**3GPP TSG-RAN WG4 Meeting # 102-e R4-220XXXX**

**Electronic Meeting, February 21st – March 3rd 2022**

**Agenda item:** 9.35

**Source:** Moderator (Qualcomm Incorporated)

**Title:** Email discussion summary for [102-e][118] NR\_Power\_Limit\_CA\_DC

**Document for:** Information

# Introduction

This document summarizes the email discussion for agenda item 9.35 on increasing the maximum output power for CA and DC. The work item (RP-212622) completion target is March 2022, so this is the last working group meeting to finalize the requirements and produce RAN4 CR’s to submit to RAN #95e. The objective for this meeting is to agree to CR’s for the introduction of this feature.

# Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2203555**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2203555.zip) | InterDigital Finland Oy | RF requirements proposals for Increased MOP for CA and DC  Obs 1: For inter-band CA maintaining PCMAX\_L using the old PPowerClass,CA makes this feature untestable.  Proposal 1: Maintain the current Pcmax for CA equations and define just the new MOP that would allow for increasing both Pcmax\_H and Pcmax\_L, making this feature testable.  Proposal 2: Add explanatory sentences in the Pcmax subclause regarding the PPowerClass or P ̂\_Total^(NR-DC) calculation/derivation for the case where the UE signals the UL Increased MOP capability while maintaining the integrity of the current Pcmax equations.  Proposal 3: Extend the powerClass by powerClass-v17.x.y to include the “PC3+PC2” with the mention that any applicable SAR duty cycles from the band combination are valid per band and are inherited. |
| [**R4-2203556**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2203556.zip) | InterDigital Finland Oy | Draft CR for Introduction of the Increased MOP for CA and DC feature |
| [**R4-2203688**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2203688.zip) | Apple | Increasing UE power high limit for CA and DC  Observation 1: The “summed” power (23dBm+26dBm) has a different power rating than PC2 (26dBm) which would cause confusion in power class definition.  Observation 2: With PCMAX\_L kept at PC2, we could simply increase PC2 upper tolerance without any other specifications change nor any capability signalling to enable the intended feature which however would also alter the original definition of PC2.  Observation 3: For the feature of this WI which we intend to achieve, the power “sum” is truly redundant.  Observation 4: For the method based on defining new power class for each different power composition, the impact to the specifications work and requirements development could be quite substantial.  Observation 5: the LUT method is no different from defining new power class for each different power composition but potentially adding even more power classes as compared to Option 2 method.  Observation 6: The new IE powerClass-v17 proposed in the LUT method is essentially redundant as the per band power class signaling should be sufficient to indicate the maximum total output power as intended in this work item.  Observation 7: Since the intended feature is to fully utilize each constituent band maximum output power capability, only the per-band outpower power requirement is of importance, and there is no need to define the combined PCMAX requirement for PC0.  Observation 8: PC0 applies where there is no regulatory UE total power limit, or the limit is equal to or higher than the total power capability of an UL CA combination.  Observation 9: There is no need to further define separate MSD requirements for PC0 with different UL CA power compositions other than PC2 and PC3.  Proposal 1: Introduce a new inter-band UL CA power class PC0 where the requirements would be based on per-band power capability. |
| [**R4-2204082**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204082.zip) | Huawei, HiSilicon | On Power class ambiguity and new power limit for NR inter-band CA  Observation 1: It has been recognised in RAN4 that keeping the lower bound P\_CMAX\_L unchanged has serious drawbacks, including that the new capability would become unverifiable and create no differentiations among UEs.  Observation 2: Keeping P\_CMAX\_L unchanged while increasing P\_CMAX\_H is equivalent to relaxing the upper tolerance of the UL CA power. No new capability/signalling would be needed.  Observation 3: The P\_CMAX\_L is always limited by the per-band power capabilities including MPR, A-MPR, etc. If a UE can meet the per-band output power requirements, it can also meet the new P\_CMAX\_L limit for CA w/o difficulty.  Proposal 1: Reuse the existing configured power formula for both P\_CMAX\_L and P\_CMAX\_H, and allow both to change with the UE power capability.  Observation 4: The power class ambiguity is a generic issue for band combinations with or without the use of TxD, regardless if the higher power limit is enabled or not.  Observation 5: Different MPR requirements may be applicable with or w/o TxD. Given that max 2Tx are supported under Rel-17, it can be safely assumed that TxD is not enabled when dual-UL CA is configured. The Tx switching is a special case, where TxD could be active when dual-UL transmission is switched to single-UL.  Proposal 2: To resolve the power class ambiguity issue, a UE shall report the power class per-band within a band combination.  Proposal 3: Given the dependency between the two issues as well as the R17 timeframe, it’s proposed to discuss and solve the power class ambiguity issue under the same WI of higher CA output power.  Proposal #4: Adopt the LUT-method as the solution for enabling higher MOP for inter-band CA, and inform RAN2 about the signaling requirement. |
| [**R4-2204083**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204083.zip) | Huawei, HiSilicon | Draft CR to TS38101-1 Addition of higher power limit for NR inter-band CA |
| [**R4-2204084**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204084.zip) | Huawei, HiSilicon | Draft LS to RAN2 on new Tx power limit for NR inter-band CA |
| [**R4-2204608**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204608.zip) | Ericsson | Draft LS to RAN2 on increasing UE power high limit for CA and DC  Proposal 1: reuse the existing signaling and define new power power classes for band combinations as needed for support of a higher UE power limit.  Proposal 2: ask RAN2 for an extension of the band-combination power class to e.g. powerClass-v17xy for a power class corresponding to PC3 + PC2 by sending the draft LS attached. |
| [**R4-2204734**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204734.zip) | Nokia, Nokia Shanghai Bell | UE RF requirements for the sum method  Proposal 1: The sum method is defined as follows.  - If a UE supporting the sum method capability, e.g., fullPowerUL-CA, for a CA band configuration also reports PC2 capability.  o This is needed for legacy networks which do not understand fullPowerUL-CA  - If the UE indicates fullPowerUL-CA, PPowerClass,CA in PCMAX\_H is replaced with 10\*log10∑pPowerClass,c while PPowerClass,CA in PCMAX\_L is NOT replaced with the 10\*log10∑pPowerClass,c which means PPowerClass,CA is PC2 in PCMAX\_L  - If the UE reports the additional PC(s) of each band within the UE capabilities of an UL CA band configuration and that is understood to override any per-band PC signalling that can limit the power  o This address a case that a PC per band is not the same as PC within a band combination like TxD.  Proposal 2: If PCMAX\_L is not increased and if the exiting MOP tolerance is reused, the MOP would be 27.8 dBm +2/-2.8 dB |
| [**R4-2204763**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204763.zip) | ZTE Corporation | On increasing UE maximum power for NR uplink inter band CA  Proposal 1. Keep the PCMAX\_L for the CA or DC configuration, and only the PCMAX\_H is raised by sum approach without a new power class is defined.  Proposal 2. Signaling shall be per-band-combination. |
| [**R4-2204814**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204814.zip) | Xiaomi | Discussion on increasing UE maximum power high limit  Proposal 1: in order to reduce the workload, it is suggested following conclusions shall be agreed.  PC3+PC2 for nominal combined power of PC2 is included as minimum scope to complete the WI. The scope can still be increased based on agreement, but at least PC3+PC2 will be included and is the focus for completing the WI.  The solution should be scalable for future power aggregation combinations. Guidelines and/or rules for scalability are TBD.  Single carrier MSD due to harmonics and harmonic mixing (i.e., sub-clause 7.3A.4 of 38.101-1), and MSD due to cross band isolation (i.e., sub-clause 7.3A.6 of 38.101-1) do not need to be reconsidered in this WI.  It is understood that 2UL IMD sensitivity may increase due to higher transmit powers, but also agreed that it is not necessary to reconsider the 2UL MSD requirement as it is currently specified.  Proposal 2: option 1 or 3 is our preference if no new MOP and MSD requirements are needed.  Proposal 3: If the total power high limit is increasing, the equation for calculating the average percentage of uplink symbols shall be changed as  DutyNR, x \*( PNR,x/ ∑ pPowerClass,c)\*SARratioNR, x + DutyNR, y \*(PNR, y/ ∑ pPowerClass,c)\* SARratioNR, y  However, if no consensus on duty cycle capability reporting, we also support the view that the WI can be closed only relying on P-MPR to address SAR issue. |
| [**R4-2204825**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204825.zip) | OPPO | R17 UE power class high limit  2.1 Pcmax\_L  Observation 1: There is no clear motivation for a UE to declare of this capability if it actually doesn’t support it.  Observation 2: There is no clear system degradation with no change of Pcmax\_L since UE with this capability will be as good as legacy UE if not better than it.  Observation 3: A simple, efficient and timely concluded approach in Rel-17 for raising UE max power approach will be important for Rel-18 new UE architecture discussions since there are more complicated PA configurations there.  Proposal 1: Keep Pcmax\_L unchanged for UEs with higher Tx power capability than the power class nominal power.  2.2 MSD  Observation 4: There is no Tx power limitation of harmonic, harmonic mixing and cross band isolation interference scenarios, and in RAN5 max Tx power is used in the testing with continues power UP command.  Observation 5: For UEs with higher power capability in one branch than the total band combination power class, increasing Tx power higher limit will increase the interference and also MSD.  Observation 6: To resolve the increased interference issue in single carrier MSD cases, it can either review the MSD, or limit max power capability of each branch in this WI, or define in the spec that max Tx power in testing is Pcmax\_L as IMD requirements.  Proposal 2: Specify UE Tx power for single carrier MSD as Pcmax\_L which is same as what has been defined for IMD requirements to avoid the increased interference issue.  Proposal 3: No MSD needs to be changed with the condition of Pcmax\_L unchanged with the precondition of Pcmax\_L is used in the single carrier MSD testing. |
| [**R4-2204939**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204939.zip) | vivo | Further discussion on the increasing UE power high limit for CA and DC  Proposal 1: PC3+PC2 is proposed as the minimum scope of this WI. The other power combinations is proposed to improve in the following release.  Proposal 2: Considering the scheduling of WI, option 1 is proposed to complete in this WI and option 3 is proposed to discuss in the following release.  Proposal 3: UE reporting an optional signaling to support increasing CA or DC MOP per band combination is proposed. |
| [**R4-2205177**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2205177.zip) | Apple | LS on new power class for inter-band UL CA and DC |
| [**R4-2205450**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2205450.zip) | NTT DOCOMO INC. | Discussion on increasing power limit of CA and DC  Observation 1: It was agreed in R4-2120064 that Pemax\_CA or equivalent mechanism needs to be in place to limit total power.  Observation 2: If Pemax on total maximum output power does not apply to UE supporting the new feature, there are concerns from the regulatory and NW operation points of view.  Observation 3: As far as we can see, solution provided in option 3 does not solve issues on regulatory aspect.  Proposal 1: Regardless of which options RAN4 will take, Pemax on total power for CA/DC still should apply to UE supporting the new feature of increasing maximum output power of CA/DC according to the previous agreement in R4-2120064.  Proposal 2: If option 3 means that Pemax on total maximum output power does not apply to UE supporting the new feature, option 3 should not be taken. |
| [**R4-2205865**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2205865.zip) | Skyworks Solutions Inc. | Valid 1Tx and 2Tx configurations for increased power option for inter-band CA  Proposal for signaling:  • A per UL band power class in inter-band CA configuration is introduced in Release 17  • For UL band where the single band power class can only be achieved with 2 Tx, the per band power class in inter-band CA configuration should signal a power class equivalent to its single band power class -3dB.  Proposal for valid configuration for increased power: UL configuration valid for increased power are those for which the power sum of the per-band power class in inter-band CA configuration is > CA power class and < CA power class + 2dB. |
| [**R4-2206106**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2206106.zip) | Qualcomm Incorporated | Increasing the maximum power limit for inter-band UL CA |

# Topic #1: Scope

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

The following proposals were made during RAN4 #101bis-e and appears to be generally agreeable.

* 1. PC3+PC2 for nominal combined power of PC2 is included as minimum scope to complete the WI. The scope can still be increased based on agreement, but at least PC3+PC2 will be included and is the focus for completing the WI.”
  2. The solution should be scalable for future power aggregation combinations. Guidelines and/or rules for scalability are TBD.

Contribution R4-2205865 from Skyworks elaborates on guidelines and rules for scalability with the following

* 1. Proposal for valid configuration for increased power: UL configuration valid for increased power are those for which the power sum of the per-band power class in inter-band CA configuration is > CA power class and < CA power class + 2dB.

### Sub-topic 1-1 Minimum scope

The moderator suggests to choose between two options to define the minimum scope of power aggregation combinations for this work item

Option 1: Agree on proposals 1 and 2

Option 2: Agree on proposals 1, 2, and 3

## Companies views’ collection for 1st round

### Open issues

Sub topic 1-1 Minimum scope

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| **Company** | **Comments** |
| Nokia | Neither  We agree with the following as the minimum scope.  PC3+PC2 for nominal combined power of PC2 is included as minimum scope to complete the WI. The scope can still be increased based on agreement, but at least PC3+PC2 will be included and is the focus for completing the WI.”  We are ok to address the following, but it should not prevent the WI from being completed.  The solution should be scalable for future power aggregation combinations. Guidelines and/or rules for scalability are TBD. |
| Huawei | We’re ok with option 2, however, strictly speaking, proposal 3 needs extra clarification, i.e. it is limited to dual UL CA. Additionally, PC3+PC5 has been requested by several companies. It should be completed as well, if time allows.  Proposal 3 could become useful when a band combination has only PC3 defined but not PC2 yet. Such band combinations should not use the higher power capability under discussion to go from 23 dBm to 27.8 dBm directly. Instead, the PC2 analysis as in TR 38.841/38.842 should be followed first. |
| Apple | Neither of the two options  We should avoid mixing up the new UE capability with the existing CA power class. For example, PC3+PC2 with the capability should no longer be called as PC2. Otherwise, how can we be sure the PC2 band under UL CA can reach PC2 power requirement? |
| Qualcomm | Generally ok with option 2, but agree with the comment from Nokia that PC3+PC2 is the minimum set to be included in a CR to close the WI. |

## Summary for 1st round

### Open issues

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

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|  | **Status summary** |
| **Sub-topic #1-1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |
| **Sub-topic #1-2** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

## Discussion on 2nd round (if applicable)

# Topic #2: PCMAX\_L

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

Option 1: Do not raise PCMAX\_L

* Since the combined power class is maintained (i.e., a new power class is not defined), then PCMAX\_L needs to be kept according to the power class
* Since PCMAX\_L is not raised, then MPR, A-MPR, MSD do not need to be re-evaluated. Timeline for Rel-17 can be met.
* Keeping PCMAX\_L enables greater flexibility in UE implementation
* There is no harm to the network if PCMAX\_L is not raised

Option 2: Do raise PCMAX\_L. This could be done by either defining a new power class (PC1.75 for example) or by clarification that for the UE signaling an increased power capability the PPowerClass,CA should be evaluated as the sum of the powers in each CC

* Raising PCMAX\_L ensures that system benefit of higher power is realized by mandating the UE to be able to transmit higher power. It makes the capability signaling meaningful and testable.
* MSD would likely need to be re-calculated unless it can be agreed that it is already covered by some other means.

Option 3: Adjust lower MOP tolerance to effectively require increased output power in PUMAX

## Open issues summary

### Sub-topic 2-1 PCMAX\_L

Choose among 3 options

## Companies views’ collection for 1st round

### Open issues

Sub topic 2-1 PCMAX\_L

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| **Company** | **Comments** |
| Nokia | As far as the sum method, i.e., option 1 in WF of R4-2202404 is taken, we accept option 1 as a compromise as the cost to make RAN4 workload smaller and specification simpler in order to deliver the necessary specification in a timely manner. |
| Huawei | P\_CMAX\_L should be allowed to change as per existing configured power formula, taking into account the increased max total power.  If it’s kept the same as PC2 (for 23+26 case), it’s equivalent to increase the upper tolerance of the total power. In this case, no new capability/signaling would be needed. As shown in our paper, a simple change to the power tolerance would achieve the same effect, which is duplicated below.  Table 6.2A.4.1.3-1: PCMAX tolerance for uplink inter-band CA (two bands)   |  |  |  | | --- | --- | --- | | PCMAX (dBm) | Tolerance TLOW(PCMAX) (dB) | Tolerance THIGH(PCMAX) (dB) | | 23 ≤ PCMAX ≤ ~~26~~ [27.8] | 3.0 | ~~2.0~~ [3.8] | | 22 ≤ PCMAX < 23 | 5.0 | 2.0 | | 21 ≤ PCMAX < 22 | 5.0 | 3.0 | | 20 ≤ PCMAX < 21 | 6.0 | 4.0 | | 16 ≤ PCMAX < 20 | 5.0 | | | 11 ≤ PCMAX < 16 | 6.0 | | | -40 ≤ PCMAX < 11 | 7.0 | |   Moreover, there appears to be some confusion around MSD and P\_CMAX\_L. MSD increases with higher tx power, which is enabled by P\_CMAX\_H. All options aim to increase Tx power, so the MSD situation is the same for all of them. |
| InterDigital | We prefer Option 2. It makes the feature testable and consistent. |
| Apple | None of the three options  It is again not clear to us why PPowerclass,CA would matter with this new feature. For example, with PC3+PC2 combination, all we want to be sure is that both the PC3 band and the PC2 band can reach their respective MOP under PCMAX. If the PC3+PC2 would be maintained as PC2, then even PC3 band failed to transmit any power under UL CA, it could still pass the UL CA MOP requirement as the sum of PUMAX is still within the PC2 PCMAX range. From UE and gNB link budget perspective, the per-band power class is what really matters, but not the sum of the power class. |
| Qualcomm | Similar to Nokia, we also accept option 1 recognizing the shortcoming of testability. On the other hand, if this feature is not introduced at all, then there would be no increase in power available, so we consider that even if the feature is not testable there is nothing lost and only possible gain to be made available. We are also ok with option 3 if companies prefer. |

## Summary for 1st round

### Open issues

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

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|  | **Status summary** |
| **Sub-topic #2-1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |
| **Sub-topic #2-2** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

## Discussion on 2nd round (if applicable)

# Topic #3: MSD

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

A concern on single carrier MSD due to harmonics and harmonic mixing (i.e., sub-clause 7.3A.4 of 38.101-1), and MSD due to cross band isolation (i.e., sub-clause 7.3A.6 of 38.101-1) was raised by OPPO in R4-2204825. The example provided is a PC3 band combination that is allowed to increase to 27.8 dBm. If this is agreed to be a problem, then the proposed solution is to limit the Tx power to PCMAX\_L, assuming that PCMAX\_L is not raised.

For dual uplink MSD, is a new MSD requirement and test needed with increased MOP?

* The specification defines a side condition for dual uplink MSD that the uplink carriers are set to min(20 dBm, PCMAX\_L,fc) for PC3 or min(23 dBm, PCMAX\_L,fc) for PC2. This means that 2UL MSD would not need to be recalculated irrespective of whether PCMAX\_L,fc is increased or not. If a new power class is defined, i.e., PC1.75, then it may be possible to reuse the “next lowest” power class MSD table to avoid recalculating MSD? If PC0 is defined, then it may be possible to agree that the MSD is already sufficiently tested with PC3 or PC2 single carrier configuration and no recalculation and additional testing of MSD is needed.
* On the other hand, would it be preferred to calculate a new MSD requirement and impose an additional test with increased output power?

## Open issues summary

### Sub-topic 3-1 Single carrier MSD

### Sub-topic 3-2 Dual UL IMD MSD

## Companies views’ collection for 1st round

### Open issues

Sub topic 3-1 Single carrier MSD

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| **Company** | **Comments** |
| Nokia | Before discussing the resolution, we’d like to better understand how the raised issue is related to this WI. The raised issues happen even for a PC2 band UL with 2 bands DL etc. Thus far, our understanding is that the raised issues are not specific to this WI. |
| Huawei | As pointed out in sub-topic 1-1, the PC3 example (from 23 dBm to 27.8 dBm) is invalid. The power increase should not be more than 2 dB if using the new feature.  As shown in TR 38.841/38.842 HPUE inter-band CA/DC, the max Tx power of the highest power class for the single UL is assumed for the MSD analysis for harmonic, harmonic mixing and cross-band isolation, which could be 26 dBm (PC2) or 29 dBm (PC1.5). Therefore, no extra analysis for single carrier MSD is needed to enable 27.8 dBm for 23+26, or similar cases. |
| InterDigital | Agree with Nokia. |
| Apple | The issue raised by OPPO in R4-2204825 is a good example that a PC3 combination may already have PC3+PC2 hardware capability. Now the question is do we need to introduce PC2 for such combination first before the new capability can be declared for the combination? In our view, it is not necessary as PC3+PC2 should not be considered as PC2. For any combination, at least the requirements for default power class (PC3) need to be specified first before the new capability can be declared. For the combination under the new capability, the MSD can be verified either based on PC2 or PC3 requirements whichever highest power class has been specified. If based on PC3 requirements, the aggressor UL power would be limited to 23dBm even its per-band power capability can go up to 26 dBm. This should have already been done for the existing PC3 band combinations where the UE has the PC2 hardware capability for either or both of the constituent bands. |
| Qualcomm | The example provided of 23+26 where the combination is defined for PC3 but then allowed to increase power to 27.8 dBm is outside of the scope of “increasing MOP”. 23+26 should be mapped to PC2, and then the power can be increased above 26 dBm. In this case, there does not appear to be a problem of single carrier MSD if our understanding is correct. |

Sub topic 3-2 Dual UL IMD MSD

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| **Company** | **Comments** |
| Nokia | At least if the methods other than the sum method with PCMAX\_L being kept were taken, all the MSD shall be revisited. It would be self-evident that a conventional new power class introduction and LUT methods require re-evaluation of the MSD since the power is surely always higher than the PC2.  Regarding PC0, in short, this tightens the lower limit of the total power and it also requires re-evaluation of MSD in our understanding. Suppose 26 dBm + 23 dBm with PC0, where each of the bands shall fulfill the MOP requirements during CA. Hence, even if we take the most conservative values such that 26 – 3 = 23 dBm and 23 – 2 = 21 dBm meaning that the total is 25.1 dBm. This is even higher than 23 dBm, which is PCMAX\_L =26 dBm(PC2) - tolerance = 3 dB. |
| Huawei | Once again, we’d like to point out that MSD increases with higher Tx power. All solutions aim to enable higher Tx power, so the MSD situation is the same for any solution.  As commented in the last meeting, the new feature under discussion is based on reusing a UE’s existing hardware capability. The Tx/Rx linearity has been checked by the PC2/PC3 MSD requirements. Re-evaluating MSD would result in slightly higher MSD (due to 1.8 dB Tx power increase), but it does not mean more stringent requirements on the UE. Therefore, the existing PC2/PC3 MSD requirements are sufficient. |
| Apple | As we commented in our earlier contributions, the MSD requirements are meant to verify the PA linearity, filter isolation, as well as receiver linearity performance. These performance can already be verified by the PC3 and PC2 UL CA requirements. There is no need to further define separate MSD requirements with different UL CA power compositions other than PC2 and PC3. This is similar to the situation that PC2 total power at 26dBm can be composed by (23dBm+23dBm) or (24dBm+21.7dBm), or many other different compositions, but there is no guarantee that (23dBm+23dBm) would always result in worst MSD. However, the specifications only define PC2 2UL MSD based on (23dBm+23dBm) UL configuration. |
| Qualcomm | If the common understanding is that increasing MOP is only a relatively small increase (i.e., <2 dB as Skyworks proposed), then the MSD requirement for the baseline MOP and tested at those power levels may be sufficient. If there is no baseline MOP, i.e., a new power class or PC0, then new MSD should be computed and tested. |

## Summary for 1st round

### Open issues

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

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|  | **Status summary** |
| **Sub-topic #3-1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |
| **Sub-topic #3-2** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

## Discussion on 2nd round (if applicable)

# Topic #4: Per CC capability (TxD UE)

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

Some companies believe that it is beneficial for the UE to signal its available maximum power per CC or CG when configured for CA or DC in case it is different from its reported max power for single carrier operation. A particular method by which a table is defined in the spec and an index into this table is signaled has been proposed by Huawei in R4-2204082. In R4-2205865 Skyworks also proposes further detail on allowed power class per CC that the power class is -3 dB compared to single carrier power class.

Other companies feel that this topic is more general and not specific to this work item. With respect to this work item, it is felt that as long as the increased power capability is optional, then the UE that is not able to increase power when configured for aggregation can simply not signal the capability. This is sufficient for the purpose of this work item.

## Open issues summary

### Sub-topic 4-1 Per CC capability (TxD UE)

Is per-CC power capability signaling needed for this work item? (yes/no)

If yes, is the following proposal also ok? (yes/no/alternative)

For UL band where the single band power class can only be achieved with 2 Tx, the per band power class in inter-band CA configuration should signal a power class equivalent to its single band power class -3dB

## Companies views’ collection for 1st round

### Open issues

Sub topic 4-1 Per CC capability

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| --- | --- |
| **Company** | **Comments** |
| Nokia | As far as the scope is 23 dBm + 26 dBm, we don’t think per-CC capability signaling is needed for this WI.  Though our answer for the 1st question is no, we’d like to share our views on the proposal by Skyworks.  We believe more clarification on the proposal is needed if we introduce a PC per band within a band combination. The delta may not be always - 3 dB as proposed. UE may achieve 26 dBm with 26 dBm + 23 dBm or 23 dBm + 23 dBm etc for a band. If we always assume - 3dB as proposed, we need to agree with a clear discipline that 2 Tx here means TxD and PA power is equally split. Or we just introduce a new capability similar to *powerClassNRPart-r16*. |
| Huawei | We believe the per-band per-BC signaling is necessary. We agree with the moderator that this issue is not specific to the WI, but the WI has dependency on the per-band power class. The group has discussed the issue in this thread for several meetings. Given that this is the last meeting for R17, there seems to be no better place to resolve this urgent issue that may affect all HPUE band combinations.  Even for the 23+26 case, the signaling is necessary. This has been pointed by Apple and Huawei since last meeting. More explicitly, for TDD BC such as CA\_n40A-41A, CA\_n41A-n77A, the UE may report PC2 on both TDD bands for single carrier operations. But for those CAs, the UE may only support 23+26, since the UE could share the PC3 PA between TDD and FDD bands.  If not explicitly signaled, the network/TE may incorrectly assume 26+26 for band combinations. This is a case even without TxD involved.  For the TxD case, we have similar questions as Nokia. Is it a formal agreement in the TxD WI that 23+26 or 26+26 are not allowed to declare TxD for PC2?  We prefer to separate the TxD reporting from per-band per-BC power class reporting. Deriving per-band per-BC power class from TxD signaling seems to be problematic and unreliable. Explicit signaling is preferred. |
| InterDigital | Per band power capability (band combination) is enough. |
| Apple | The per CC (or per band) power capability is needed only when the per-band power class under UL CA configuration is different from single band power class. This issue already happens to PC2 UL CA and not limited to the case where the single band power class is achieved by 2Tx. For example, a UE may have only 1 PC2 PA and 1 PC3 PA which are shared by multiple bands. The PC2 PA may be shared by Band A and Band B in single band operation. However, when Band A and Band B are aggregated for UL CA, one of the bands can only use PC3 PA. In this case, the per-band power class under UL CA would be different from its single band power class.  It is worth noting that the power class for single UL CA can also be signaled with different power class than its single band power class as they are independently signaled. |
| Qualcomm | Not needed for this WI since the capability signaling is optional and therefore UE’s that aren’t able to meet the power requirement when configured for CA/DC don’t need to signal it. |

## Summary for 1st round

### Open issues

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

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic #4-1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

## Discussion on 2nd round (if applicable)

# Topic #5: Total power limit

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

A concern was raised by NTT DoCoMo in R4-2205450 that some countries have regulations that limit the total output power of the UE and a way forward was previously agreed that a Pemax or similar mechanism would be available on total power. Yet, the PC0 proposal by Apple in R4-2203688 removes requirements on total power relying solely on the requirements of each CC independently.

Option 1. PC0 is modified to incorporate a Pemax limit on total power as previously agreed in the way forward. Please explain the modifications required.

Option 2. Power limits can be applied per CC, even if this reduces flexibility in allocating power between the two CC’s.

Option 3. The increased power capability is not applicable for those band combinations used in countries where there is a total power limit. This would disallow increased power for those band combinations in other countries as well.

Option 4. A non-standardized UE implementation is assumed to limit the total power as necessary to comply with regulations.

Option 5. PC0 approach is discarded since it does not provide the ability to limit the total power and the advantages of PC0 are available in other options.

## Open issues summary

### Sub-topic 5-1 Total power limit

Choose among 5 options

## Companies views’ collection for 1st round

### Open issues

Sub topic 5-1 Total power limit

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia | Option 5.  We should keep the previous agreement.  If the option 1 was taken, PC0 proposal would become (almost) the same as the sum method. The per CC limit by network configuration will artificially kill the benefit of UE’s inherited ability of 23 dBm + 26 dBm. Because if the network wants to use the UE with PC0 up to the total power of 23 dBm, each Cell needs to be limited to 20 dBm each but if the total power consisting of two Cells can be limited by 23 dBm, this makes e.g., 17 dBm + 21 dBm possible. |
| Huawei | Option 5  The network should be able to control the total Tx power from a UE. This actually gives more flexibility to the UE compared with the per-CC limit, which the UE could leverage to optimize heat dissipation, SAR compliance, etc.  The total power limit may not be just regulatory requirements for limited regions. In many countries, there could be the need for the network to reduce the UE Tx power in hospitals or other sensitive locations.  Additionally, the PC0 method seems to abandon the requirement for the configured Tx power for CA and relies on the single-carrier requirement only. From conformance point of view, it’s also necessary to verify the UE performance when transmitting from both UL simultaneously. Hence the requirement on the total CA power should be kept. |
| InterDigital | Option 5. |
| Apple | We would like to clarify that our PC0 proposal is not meant to remove the PEMAX,CA requirement, but to avoid using the sum of the power classes which in our view is redundant. In general, the concern raised by NTT Docomo should not exist as even PEMAX,CA is not explicitly specified for PC0, the UE should always recognize the PEMAX,CA broadcast by the network and follow the regulation. We do not believe UE vendors would configure their devices to intentionally violate the regulations under any power classes including PC0.  Nonetheless, to ease the concern that the PEMAX,CA requirement not being explicitly specified, the proposed “Configured transmitted power for Inter-band CA power class 0” can be modified to as below,    Also to Huawei’s comment, PC0 requirement is verified when both ULs are transmitting at PCMAX simultaneously, not one at a time. As we commented earlier, if per-band power requirement is met, the total power sum is automatically met. Why do we have to bother to measure the sum of the power again or do the mathematical sum from the measured power for each band? The real issue would be if we only verify the total CA power but not check the power from each individual band, the UE could still pass the requirement even if one of the bands failed to transmit any power. |
| Qualcomm | As agreed in previous WF, a total power limit needs to be available. Hence, a combined Pcmax is needed which we propose to be constructed by the sum method. Therefore, the PC0 proposal does not seem to accommodate this, so our preference is option 5. But we could consider option 1 if a workable solution is provided including the Pcmax equation (the text above in Apple’s comment is not sufficient for us). |

## Summary for 1st round

### Open issues

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

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic #5-1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

### CRs/TPs

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

*Note: The tdoc decisions shall be provided in Section 3 and this table is optional in case moderators would like to provide additional information.*

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

## Discussion on 2nd round (if applicable)

# Topic #6: Others

## Open issues summary

### Sub-topic 6-1 SAR

A contribution from Xiaomi in R4-2204814 proposes to modify the equation for average percentage of uplink symbols by replacing P26 with ∑ pPowerClass,c as follows

DutyNR, x \*( PNR,x/ ∑ pPowerClass,c)\*SARratioNR, x + DutyNR, y \*(PNR, y/ ∑ pPowerClass,c)\* SARratioNR, y

Is this agreeable? (Yes, no, or alternative)

## Companies views’ collection for 1st round

### Open issues

Sub topic 6-1 SAR

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia | We respectfully disagree with the proposal. As we commented for a few meetings, the derived UL Duty Cycle with scaling becomes very conservative. We don’t say that this is wrong, and we can say that the derived value would be safe. But this must not be suitable to make maximum use of the UE’s ability. This will create a very unfortunate situation for both UE and NW since network has to limit the duty cycle assuming that the UE can achieve 27.8 dBm, even if the UE may not be able to reach the respective rated PCs. |
| Apple | We understand the formula might originate from the PC2 inter-band UL CA WI. Can anyone explain what do we intend to achieve with this formula? Was it intended to request the network to dynamically schedule the Band x and Band y UL duty cycles based on their respective output power? |
| Qualcomm | We would prefer to further consider this rather than to agree to it now. This could be addressed (if needed) in the future as TEI or as maintenance. |

## Summary for 1st round

### Open issues

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

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic #5-1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

# Topic #7: CR’s and LS’s

CR’s and LS’s need to be agreed this meeting in order to finalize the work item according to schedule.

The following options have been discussed

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Option | Description | Pros | Cons | CR or draft CR | LS |
| 1 | Sum method. PCMAX\_L is or is not raised. | Minimal spec changes  Generic approach for future flexibility | Increased power is not testable | R4-2206106  R4-2203556 (this CR also increases PCMAX\_L) |  |
| 2 | New power class, PC1.75 for PC3+PC2 | No new signaling is required, only a new enumeration on power class | The number of new power classes can become very large |  | R4-2204608 |
| 3 | PC0 where no requirements on combined power, but only individually on each CC/CG | Minimal spec changes  General approach for future flexibility | The total power cannot be limited |  | R4-2205177 |
| 4 | Indexed LUT where per-CC power is identified for each combined PC | Removes ambiguity about power capability per CC when configured for CA/DC | The number of configurations can become very large  The capability per CC is a generic topic not specific to this work item | R4-2204083 | R4-2204084 |

### CRs/TPs comments collection

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

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| R4-2206106 | Nokia: We support the CR in principle, though some modification may be needed depending on the outcome of the discussion. |
| Huawei: The P\_CMAX\_L should also be changed. The per-band power class ambiguity issue remains. Note 7 only addresses FDD+TDD CA, what about TDD+TDD? Last question for clarification: is the new [HigherPowerLimitCADC] signaling per-BC or not? |
| Apple: We have concern with the principle of the CR since it has a couple of issues as we point out in R4-2203688 for Option 1 approach. For example, (23dBm+26dBm) has a different power rating than PC2 (26dBm) which would cause confusion in power class definition. Also, if (23dBm+26dBm) would still be defined as PC2, we could simply increase PC2 upper tolerance without any other specifications change nor any capability signaling to enable the intended feature which however would also alter the original definition of PC2. |
| Qualcomm: To Huawei, the [HigherPowerLimitCADC] should be per-BC. An LS to RAN2 would be needed. Some better wording and other modifications may be needed in a revision for the CR. |
|  |
|  |
| R4-2203556 | Nokia: We guess this proposal would be the introduction of the sum method together with new power classes? while “the PPowerClass,CA parameter is replaced by the derived value” is not very clear. What is the derived value? On the other hand, the introduction of a new power class *powerClass-v17.x.y*, is proposed. Overall, we believe that R4-2206106 is the basis for the further revisions if necessary. |
| Huawei: We share similar concerns as Nokia. The CR is not very clear. Plus, the NR-DC power control has not been discussed much in this WI. We’re open to discuss it in the future but not ready to change it in this meeting. |
| IDC: Some clarifications:  I guess, I have to explain the intention of this draft CR. Derivation of the PPowerClass,CA value means that is kept out of the equations, and this is for future flexibility. Also, it mean that we can place it in the text describing PPowerClass,CA parameter or somewhere else.  The *powerClass-v17.x.y*, capability is extended to describe the per band power and eventually the total limit, that may not be exactly the pure sum of the per band powers.  So, probably it is a matter of semantics, rather than essential decisions, and thus I kept the draft CR text at a minimal impact, while allowing for Pcmax\_L to increase accordingly. |
| Apple: The proposed draft CR seemed to try to combine different options being considered but the real requirements are not clearly specified. |
| Qualcomm: With the comment from IDC, we think that having a more complete CR would help to see the whole picture. As it is, we were also a bit unclear on the exact proposal. |
|  |
| R4-2204083 | Thanks Huawei for the draft CR, but we cannot agree with this. This makes the existing situation more complicate. |
| Huawei: To Nokia. The proposed table contains more entries other than 23+26 and 23+20. The purpose is to explicitly report the per-band power classes and solve the power class ambiguity issue. Two birds with one stone.  To Moderator: we’d like to request a revision to change the CA power tolerance table as suggested in Qualcomm’s CR. |
| Apple: We have concern with the principle of this CR as the LUT method is no different from defining new power class for each different power composition but potentially adding even more power classes as compared to Option 2 method. For example, indices 0, 1, 2, and 5 are already covered by existing PC2. It is not clear why we need to introduce additional 4 power classes to replace the existing PC2 requirements. The impact to the specifications complexity needs to be justified. |
| Qualcomm: We don’t think it is necessary to include the per-CC capability reporting in this WI. Although Huawei mentions “Two birds with one stone”, the work item is only targeting one bird. The second bird on power class ambiguity of power class should be treated separately. Otherwise, what is the point of having WID’s with TU’s and objectives and project management if RAN4 is going to extend the scope of the work beyond what was agreed in the WID? For the purpose of this WI, we think optional capability signaling is enough. |
|  |
|  |

## Summary for 1st round

### CRs/TPs

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

*Note: The tdoc decisions shall be provided in Section 3 and this table is optional in case moderators would like to provide additional information.*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |
| R4-2206106 |  |
| R4-2203556 |  |
| R4-2204083 |  |

## Discussion on 2nd round (if applicable)

# Recommendations for Tdocs

## 1st round

**New tdocs**

|  |  |  |
| --- | --- | --- |
| **Title** | **Source** | **Comments** |
| WF on … | YYY |  |
| LS on … | ZZZ | To: RAN\_X; Cc: RAN\_Y |
|  |  |  |

**Existing tdocs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
| [**R4-2203555**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2203555.zip) | RF requirements proposals for Increased MOP for CA and DC | InterDigital Finland Oy |  |  |
| [**R4-2203556**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2203556.zip) | Draft CR for Introduction of the Increased MOP for CA and DC feature | InterDigital Finland Oy |  |  |
| [**R4-2203688**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2203688.zip) | Increasing UE power high limit for CA and DC | Apple |  |  |
| [**R4-2204082**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204082.zip) | On Power class ambiguity and new power limit for NR inter-band CA | Huawei, HiSilicon |  |  |
| [**R4-2204083**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204083.zip) | Draft CR to TS38101-1 Addition of higher power limit for NR inter-band CA | Huawei, HiSilicon |  |  |
| [**R4-2204084**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204084.zip) | Draft LS to RAN2 on new Tx power limit for NR inter-band CA | Huawei, HiSilicon |  |  |
| [**R4-2204608**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204608.zip) | Draft LS to RAN2 on increasing UE power high limit for CA and DC | Ericsson |  |  |
| [**R4-2204734**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204734.zip) | UE RF requirements for the sum method | Nokia, Nokia Shanghai Bell |  |  |
| [**R4-2204763**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204763.zip) | On increasing UE maximum power for NR uplink inter band CA | ZTE Corporation |  |  |
| [**R4-2204814**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204814.zip) | Discussion on increasing UE maximum power high limit | Xiaomi |  |  |
| [**R4-2204825**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204825.zip) | R17 UE power class high limit | OPPO |  |  |
| [**R4-2204939**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204939.zip) | Further discussion on the increasing UE power high limit for CA and DC | vivo |  |  |
| [**R4-2205177**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2205177.zip) | LS on new power class for inter-band UL CA and DC | Apple |  |  |
| [**R4-2205450**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2205450.zip) | Discussion on increasing power limit of CA and DC | NTT DOCOMO INC. |  |  |
| [**R4-2205865**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2205865.zip) | Valid 1Tx and 2Tx configurations for increased power option for inter-band CA | Skyworks Solutions Inc. |  |  |
| [**R4-2206106**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2206106.zip) | Increasing the maximum power limit for inter-band UL CA | Qualcomm Incorporated |  |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics incl. existing and new tdocs.
2. For the Recommendation column please include one of the following:
   1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
   2. Other documents: Agreeable, Revised, Noted
3. For new LS documents, please include information on To/Cc WGs in the comments column
4. Do not include hyper-links in the documents

## 2nd round

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
| R4-210xxxx | WF on … | YYY | Agreeable, Revised, Noted |  |
| R4-210xxxx | LS on … | ZZZ | Agreeable, Revised, Noted |  |
|  |  |  |  |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics.
2. For the Recommendation column please include one of the following:
   1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
   2. Other documents: Agreeable, Revised, Noted
3. Do not include hyper-links in the documents

# Annex

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Note:

1. Please add your contact information in above table once you make comments on this email thread.
2. If multiple delegates from the same company make comments on single email thread, please add you name as suffix after company name when make comments i.e. Company A (XX, XX)