination *powerClass/powerClass-v1610* is higher than the power class *ue-PowerClassPerBandPerBC-r17* indicated for a band, the latter determines the maximum TX power available in this band (similarly to the relation between *powerClass* and *ue-PowerClass*).
 |
| R4-2319725 | Samsung | ***Proposal 1: The applicable power for a band within a BC should be capped by the value indicated by IE PowerClass for this band combination, in terms of intra-band ULCA, inter-band ULCA(2CC), and inter+intra(3CC) ULCA.*** ***Observation 1: Regarding the applicable power class for a band within a BC, both alternatives (Alt 1 is ue-PowerClass; Alt2 is Min (ue-PowerClass, PowerClass)) are workable with pros and cons for each.******Observation 2: It appears the group have concern on changing the power class for the constituent band within the BC.******Proposal 2: For DLCA only, intra-band ULCA, inter-band ULCA(2CC), inter+intra ULCA(3CC), it is suggested to adopt ue-PowerClass as default power class.******Proposal 3: ue-PowerClassPerBandPerBC-r17 if indicated for a band shall determine the power class of this constituent band of a band combination (It is not expected that the power class indicated in this field would be higher than the power class of the band combination), otherwise ue-PowerClass/ue-PowerClass-v1610/ue-PowerClass-v1700 applies.******Proposal 4: ue-PowerClassPerBandPerBC-r17 does not modify powerClass/powerClass-v1610 for a band combination and conversely. The capability definition of powerClass/powerClass-v1610 requires update to include ue-PowerClassPerBandPerBC-r17, i.e., if the power class indicated by powerClass/powerClass-v1610 is higher than the power class that the UE supports on the individual bands of this band combination (ue-PowerClassPerBandPerBC-r17 if indicated or ue-PowerClass in BandNR otherwise), the latter determines maximum TX power available in each band.*** |
| R4-2319900 | OPPO | **Observation 1: In UE implementation the MPR/AMPR settings are determined by power class, and it will not be changed due to for example max UL duty cycle though the max Tx power may be restricted.****Proposal 1: Min {*ue-PowerClass, powerClass*} should be used to determine the power capability and MPR for the band under inter-band UL CA.****Observation 2: From PA ability perspective, there is no difficulty to keep same Tx power as the single band power class as long as the MSD if any has been introduced in the spec.****Observation 3: From signalling perspective, if *powerClass* IE is applicable to DL-only CA case, then it can be different from *ue-powerClass* IE.****Proposal 2: Clarify *powerClass* IE is applicable to DL-only CA scenario.****Proposal 3: For DL-only CA scenario, the MIN {*powerClass*, *ue-powerClass*} is applied.****Observation 4: Apply the *ue-powerClass* IE to determine the intra-band UL CA in inter-band UL CA will overestimate UE power capabilities.****Observation 5: It is more nature to apply the power class of intra-band UL CA to determine the power capability of intra+inter band combination and this is also what specified in current spec.****Observation 6: For the intra-band UL CA, as long as the DL CA configuration is fixed, the applicable power capability is clear no matter it is reported via *powerClass* IE or inherited from parent BC power class.****Observation 7: For the same intra-band UL CA, if UE report different power classes when the DL CA configuration is different, then there will be some ambiguity in which power class should be applied for this intra-band UL CA.****Observation 8: Neither *ue-powerClass* IE or *powerClass* IE is perfect in determining the power class of intra-band CA in inter-band UL band combination.****Observation 9: The Tx power of n41C in CA\_n1A-n41C will not exceed the total power class and the single band power class which makes apply the MIN {powerClass of CA\_n1A-n41C, ue-powerClass of n41} for n41C band in UL CA\_n1A-n41C if the ue-PowerClassPerBandPerBC-r17 is not reported is possible. And if this is different from UE implementation, then it can still use the ue-PowerClassPerBandPerBC-r17 IE to report the exact power capability.****Proposal 4: Apply MIN {*powerClass* of intra+inter UL CA, *ue-powerClass*} to determine the power capability of intra-band UL CA part in intra+inter UL CA.** |
| R4-2320647 | Qualcomm | **Proposal 1: Allow UE to exceed PowerClass for single UL transmissions when ue-Powerclass is higher than PowerClass****Proposal 2: Do not limit ue-PowerClassPerBandPerBC-r17 to only indicate lower power class, as it can remove ambiguity on single band maximum power capabilities more widely.****Proposal 3: Adopt the new general clause to TS 38.101-1 as shown below**6.2A.0 GeneralFor UEs configured with downlink-only carrier aggregation with non-CA in the uplink, the UE shall meet the maximum output power requirements in clause 6.2.1 for the power class indicated by the *BandNR* capability *ue-PowerClass*.Non-CA UL transmissions are not bounded by the power class for the band combination indicated by *powerClass* and *powerClass* may be ignored in setting the configured maximum output power for CA with single CC UL transmission.The non-CA and CA configurations for which minimum requirements have been evaluated for Power Class 2 or Power Class 1.5 operation are indicated in clause 5.5A. |
| R4-2320666 | Huawei, HiSilicon | **R17/R18 CR** |
| R4-2319427/8 | Ericsson | **R17/18 CR on Corrections to configured maximum power and MPR for serving cells of UL CA** |
| R4-2319429/30 | Ericsson | **R17/18 CR on Corrections to configured maximum power and MPR for serving cells of UL CA** |

*The moderator can suggest a limited number of papers which could be presented.*

## Open issues summary

*Before f2f meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions..*

### Sub-topic 2-1: higherPowerLimit-r17

*Sub-topic description:*

*Open issues and candidate options before f2f meeting:*

**Issue 2-1-1: RAN4 should reconsider if extending the higher-power limit to NSA band combination is required given that the powerClass can be extended. This to avoid further ambiguity in UE power capability signalling for supported band combinations.**

* Proposals
	+ Option 1: Yes
	+ Option 2: No
* Recommended WF
	+ Yes, maybe with some wording refinement.

**Issue 2-1-2: Reply LS to RAN2**

* Proposals
	+ Option 1: Inform RAN2 that 1) There is no higherPowerLimit-r17 related requirements for NR-DC 2) It is up to RAN2’s decision on whether to extend the existing IE of higherPowerLimit-r17 to also support FR1 inter-band NR DC in Rel-18 as this feature is considered useful for NR-DC
	+ Option 2: The higher limit is not applicable to NR-DC from RAN4’s perspective at least in Rel-17 and Rel-18.
	+ Option 3: RAN4 confirms that higher power limit capability is not applicable to NR-DC.
* Recommended WF
	+ To be discussed

### Sub-topic 2-2: ue-PowerClassPerBandPerBC-r17

*Sub-topic description:*

*In current RAN4 specs, it is not clear on the applicable power and the applicable power class(and the requirements) for a band in a band combination in terms of intra-band ULCA, inter-band ULCA(1cc in each band), inter+intra-band ULCA, and DLCA only. In particular, when a band has a higher power class when operating in a single band than that in a band combination.*

*CR and LS can be updated according to the consensus on the following issues.*

*Note that below discussion is for Rel-17 and onwards.*

*Open issues and candidate options before f2f meeting:*

**Issue 2-2-1: In terms of intra-band ULCA, inter-band ULCA(1cc in each band), inter+intra-band ULCA, whether the applicable power (PCMAX, f,c) for a constituent band within a band combination is capped by powerClassof the band combination.**

* Proposals
	+ Option 1: Yes, and insert the new PCMAX,f,c equation in clause 6.2A.4.1
	+ Option 2: No
* Recommended WF
	+ Yes, and insert the new PCMAX,f,c equation into clause 6.2A.4.1

**Issue 2-2-2: In terms of inter-band ULCA (1cc in each band), inter+intra-band ULCA, if the IE ue-PowerClassPerBandPerBC-r17 is absent, which power class is applicable for a band in the band combination?**

* Proposals
	+ Option 1: ue-PowerClass
	+ Option 2: min{ue-PowerClass, PowerClass}
* Recommended WF
	+ Check whether Option1 can be agreed

**Issue 2-2-3: In terms of intra-band ULCA, which power class is applicable to this UL band?**

(Note this issue can be considered/discussed together with Issue 2-2-4)

* Proposals
	+ Option 1: ue-PowerClass
	+ Option 2: min{ue-PowerClass, PowerClass}
* Recommended WF
	+ To be discussed

**Issue 2-2-4: Whether to extend the applicability of PowerClassPerBandPerBC-r17 to intra-band ULCA and DLCA-only?**

* Proposals
	+ Option 1: Yes
	+ Option 2: No
* Recommended WF
	+ To be discussed

**Issue 2-2-5: Whether MPRc and A-MPRc allowed for serving cell c of a configured band combination is determined according to the power class with nominal maximum output power of MIN {PPowerClass, PPowerClass,CA}**

* Proposals
	+ Option 1: Yes
	+ Option 2: No
* Recommended WF
	+ To be discussed

**Issue 2-2-6: Whether ue-PowerClassPerBandPerBC-r17 shall not exceed the maximum output power level of its parent inter-band UL combination power class powerClass/powerClass-v1610 when both UL bands are configured.**

* Proposals
	+ Option 1: Yes
	+ Option 2: No
* Recommended WF
	+ To be discussed

**Issue 2-2-7: In terms of DLCA only (with single UL), whether the applicable power (PCMAX, f,c) for this UL band is capped by powerClassof the band combination.**

* Proposals
	+ Option 1: Yes
	+ Option 2: No, allow UE to exceed PowerClass for non-CA UL transmissions when ue-Powerclass is higher thanPowerClass
* Recommended WF
	+ To be discussed

**Issue 2-2-8: For DLCA only (with single UL), which power class is applicable?**

Proposals

* + Option 1: ue-PowerClass
	+ Option 2: min{ue-PowerClass, PowerClass}
	+ Option 3: PowerClass if reported, min {ue-PowerClass, PowerClass of the parent BC} otherwise
	+ Option 4: Other
* Recommended WF
	+ To be discussed

# Topic #3: Reply LS on power scaling and PHR in 38.213 (R1-2310555)

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318961 | vivo | Proposal 1: No more reply LS to RAN1 is needed.Proposal 2: RAN4 requirements would not consider the power scaling factor ‘s’ issue. |

*The moderator can suggest a limited number of papers which could be presented.*

## Open issues summary

*Before f2f meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions..*

### Sub-topic 3-1:

*Sub-topic description:*

*Open issues and candidate options before f2f meeting:*

**Issue 3-1-1: Proposal 1: No more reply LS to RAN1 is needed.**

* Proposals
	+ Option 1: agreeable
	+ Option 2: not agreeable
* Recommended WF
	+ TBA

**Issue 3-1-2: Proposal 2: RAN4 requirements would not consider the power scaling factor ‘s’ issue.**

* Proposals
	+ Option 1: agreeable
	+ Option 2: not agreeable
* Recommended WF
	+ TBA

# Topic #4: Reply LS on applicability of requirements for RedCap UE

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2320545 | Ericsson | For a RedCap UE equipped with 1 Rx port or operating in HD-FDD mode for a FDD band, indicating a SUL band combination, there is no corresponding specification in current release of TS 38.101-1. As such the requirements in clause 7.3C in 38.101-1 [3] cannot be verified with REFSENS specified in clause 7.3I. |

*The moderator can suggest a limited number of papers which could be presented.*

## Open issues summary

*Before f2f meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions..*

### Sub-topic 4-1:

*Sub-topic description:*

*Open issues and candidate options before f2f meeting:*

**Issue 4-1-1: Can we agree with the proposal “For a RedCap UE equipped with 1 Rx port or operating in HD-FDD mode for a FDD band, indicating a SUL band combination, there is no corresponding specification in current release of TS 38.101-1. As such the requirements in clause 7.3C in 38.101-1 [3] cannot be verified with REFSENS specified in clause 7.3I?”**

* Proposals
	+ Option 1: agreeable
	+ Option 2: not agreeable
* Recommended WF
	+ TBA