**3GPP TSG-RAN WG4 Meeting #94-e R4-2002697**

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

**Agenda item:** 8.14.1.9

**Source:** Moderator (Samsung)

**Title:** Email discussion summary for RAN4#94e\_#24\_NR\_RF\_FR2\_req\_enh\_Part\_5

**Document for:** Information

# Introduction

The Rel-16 work item on FR2 RF enhancements contains the following study objective:

*“This work item will also study if FR2 UE spherical coverage requirements for PC3 for >20%-tile can be defined”*

During the RAN4 #93 meeting a way forward of R4-1916184 captured potential alternatives related to this objective:



The scope of RAN4 #94-e is to collect the companies view and discuss whether/how to enhance the current requirement during the WI period given the study objective and previous WF.

In this regard, the email discussion using this thread aims to have a common understanding of whether/how RAN4 moves forward for the spherical coverage improvement. To support that target and to make a progress, the email discussion will focus on following three open issues based on the contributions:

1. Contributing factors/parameters for re-evaluating spherical coverage for handheld UE type
2. Method to specify possible enhancements
3. Work plan for possible enhancements

Further details can be found in Section 1.2, and the candidate target for each round can be set up as below.

* 1st round: Collect companies view on the open issues, and summarize the possible way forwards of each open issue
* 2nd round: Further discuss the summary of 1st round, and find the tentative agreements on whether/how to move forward for the spherical coverage improvement in RAN4.

Companies are strongly encouraged to provide comments/concerns within the period of each stage as RAN4 chair announced. It is also guided that each company/delegate consolidate their comments/views and send them out in one email.

# Topic #1: Improvement of spherical coverage requirements for PC3

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2000020  [1] | Apple | **Proposal 1: Any change to the %-tile value or dBm value of the EIRP spherical coverage requirement for an already defined Rel-15 power class in any subsequent release violates the assumption on power class release independence and shall be precluded.** |
| R4-2000317  [2] | Samsung | Observation 1: The current spherical coverage requirement is based on the result of extensive discussions such as real product considerations and network performance analysis during the Rel-15 timeframe.  Observation 2: Parameters considered during the Rel-15 is thorough enough in UE design aspect, hence no further parameters can be considered to enhance spherical coverage requirement.  Observation 3: RAN4 should consider how to improve the future UE or to design a new work plan for the enhancement rather than how to overturn the previous agreement from the same data provided 2 years ago.  Observation 4: Current Rel-15 spherical coverage requirement does not have implication on the number of panel UE implements, and the panel number does not necessarily mean a criterion of the spherical coverage or UE performance unless all UEs shall share the same form factor and design principle.  Observation 5: Multiple requirements for various possible UE designs would not only limit the UE implementation flexibility, but also might break out of the role of RAN4 specifications.  Observation 6: In view of the history of RAN4, current requirement of 50%-tile is inevitable decision considering the UE implementation impact and its network performance.  Observation 7: Alt 2 will lead the new power class to a sub part of the current PC3 since there is no upper tolerance in each power class of FR2.  **Proposal 1: The spherical coverage enhancement can be discussed only if there is a common understanding of its necessity or benefits.**  **Proposal 2: If needed according to the discussion, RAN4 should set up a new work plan and consider other parameters that might help the spherical coverage but missed in the previous work.** |
| R4-2000750  [3] | Vivo | Observation1: Rel-15 spherical coverage for PC3 were settled for handheld UE after long evaluation and are results of balance and difficult compromises.  Observation 2: RAN4 usually doing RF requirements enhancement based on long evolvement of implementation and sufficient test on commercial products.  Observation 3: Basic assumptions could be discussed when enhancement requirements would be discussed, however, serious technical analysis is not likely to be done considering Rel-16 time frame.  **Proposal: Discuss basic assumptions in Rel-16 and starting technical analysis in Rel-17.** |
| R4-2000956  [4] | Intel | Observation 1: Keeping a singular percentile point for each power class is sufficient and preferred.  **Proposal 1: Each FR2 power class will have a single percentile point. This can be considered the default or baseline assumption.**  Observation 2: Increasing the current EIRP level of the 50%-tile point can a reasonable enhancement, but it may take time to reach an agreement on the tightening value.  Observation 3: Introducing a new power class for an enhanced handheld UE needs to be supported by sufficient data to indicate the enhancements are achievable with the constraints of the form factor.  Observation 4: The significantly greater impact removing multi-band relaxations will have beyond the spherical coverage requirements of PC3, make this a more complicated option.  **Proposal 2: Do not remove multi-band relaxations in Rel-16.** |
| R4-2001233  [5] | OPPO | Observation 1: Rel-15 spherical coverage requirement definition is based on the assumption of UE implemented with one or two antenna panels implemented.  Observation 2: Without big improvement in UE design and antenna panel design, the implementation constrains will be same as Rel-15, and spherical coverage performance is expected to be the same.  **Proposal 1: The Alt 1, i.e. enhance spherical coverage requirements by enhance %-tile or dBm, is not considered before there is big improvement in UE design and antenna panel design.**  Observation 3: FR2 power class is mapped to certain UE type, and it is not clear what kind of new handheld UE type with less constrains in antenna module implementation that the alt 2 actually is targeting.  **Proposal 2: Further clarify which kind of new handheld UE type that the Alt 2 is targeting before discuss the spherical coverage enhancement and the introduction of new power class.** |
| R4-2001495  [6] | Sony | Observation 1: The EIRP spherical coverage performance of many currently available handheld UEs exceeds the current requirements set for power class 3 (PC3). Therefore, there is room for enhancing the PC3 spherical coverage.  Observation 2: Improvements of EIRP spherical coverage values of handheld UEs (see Figure 1) translate directly into NR network performance improvements (see Figure 5).  **Proposal 1: A new power class for high performance handheld UEs, which should have significantly more stringent EIRP spherical coverage requirements than those of current PC3 but still based on a handheld UE form factor.**  **Proposal 2: For the optional new power class for handheld devices, the EIRP spherical coverage requirements of the new power class can be formulated as**  • 50%-tile EIRP spherical coverage value of [15.5] dBm or better  and/or  • 20%-tile EIRP spherical coverage value of [11.5] dBm or better  Other power class related parameter can be for further study.  **Proposal 3: Supporting the new power class can be designed be an optional and dynamic feature of handheld UEs.** |
| R4-2002113  [7] | NTT DOCOMO | **Proposal 1: Define the enhanced spherical coverage requirement using the improved practical factors  - The number of antenna panels is assumed to be more than 2 panels.  - Other improved practical factors is not precluded.**  **Proposal 2: Evaluate the required practical factors to achieve the targeted value of enhanced spherical coverage requirement of 18dBm@CDF 35%-tile.**  **Proposal 3:  - RAN4#94-e:**  > Capture the input of the feasibility studies in TR   > Clarify which practical factors need to be improved to enhance spherical  coverage requirements  **- RAN4#94bis:**   > Decide the value of the enhanced spherical coverage requirements.  : Option1: Specify a X %-tile for 11.5dBm EIRP spherical coverage  value  : Option2: Specify a 50%-tile for Y dBm EIRP spherical coverage value  : Option3: Specify a X%-tile for Y dBm EIRP spherical coverage value  > Decide how to specify the new requirements, and send LS to RAN2 if it  has impact on RAN2 signalling.  : Option A: Introduce new power class  : Option B: Introduce new UE capability to enhance the spherical  coverage value of power class 3  > Other options are not precluded.  **- RAN4#95:**  > Approve final CR in Rel-16, or/and make RAN4 agreement to introduce  Rel-17 WI related to enhanced spherical coverage requirements.  > Approve TP about the summary of the feasibility studies in TR if needed. |

## Open issues summary

### Sub-topic 1-1: Contributing factors/parameters for re-evaluating spherical coverage for handheld UE type

*Sub-topic description: As noted in WID, i.e. “study if FR2 UE spherical coverage requirements for PC3 for >20%-tile can be defined”, it is highly recommended to clarify the factors that might improve the spherical coverage performance of PC3 UE before the discussion on enhancements of the requirement. The factors already have been considered in Rel-15 can be found in [2].*

*Related contributions: [2], [3], [5], [6], [7]*

* Proposals
  + Option 1: No more at this stage / FFS
  + Option 2: Based on more than 1 panel assumptions of Rel-15
* Companies view

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| **Company** | **Comments** |
| LG Electronics | Our position is Option 1.  RAN4 defined the current Rel-15 spherical coverage requirements for PC3 after a lot of technical discussion based on companies’ measurement results. At this moment, we don’t see the point in enhancing the spherical coverage requirements. According to the agreement on power class definition in FR2, a certain UE type is mapped to a single power class, and a single spherical coverage EIRP requirement has been defined per power class. If additional power class or spherical coverage is introduced for the same UE type, too many power classes for FR2 would be defined in further release. |
| OPPO | Suggest Option 1.  Spherical coverage actually highly rely on UE antenna performance and also number of antenna modules implemented. Without big improvement in UE design and antenna panel design, the antenna panel performance and also implementation constrains will be expected to be the same. |
| MediaTek | We support “Option 1”. Furthermore, Rel-15 is actually not limited to 1 antenna panel in our understanding. |
| Apple | Option 1 |
| Huawei | We suggest Option 1. And we provide reason and raise question in subtopic 1-2. |
| NTT DOCOMO, INC: | For LG, about the number of power classes, we are open how to introduce a new requirement. As mentioned in R4-1909981 and R4-1911715, we have the same concern about the increasing number of power classes in the future specification. Therefore, we proposed to use a capability approach to enhance PC3 spherical coverage requirement similar to PC2 framework in NR FR1, which is also pointed out by Sony in this meeting. Another way is to specify the requirement of each power class so that we specify the power class feature (i.e., Max TRP, Max EIRP, Min peak EIRP, and spherical coverage EIRP) far away from each other in order to reduce the number of power classes. For UE types, although we think UE type is just an assumption, the most effective way to reduce the number of power classes is to remove UE type definition, and then we can develop any type of UEs in future without introduction of new power classes. NW does not care whether a UE is handheld or non-handheld, but care about what power requirements and/or other requirements the UE has. We would like to know your preference on how to introduce.  For LG and OPPO, about the number of antenna modules, this is a fact that Rel-15 requirement was specified based on the analysis between one panel and two panels assumption. However, we can see that real products implement three or four modules. There is a difference between 3GPP assumption and real products. Would you mean it is impossible to implement more than two panels, or it is difficult to enhance spherical coverage performance with more than two panels? |
| Samsung | We support Option 1. As explained in our paper, parameters considered during the Rel-15 is thorough enough in UE design aspect. Current Rel-15 spherical coverage requirement does not have implication on the number of panel UE implements, and the panel number does not necessarily mean a criterion of the spherical coverage or UE performance |
| SONY | We think option 2 can be a feasible assumption. For PC3 spherical coverage, the requirement was defined as a compromised value between 1 antenna panel and 2 antenna panels. In our view, handheld UEs can be equipped with more than 1 (or even more than 2) panel and perform better than mandated by PC3 in terms of spherical coverage. |
| Intel | Option 1 |

### Sub-topic 1-2: Method to specify possible enhancements

*Sub-topic description: Currently, the FR2 power classes are specified based on the UE type assumptions. Since PC3 is already designed for handheld Ues which is the objective of this topic, it is important to discuss how to specify the possible enhanced requirement if it is necessary in the future.*

*Related contributions: [1], [2], [3], [4], [5], [6], [7]*

* Proposals
  + Option 1: No change
  + Option 2: Update the requirement of PC3
    1. Change or add to the Rel-15 requirements
  + Option 3: Introduce new power class for handheld UE

1. Optional and dynamic feature of handheld Ues

* Companies view

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| **Company** | **Comments** |
| LG Electronics | In Rel-15 phase, companies provided EIRP CDF curves by considering their own form factors of UE and it will impact on developing FR2 PC3 UE if any spherical coverage requirements are updated. As mentioned in subtopic 1-1, we prefer to keep FR2 power class definition; single power class is mapped certain UE type. Therefore, we support option 1. |
| OPPO | Suggest Option 1.  As mentioned in sub-topic 1-1, without big improvement in UE design and antenna panel design, the implementation constrains will be same as Rel-15, and spherical coverage performance is expected to be the same.  Besides, in FR2 the power class is mapped to certain UE type, for example the PC3 actually is handheld UE. Introduce a new power class, in other words new UE type within handheld UE. It is a little difficult to understand what kind of handheld UE actually is different from today’s smart phone and has less constrains in UE antenna module implementation. When there is clear picture, maybe this can be further discussed how to define the improved spherical coverage requirement. |
| MediaTek | We support “Option 1”.  About “Option 3”, whether or not to introduce another power class for handheld UE can be further discussed. But there is no need to rush it in Rel-16. |
| Apple | Option 1. As we had shown in our paper, modifying any parameter of the power class requirement in a subsequent release has no precedence in 3GPP, and Option 2 shall be precluded. Regarding Option 3, we do not see a strong need for a new handheld UE power class at this time, and we do not see the motivation to reach such an agreement in RAN4. Possible discussions around Option 3 should be held at the RAN Plenary level, since they impact future 3GPP work scope. |
| Huawei | We suggest Option 1, since spherical coverage requirement at this stage may not get improved much considering the UE form factor, chipset size, antenna placement on FR2 (and already many FR1 antennas), there are many integration problems on UE production.  But there is one issue we think need to be clarified. Whether RAN4 agrees on one power class corresponds to only one UE type? In our understanding, RAN4 has discussed this issue in year 2018, after that we change the spec that one power class only based on a certain assumption, it doesn’t mean PC3 can only be handheld UE or PC2 can only be vehicle UE. It may be the start line of our discussion in the next step of this topic. |
| NTT DOCOMO, INC. | For LG, we would like to know the reason why you prefer that single power class is mapped with certaion UE type.  For OPPO, the difference of UE design is the number of antenna panels as mentioned in subtopic 1-1. We think PC2 and PC3 for NR FR1 is specified for smartphone or other eMBB, where two power requirements are within one UE type of handheld UE. We appreciate if you could further clarify your concern.  For Apple, we don’t try to modify the parameter of the power class requirement in Rel-15, but try to introduce additional parameter set in PC3 in Rel-16. So there will be two parameter sets within PC3 such as the existing parameter set for Rel-15 and the new parameter set for enhanced handheld UE. We can compromise to introduce new PC if there is a strong concern to introduce additional parameter sets within PC3. PC3 spherical coverage enhancement is already included in a scope of UE RF FR2 enhancement WI based on RAN Plenary decision, and many companies cosigned the approved WF R4-1916184 in the last meeting, so we think RAN4 can make a decision on spherical coverage enhancement. |
| Samsung | We support Option 1. Other options can be discussed only if there is a common understanding of contributing factors for re-evaluating in RAN4. |
| SONY | Option 3: Introduce new power class for handheld UEs. In our view, The PC 3 can still be the default power class for handheld UEs, but the new power class can be optional feature (3a). |

### Sub-topic 1-3: Work plan for possible enhancements

*Sub-topic description: Given the insufficient discussion until last meeting and limited time schedule of the WI and Rel-16 to go, the work plan for possible enhancements also need to be discussed. Based on the work plan, a way forward for this objective can be further clarified with the discussion about other sub-topics.*

*Related contributions: [2], [3], [4], [5], [7]*

* Proposals
  + Option 1: Discuss additional factors in Rel-16, and technical analysis in Rel-17 if necessary
  + Option 2: Discuss and decide the enhanced value of the requirements in Rel-16 (until RAN4 #95)
* Companies view

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| **Company** | **Comments** |
| OPPO | Our suggestion is the discussion can happen only when there is big improvement in UE design and antenna panel design which leads to less implementation constrains comparing to Rel-15, otherwise, spherical coverage performance is expected to be the same. |
| Apple | As we had shown in our paper, modifying any parameter of the power class requirement in a subsequent release has no precedence in 3GPP. Thus, both of the options are out of scope of this work item. |
| Vivo | We are open to discuss factors that could be enhanced. However, R17 might be more realistic for technical discussion and evaluation. |
| NTT DOCOMO, INC. | RAN4 should follow the approved WF, and firstly study the possible enhancement 1 and 2. After that we will discuss how to introduce in specification. |
| Samsung | We support Option 1. RAN4 can discuss possible contributing factors in Rel-16. However, no further discussion for Rel-17 is needed if no further parameter can be found during Rel-16. |
| SONY | Option 1: We think it is at least possible to study the feasibility of enhancement for Rel-16 and give the technical analysis for Rel-17. |
| Intel | Our view is that we should discuss additional factors in Rel-16 |

## Summary for 1st round

### Open issues

* Sub-topic 1-1: Contributing factors/parameters for re-evaluating spherical coverage for handheld UE type
  + Option 1: Supported by (7) companies
  + Option 2: Supported by (2) companies
* Sub-topic 1-2: Method to specify possible enhancements
  + Option 1: Supported by (6) companies
  + Option 2: Supported by (0) companies (+1 company is open to discuss)
  + Option 3: Supported by (1) companies (+2 companies are open to discuss)
* Sub-topic 1-3: Work plan for possible enhancements
  + Option 1: Supported by (5) companies
  + Option 2: Supported by (0) companies
  + Others: Supported by (2) companies

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|  | **Status summary** |
| **Sub-topic#1** | ***1st round comments summary:***  - Majority companies support Option 1 that no contributing factor can be seen for re-evaluating the spherical coverage requirement for handheld UE at this stage. The number of panels is already considered in Rel-15 discussion and it actually does not limit the UE to implement multiple panels  - Another view is that the differences in the number of panels from previous Rel-15 discussion to present real products can justify the reason to enhance the requirement  ***Tentative agreements:*** *(According to the contributions and 1st comments provided by companies)*  Either of options below will be used as a baseline for the possible enhancement discussion at the next meeting. The result of 2nd round discussion should be noted in the WF of this meeting.  ***Candidate options:***  Option 1. RAN4 will continue the discussion on new factors except the number of panels (7)  Option 2. RAN4 will continue the discussion with 2 or 3 panel assumptions of Rel-15 (2)  ***Recommendations for 2nd round:***  The number of panels is the only factor proposed to this meeting, but majority companies mentioned “no more” or want to see other factors which had not been considered in Rel-15 if needed. Companies are encourage to provide their views on whether/why RAN4 can take 2 or 3 panel assumptions for the possible enhancement during the WI period. |
| **Sub-topic#2** | ***1st round comments summary:***  - Majority companies support Option 1 that there is no reason to change the current requirement without the factors in Sub-topic 1-1 or precedence in 3GPP. It is also noted that Option 3 for a new power class does not have the motivation to introduce multiple power classes for the same handheld UE in FR2 which has no tolerance  - Another view is that specifying multiple power classes within one UE type of handheld UE is possible solution as FR1, and it can be a compromised one to move forward. It is also commented that the new power class and its capability signaling can be discussed in the future  ***Tentative agreements:*** *(According to the contributions and 1st comments provided by companies)*  RAN4 should focus on the factors in Sub-topic#1 before going any further.  ***Recommendations for 2nd round:***  Although Option 1 (No change) is the majority view, the method to specify the possible enhancement can be further discussed in light of the progress of this study.  Companies can provide further comments for the way forward on the method if any.  Clarification on following issues can be discussed to help the group have a common understanding.  Issue 1: If the requirement is unchanged  Issue 2: If additional power level is introduced within PC3  Issue 3: If additional power class is introduced for handheld UE |
| **Sub-topic#3** | ***1st round comments summary:***  - Majority companies support Option 1 but most of them want to focus on the discussion about contributing factor for the UE performance improvement during the WI period (Rel-16). Technical analysis can follow the Sub-topic 1-1 in the future depending on the discussion  - Two different views are also provided by each company. One is no need to proceed due to the scope of the WI, the other is RAN4 should follow the time plan in the approved WF  ***Tentative agreements:*** *(According to the contributions and 1st comments provided by companies)*  RAN4 should focus on the factors in Sub-topic#1 before going any further.  ***Recommendations for 2nd round:***  Companies can provide further comments for the way forward on the work plan if any. |

*Recommendations on WF/LS assignment*

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|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 | *WF on spherical coverage improvements*  *(to capture the progress during this meeting)* | *TBA* |

## Discussion on 2nd round

* Companies view on candidate options in 1.3.1
  + Option 1: RAN4 will continue the discussion on new factors except the number of panels
  + Option 2: RAN4 will continue the discussion with 2 or 3 panel assumptions of Rel-15

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| **Company** | **Comments** |
| Samsung | We support Option 1. As we can see the table in 38.817-01, current requirements were not derived by averaging between 1-panel and 2-panel assumptions, and a UE performance can be lower than the current requirement even with 2 panels, depending on UE implementations. In RAN4#87, RAN4 was trying to have an agreement between vendors and operators without the averaging work. Not only the panel number, but RAN4 also had tried to capture most factors that might affect the performance into the assumption. Since the final assumption also considered 3-panel implementation, in our view, it does not make sense to change the requirement with Option 2 turning the clock back two years. RAN4 even has no problem for a UE to have a number of panels with the current requirement. However, we are fine to continue the discussion to see if any new factors that might help the UE performance. |
| OPPO | Option 1 |
| MediaTek | We echo Samsung’s comment and as our comment in 1st round, prior requirement discussion is actually not limited to 1 panel. |
| LGE | As we mentioned in 1st round, companies provided various factors/parameters to define the current spherical coverage requirements. Therefore, re-evaluating the spherical coverage requirement would not be beneficial and we keep our position as Option 1. |
| SONY | **Option 2 but also with other possible factors:** Firstly, we would like to clarify that we have no intention to change the requirement of PC3 UEs which have been agreed. All the possible enhancement we discussed here are intended to be an optional or dynamic capability of handheld UEs.  we think the number of antenna panels and the face they can cover are the most critical point for the spherical coverage of a handheld UE. We think a handheld UE with only a single panel cannot perform well in real life since it can be blocked the user’s hand. Therefore, it may still be worthy to further look into UE with more panels, at least not exclude this factor for further discussion.  Other factors can also be discussed in next meeting. |

* Further clarification on possible issues noted in 1.3.1 (if any)
  + Issue 1: If the requirement is unchanged
  + Issue 2: If additional power level is introduced within PC3
  + Issue 3: If additional power class is introduced for handheld UE

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| **Company** | **Comments** |
| Samsung | Issue 3: As explained in our document, it should be noted that the spherical coverage requirements is the minimum requirement without upper or lower tolerance. It is a baseline for the conformance which is a must to meet. Therefore, if additional power class is introduced for handheld UE, the enhanced one will be a sub part of the current PC3, and in our view, these are different things with PC2 of FR1. |
| LG | There is fundamental differences between power classes of FR1 and FR2. For instance, the power class of FR2 has the minimum peak and EIRP spherical coverage requirements and it implies that any types of UE should meet these minimum requirements regardless of difference in UE implementations. Therefore, introducing new power level or power class for the handheld UE will be ambiguous in the concept of power classes in FR2. |
| SONY | Issue 3: We think it is feasible to introduce a new PC for handheld UE if RAN4 would agree with any enhancement on spherical coverage. However, the PC 3 shall still be the default PC for handheld UE without changing the current requirements. Supporting the new PC can be an enhanced capability of handheld UE.  We agree that the definition of PC is different in FR1 and FR2. However, one thing in common here is that we try to define a new PC for handheld UE which can offer better uplink coverage, this is similar to the concept of HPUE in FR1. |

* Companies view for the next meeting (if any)

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| **Company** | **Comments** |
| Samsung | In our view, the multi-band relaxation (MBR) is also related to the spherical coverage discussion since the MBR structure and its value for spherical coverage can be updated depending on the discussion happened in another topic. The two discussions can be handled together from the next meeting to catch up with each progress if the MBR discussion needs more time. |
| SONY | Further discussion on the feasibility of spherical coverage enhancement with all the possible factors might be needed. |

## Summary on 2nd round (if applicable)

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

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