**3GPP TSG-RAN WG4 Meeting #104-bis-e R4-22xxxxx**

**Electronic Meeting, Oct 10 – Oct 19, 2022**

**Agenda item:** 6.6.5

**Source:** Moderator (Huawei, HiSilicon)

**Title:** Email discussion summary for [104-bis-e][127] FR1\_enh2\_part1

**Document for:** Information

# Introduction

Thread [127] includes following topics:

1. Topic #1: Genera issues
2. Topic #2: Study of MSD improvement (Agenda 6.6.4.1)
3. Topic #3: Study of signaling for Lower MSD (Agenda 6.6.4.2)

NOTE: Assumptions for CPE/FWA/vehicle/industrial devices (Agenda 6.6.1) is handled in thread [128]

It is appreciated that the delegates for this topic put their contact information in the table below.

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|  |  |  |
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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)

# Topic #1: General issues (Agenda 11.6.1)

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** | **T-doc name** | **Company** | **Proposals / Observations** |
| R4-2216675 | TR 38.881 lower MSD v0.1.0 | Huawei, HiSilicon | ***Reserved TR to capture the agreed TPs in 1st round.*** |
| [**R4-2216676**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216676.zip) | TP for TR 38.881 Example band combinations for lower MSD | Huawei, HiSilicon | ***TP of example band combinations based on WF in last RAN4 meeting.*** |

## Open issues summary

### Sub-topic 1-1: TP for TR

***The proposed TP includes the example band combinations for the MSD analysis based on the WF in last meeting.***

* Recommended WF
  + Agree the TP in [**R4-2216676**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216676.zip)

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | We are fine with this TP. |
| AT&T | We are generally OK with the TP. However, we still don’t understand Note 2 since the three-band combination was agreed as the example band combination to evaluate the IMD cases. It seems that the IMD cases should not have second priority behind cross-band isolation and harmonic mixing. Maybe we can just remove Note 2? |
|  |  |

## Companies views’ collection for 1st round

### Open issues

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
|  | Company A |
| Company B |
|  |

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

### CRs/TPs

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

|  |  |
| --- | --- |
| **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)

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
|  |  |  |

*Moderator can provide summary of 2nd round here. Note that recommended decisions on tdocs should be provided in the section titled ”Recommendations for Tdocs”.*

# Topic #2: Study of MSD improvement (Agenda 6.6.4.1)

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** | **T-doc name** | **Company** | **Proposals / Observations** |
| [**R4-2215379**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215379.zip) | Investigation of band combinations for MSD reduction | Qualcomm Incorporated | ***Observation 1: For CA-n3\_n78 the MSD due to IMD2 where n78 Tx and n3 Tx mix and fall into n3 Rx shows the following behaviour with PCB and antenna isolation:***   |  |  |  | | --- | --- | --- | | ***Ant ISO (dB)*** | ***PCB ISO (dB)*** | ***MSD (dB)*** | | ***10*** | ***70*** | ***25.6*** | | ***10*** | ***80*** | ***17.3*** | | ***10*** | ***90*** | ***13.0*** | | ***20*** | ***70*** | ***25.6*** | | ***20*** | ***80*** | ***14.4*** | | ***20*** | ***90*** | ***8.1*** |   ***Observation 2: For CA-n3\_n78 the MSD due to IMD4 where n78 Tx and 3\*n3 Tx mix and fall into n3 Rx shows the following behaviour with PCB and antenna isolation:***   |  |  |  | | --- | --- | --- | | ***Ant ISO (dB)*** | ***PCB ISO (dB)*** | ***MSD (dB)*** | |  |  |  | | ***10*** | ***70*** | ***9.5*** | | ***10*** | ***80*** | ***5.5*** | | ***10*** | ***90*** | ***4.0*** | | ***20*** | ***70*** | ***4.8*** | | ***20*** | ***80*** | ***3.9*** | | ***20*** | ***90*** | ***2.7*** |   ***Observation 3: For CA-n3\_n78 the MSD due to HD2 where the second harmonic of n3 falls into n78 Rx shows the following behaviour with PCB and antenna isolation:***   |  |  |  | | --- | --- | --- | | ***PCB ISO (dB)*** | ***Ant ISO (dB)*** | ***MSD (dB)*** | | ***70*** | ***10*** | ***11.9*** | | ***80*** | ***10*** | ***4.4*** | | ***90*** | ***10*** | ***1.7*** | | ***70*** | ***20*** | ***11.8*** | | ***80*** | ***20*** | ***3.9*** | | ***90*** | ***20*** | ***0.7*** |   ***Observation 4: For CA-n41\_n77 the MSD due to cross band isolation where n77 Tx noise falls into n41 Rx the following behaviour is observed with antenna isolation:***   |  |  | | --- | --- | | ***Ant ISO (dB)*** | ***MSD (dB)*** | | ***15*** | ***3.3*** | | ***20*** | ***1.3*** | | ***25*** | ***0.5*** |   ***In our opinion the low MSD for this band combination does not make it a candidate for the low MSD feature***  ***Observation 5: For CA-n28\_n40 the MSD due to 3rd RX LO harmonic of n28 mixing with n40 Tx and falling into 28 Rx the following behaviour is observed with PCB and antenna isolation:***   |  |  |  | | --- | --- | --- | | ***PCB ISO (dB)*** | ***Ant ISO (dB)*** | ***MSD (dB)*** | | ***70*** | ***10*** | ***26.1*** | | ***80*** | ***10*** | ***19.7*** | | ***90*** | ***10*** | ***17.8*** | | ***70*** | ***20*** | ***25.6*** | | ***80*** | ***20*** | ***16.2*** | | ***90*** | ***20*** | ***10.1*** |   ***Observation 6: The band combinations analysed in this study shows that MSD can be lowered by increasing PCB and or antenna isolations*** |
| [**R4-2215666**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215666.zip) | Further analyses and views on MSD improvement for inter-band CA/DC | Apple | ***Observation 1: When harmonic filter rejection is above 20 dB, the MSD would be dominated by other impairments.***  ***Observation 2: When the combined diplexer+n78 filter rejection ratio to n3 Tx is above 60 dB, the MSD would be dominated by other impairments.***  ***Observation 3: When the PA 2nd harmonic rejection ratio is above 56 dB, the MSD would be dominated by other impairments.***  ***Observation 4: MSD though improved with increasing LNA IP2, the improvement is quite limited even with LNA IP2 up to 30 dBm.***  ***Observation 5: Without PCB and antenna isolations improvement, the UL 2nd harmonic MSD from other improved RF parameters alone cannot be reduced to below 18 dB.***  ***Observation 6: When the duplexer rejection ratio for IMD2 at n3 DL is above 70 dB, the MSD would be dominated by other impairments.***  ***Observation 7: When the PA forward mixing IP2 is above 45 dB, the MSD would be dominated by other impairments.***  ***Observation 8: MSD though improved with increasing LNA IP2, the improvement is quite limited even with LNA IP2 up to 20 dBm.***  ***Observation 9: when the n3 diversity Rx filter rejection ratio to n3 and n78 UL is above 46 dB, the MSD would be dominated by other impairments.***  ***Observation 10: Without PCB and antenna isolations improvement, the 2UL IMD2 MSD from other improved RF parameters alone cannot be reduced to below 18 dB.***  ***Observation 11: It would be rather challenging to improve MSD caused by 3rd order harmonic mixing to below 30 dB based on practical UE implementation.***  ***Proposal: When considering the potential MSD improvement, company shall present their assumptions for link analysis or measurement results instead of only showing the MSD numbers.*** |
| [**R4-2215734**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215734.zip) | Views on feasibility of improved MSD | Samsung | ***Observation 1: It is observed that in terms of PC3, MSD due to IMD2 of CA\_n3-n78 could be reduced to around 15dB with 85dB PCB isolation and 20dB antenna isolation, in contrast to 26dB specified MSD.***  ***Observation 2: It is observed that in terms of PC3, MSD due to IMD4 of CA\_n3-n78 could be reduced to around 5dB with 85dB PCB isolation and 20dB antenna isolation, in contrast to 8dB specified MSD.***  ***Observation 3: It is observed that in terms of PC3, MSD due to 2nd harmonic of CA\_n3-n78 could be reduced to around 13dB with 85dB PCB isolation and 20dB antenna isolation, in contrast to 23.9dB specified MSD.***  ***Observation 4: It is observed that in terms of PC3, MSD due to 3rd harmonic mixing of CA\_n28-n40 could be reduced to around 25dB with 85dB PCB isolation and 20dB antenna isolation, in contrast to 37.8dB specified MSD. Note that antenna isolation has almost no contribution to the MSD improvement.***  ***Observation 5: It is observed that in terms of PC3, MSD due to 3rd harmonic mixing of CA\_n28-n40 could be reduced to around 15dB with 85dB PCB isolation and 30dB Rx harmonic rejection, in contrast to 37.8dB specified MSD.***  ***Observation 6: It is observed that in terms of PC3, MSD due to cross band isolation of CA\_n1-n3 could be reduced to around 10dB with 85dB PCB isolation and 20dB antenna isolation, in contrast to [19.7]dB specified MSD.***  ***Observation 7: It is unnecessary to report the MSD values in case the specified MSD itself is small or the improvement is not significant.***  ***Proposal 1: For sake of sufficient information provided to facilitate network scheduler, 15dB, 10dB, 5dB could be considered as PC3 candidate thresholds in case multiple exact absolute thresholds would be defined with assumption that identical thresholds shared by different interference source.*** |
| [**R4-2215758**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215758.zip) | Consideration on the lower MSD study and capability signaling | Meta Ireland | ***Proposal #1: The example RF architectures in TR36.860-12 can be reused to evaluate lower MSD according to the different MSD sources.***  ***Proposal #2: When both ACLR1 and ACLR2 ranges are impacted in the victim carrier due to cross band isolation, RAN4 indicate “ACLR1 & ACLR2” as the interference source in the new MSD Table.***  ***Proposal #3: To avoid confusion, RAN4 need to define the terminology to use NR\_ACLR1 and/or NR\_ACLR2 to indicate a cross-band interference source(s), instead of using just ACLR1 and/or ACLR2.***  ***Proposal #4: RAN4 can derive the MSD difference value by average manner from the conventional MSD requirements in TS38.101-1 for those example CA band combinations.***  ***Proposal #5: RAN4 only introduces a threshold to indicate the lower MSD capability according to the different MSD sources and do not define the individual MSD levels for all CA/DC band combinations if RAN4 has clear evaluation results to define lower MSD capability.***  ***Proposal #6: Single difference value of the MSD as the threshold is considered for the lower MSD capability according to the different MSD sources when UE report the capability of lower MSD for the inter-band CA/DC band combinations if RAN4 has clear evaluation results to define the lower MSD capability.***  ***Proposal #7: RAN4 can recommend that the single difference MSD value for the lower MSD level according to the different MSD sources will be reported with 1dB granularity MSD step and the largest difference is up to 8dB with 3bits.*** |
| [**R4-2215792**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215792.zip) | Feasibility study on amount of MSD improvement | Nokia, Nokia Shanghai Bell | *For 2nd harmonic interference, following observations are obtained.*  ***Observation 1: Feasibility of MSD improvement by PA H2 performance improvement was already proposed by a UE vendor in [2], where it showed 10 dB improvement is possible.***  ***Observation 2: Around 10 dB MSD improvement for CA\_n3-n78 2nd UL harmonics is feasible at least e.g., by PA H2 suppression of 48 dBc or isolation like PCB in Path 2 and Path 3 of 85 dB. Single RF component performance improvement alone, however, cannot achieve even better MSD like 20 dB since other gating factor(s) appears in one or two of the three Paths once noise in two or one of the three Paths is improved.***  ***Observation 3: In case of PA H2 suppression of 35 dB, 20 dB MSD improvement is not possible even if antenna isolation is 20 dB and isolation improvement of Path 2&3 was infinity if the other assumptions are the same as those in Table 1.***  ***Observation 4: In order to achieve 20 dB MSD improvement with PA H2 suppression of 48 dBc, around 25 dB isolation improvement, i.e., 95 dB isolation, for Path 2 &3 is required if the other assumptions are the same as those in Table 1.***  ***Observation 5: Antenna isolation improvement helps improve combined MSD more when DRX H2 levels at LNA for Paths 2 and 3 are even lower than DRX H2 level at LNA for Path 1 while the amount of maximum improvement by antenna isolation is around 5 dB with antenna isolation of 20 dB.***  ***Observation 6: If harmonic filter rejection, HB switch H2 and Triplexer Rejection towards H2 are improved by 8 dB, 8 dB and 5 dB, respectively, all the LNA H2 levels at the three Paths are almost equally lower than or equal to -103 dBm, as shown in Table 3, the required isolation of Path 2 & 3 can be reduced to 83 dB from 95 dB.***  ***Observation 7: Theoretically it is not impossible to achieve MSD = 0dB for CA\_n3-n78 for 2nd UL harmonic. However, as MSD approaches 0 dB, it requires more cost, i.e., components performance improvement compared to the cost to improve MSD by 20 dB.***  *For 2nd harmonic mixing, a following observation is obtained.*  ***Observation 8: MSD of 0 dB for CA\_n3-n78 harmonic mixing is feasible by PCB isolation improvement, e.g., 84 dB, mixer spur rejection improvement, e.g., 66 dBc or combination of the two RF components performance improvement, e.g., PCB isolation is 75 dB and mixer spur rejection is 60 dBc. Antenna isolation improvement doesn’t help improve MSD for 2nd harmonic mixing for CA\_n3-n78.***  *For IMD2, a following observation is obtained.*  ***Observation 9: Around 10 dB MSD improvement of IMD2 for CA\_n3-n78 is possible if antenna isolation is around 20 dB or PCB isolation is around 80 dB. Around 20 dB improvement is also possible, if IP2 of antenna switch as well as diplexer is around 125 dBm. Further MSD improvement is also possible while the cost and performance = “the amount of MSD improvement”/”the amount of RF component performance improvement” becomes less and less.***  *For relation between the amount of MSD improvement and MSD types, a following observation is obtained.*  ***Observation 10: The amount of the MSD improvement is not always the same or similar across MSD types even if one common RF component performance improvement is considered. Provided that it is not always the case that UE vendors will always use one single RF component performance improvement, e.g., only PCB isolation, to improve MSD, the amount of MSD improvement can be very different from MSD types to types.***  *From the all the above observations and in order to move forward, we propose a following.*  ***Proposal: RAN4 should confirm that lower MSD(s) than minimum requirements is possible under the condition that the extent of the amount of MSD improvement and measures are different from MSD types to types as well as UE to UE.*** |
| [**R4-2215889**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215889.zip) | Discussion on lower MSD for inter-band CA/ENDC | ZTE Corporation | ***Proposal 1. No need to defined another new set of MSD values in the TS38.101-1 spec, i.e. the improved MSD values (i.e. the new MSD value) should not be defined in TS38.101-1 spec.***  ***Observation 1. How much the MSD can be improved in practical should be based on the commercial UE measurement.***  ***For n3-n78:***  ***Observation 2. PCB isolation for harmonic/IMD and harmonic mixing are used to derive the corresponding MSD values are different.***  ***Observation 3. For IMD2 and H2 MSD, it is difficult to improve 20dB MSD by only increasing PCB isolation or antenna isolation.***  ***Observation 4. For IMD2 and H2 MSD, to achieve ~10dB MSD value, the antenna isolation needs to better than 20dB associated with PCB isolation better than 85dB.***  ***Observation 5. For IMD4, the improved MSD is less than 5dB when the antenna isolation is 20dB associated with PCB isolation is 85dB.***  ***Observation 6. For IMD2/4, H2 and harmonic mixing MSD, the improved MSD is limited when PCB isolation >75dB for a certain antenna isolation.***  ***For n28-n40:***  ***Observation 7. For n28-n40 harmonic mixing, some other method may need to be adopted to further improving the MSD value.***  ***Observation 8. For harmonic mixing MSD, antenna isolation pay less role on improving the MSD.***  ***Proposal 2. It would be better to discuss the achievable PCB isolation/antenna isolation values in practice when companies re-evaluate how much the MSD can be improved.***  ***Proposal 3. To discuss how much MSD is improved can be considered as valuable in practical?***  ***Proposal 4. Delta MSD compared to the minimum requirements or real time MSD could be as the candidates for the new signaling.*** |
| [**R4-2216117**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216117.zip) | Analysis on improve MSD | vivo | ***Observation 1: Typical antenna isolation between n3 and n78 can be 13~17 dB. 10dB is still a valid number for minimum requirement, and an enhanced value such as [15]dB can also be considered based on the results.***  ***Observation 2: A range of 70-80dB PCB isolation can be considered based on implementation, but it may be hard and also unnecessary to be accurate, since there are measurements problem and also other unaccounted interference source and path in real implementation.***  ***Observation 3: B3 PA H2 up to 48dB is aligned with some implementation, but there are other unaccounted interference sources.***  ***Proposal: The parameters used for “traditional” MSD analysis can be based on previous observations which is also summarized here:***   |  |  | | --- | --- | | ***Parameter*** | ***Values*** | | *Antenna Isolation* | *[15] dB* | | *PCB Isolation* | *[70~80] dB* | | *B3 PA H2* | *[48] dB* | |
| [**R4-2216145**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216145.zip) | Discussion on lower MSD for inter-band CA/EN-DC/DC | Xiaomi | ***For all MSD types ( 2nd harmonic, IMD2 and IMD4) in CA\_n3-n78***  ***Observation 1: improving the PCB isolation can reduce the MSD, but when PCB isolation is above 80dB, the impact becomes very small.***  ***Observation 2: improving the antenna isolation can reduce the MSD, especially when PCB isolation is high.***  ***Proposal 1: For the MSD improvement for band combination n3 and n78, it is not necessary to consider PCB isolation higher than 80dB.***  ***Observation 3: even when antenna isolation is 20dB and PCB isolation is 80dB, the MSD value is still above 15dB for IMD2 for CA\_n3-n78***  ***Observation 4: the delta MSD value due to MSD improvement for different MSD types is different. When the minimum requirement of MSD is high, the delta MSD value could be above 10 dB.*** |
| [**R4-2216187**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216187.zip) | MSD evalueation considering the high PCB isolation for CA n1-n3 | LG Electronics France | ***observation1: In CA\_n1-n3, when the PCB isolation is 70 dB, it has a much lower MSD value than 60 dB PCB isolation. Further analysis is required for other combinations using 70 dB PCB isolation.***  ***Proopsal1: 70 dB PCB isolation is feasible for lower MSD.***  ***Proposal2: Further MSD analysis using 70 dB PCB isolation is needed for other combinations*** |
| [**R4-2216434**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216434.zip) | R18 Discussion on MSD improvement | OPPO | ***Observation 1: The target of this improvement study is not quite clear in the WID, whether it is to justify the necessity of MSD reporting signaling design, or to define another set of requirements in RAN4.***  ***Observation 2: MSD improvement study target/outcome have impact on the signaling design.***   * ***If the MSD improvement study is only for the feasibility justification purpose, then the MSD signaling design can be considered independently from the improvement study as long as the improvement is feasible.*** * ***Otherwise, if the MSD improvement study will lead to another set of MSD requirement, then the signaling will be used to indicate which MSD requirement the UE will compliant.***   ***Proposal: Propose to clarify which option is the MSD improvement targets to facilitate the improved value discussion and also signaling design.***   * ***Option 1: Define separate improved MSD requirements in RAN4*** * ***Option 2:*** ***Only for feasibility justification purpose to serve signaling design*** |
| [**R4-2216776**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216776.zip) | Further discussion on the feasibility of improving MSD | Huawei, HiSilicon | ***Observation 1: Different types of MSDs may have different limiting factors. Which one can be improved for what band combinations are design choices of the UE implementation.***  ***Observation 2: For large MSD values (>20dB) it’s very challenging to reduce them to below 10dB. The relatively small MSD values (<10 dB) may be further improved depending on UE implementation.***  ***Observation 3: The antenna isolation plays an important role in MSD performance. However, the effect is not verified by the existing conductive tests.***  ***Observation 4: For a given band combination, MSD from different sources are unlikely to happen simultaneously, depending on the configuration of carrier frequencies, duplex mode of the component bands, the order of IMD or harmonics and etc.***  ***Proposal 1: When the MSD is improved to below [5] dB, the concern about the self-interference level for such Ues may be alleviated.***  ***Proposal 2: There is no need to report MSD > [15] dB. Adaptive scheduling by the network will be the main means to avoid the high self-interference level for such Ues. Whether/how to report MSD values between [5] and [15] dB is FFS.***  ***Proposal 3: Given that the MSD of different types are unlikely to happen simultaneously, the network should be able to enquire and select the most relevant MSD capability to be reported by the UE.*** |

## Open issues summary

### Sub-topic 2-1: Clarificaion on lower MSD improvement

#### ***Issue 2-1-1: Clarification on purpose of study for MSD improvement***

* ***Proposal: clarify which option is the MSD improvement targets to facilitate the improved value discussion and also signaling design (R4-2216434, OPPO).***
  + Option 1: Define separate improved MSD requirements in RAN4
  + Option 2: Only for feasibility justification purpose to serve signaling design

***Moderator’s recommendation:***

***The clarification is necessary to have further discussion on MSD improvement.***

* Recommended WF
  + TBA based on 1st round discussion

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| --- | --- |
| **Company** | **Comments** |
| Samsung | Option2  It is agreed in last meeting the minimum requirement of MSD would keep unchanged, in other words there would be no requirement tightening or another set of requirement defined for all Ues or specific kind of Ues to mandatorily conform to.  In our view, the intention of studying MSD improvement, is to investigate how the MSD could be improved, as well as to derive the potential Low MSD capability threshold(s) to serve signaling design. According to the MSD trend analysis from companies in these two meetings and the measurement data provided in past meetings, it is justified to confirm the feasibility of MSD improvement already in both theory and practice. It is suggested to confirm the feasibility of the MSD improvement this meeting. |
| OPPO | Option 2 is preferred.  This question needs to be aligned in the group, though we have agreed that the minimum requirements are not changed but this agreement doesn’t preclude defining another optional tighten requirements in principle.  Our view is that the study is for feasibility study to justify the signaling design. |
| Xiaomi | The question is relevant to how to justify the MSD improvement and whether there is an explicitly threshold defined in RAN4. |
| Nokia | Option 2. At least we haven’t had an intention to go with Option 1. Though we didn’t have reason to do this feasibility study since it is apparent that some Ues can have better MSD performance, but UE vendors requested to conduct this feasibility. |
| Huawei (JW) | Based on the feedback from the group, it seems very difficult to proceed with option 1. So option 2 is fine for us. |
| Meta | Support option 2. In feasibility phase, we only check the feasible MSD improvement based on the reasonable RF parameters. After that, we can finalize how to apply the lower MSD capability in system aspect. |
| Skyworks | Option 2: depending on whether all types or specific types of MSD are improved may change the signaling design and the amount/granularity of the improvement |
| Sony | Option 2. This aligns with the agreement from last meeting. |
| AT&T | We would prefer Option 1 so that there is a mechanism to verify the improved performance level claimed by the UE in the future. However, we think that RAN4 agreed to the way forward in Option 2 so we can stick to this agreement. |
| Qualcomm | Option 2: In our opinion the purpose of the MSD study is to illustrate that lower MSDs are possible for certain band combinations and the exact value of lower MSD targeted for each band combination should be left up to the UE as indicated in our paper (R4-2215378). We think that in this meeting the possibility of MSD improvement for certain band combinations should be agreed and RAN4 should focus on MSD signaling in subsequent meetings. |
| Verizon | Option 1 is better as the results of this work will be applied to all other HP device works in future. The improved performance needs to be applied to all power classes. |
| Apple | In our view, the studies are meant to demonstrate that there is an opportunity to improve MSD performance to certain extent which however does not necessarily lead to the need for capability signaling as the benefit for signaling is still subject to further discussions and justifications. |
| NTT DOCOMO | Our understanding is option 2 for this WI according to the previous discussion. |

#### ***Issue 2-1-2: Evaluation assumptions for MSD improvement***

***Whether unified assumptions are needed for the evaluation of MSD improvement, e.g. reference architectures, antenna isolation, PCB isolation, component linearity, etc.***

* + Option 1: Yes
  + Option 2: No

***Moderator’s recommendation:***

***The question is based on observations from companies’ contributions, which is a fundamental issue to be concluded for further study and discussion.***

* Recommended WF
  + TBA based on 1st round discussion

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| --- | --- |
| **Company** | **Comments** |
| Samsung | Option 2: No  In our view, it would be very difficult to reach consensus on the unified assumptions for MSD improvement, however the parameters adopted in the MSD analysis should be presented for the group’s reference and review.  As could be found in this WI and BC basket WIs, the parameters companies adopted on MSD analysis are quite diverse, even the architectures could be different (shared antenna or separated antenna, whether HTF is used, etc….). We see no need to further unify the assumptions for MSD improvement study since it is more relevant to implementation. |
| OPPO | Option 1 if possible, especially for the key MSD contributor like PCB isolation, antenna isolation.  It is understood that different companies may use different assumptions but the values used should be in a reasonable range, e.g. 90dB PCB isolation probably should not be used. If no alignment is to be aligned on these key contributors, how to align the final results is questionable since the results could be quite different. |
| Xiaomi | Option 2  We don’t agree using unified assumptions for MSD improvement especially for reference architectures and diplexer/duplexer/filter rejection for different band combination. For antenna isolation, PCB isolation, we are ok to have a small range or a uniform reasonable value. |
| Nokia | Option 2  No, we don’t think unified assumptions is necessary. RAN4 hasn’t had the unified assumptions to derive even minimum requirements. We don’t see the necessity of setting the unified assumptions for the requirements for “Optional” feature. If it were necessary, we just would get the same results. |
| Huawei (JW) | Option 2. |
| Meta | Option 1. This is feasibility study how much MSD level could be improved. So some need to reference RF architecture, ant. Isolation and PCB isolation levels with some ranges. Because RAN4 need to support all type devices but baseline device type is smart phone factor. So the RF requirements shall be applied for all device type with flagship model and other low cost model. So we need to define the specific range based on UE vendor proposals. |
| Skyworks | Option 2: We do not think the parameters needs to be aligned it is even better if the MSD improvement is evaluated based on a set of different parameters. For antenna and PCB isolation improvement it might be sufficient to agree on a range of potential improvement. |
| Sony | Option 2. The main intention for the evaluation is to assess the feasibility of MSD improvement. Therefore, as long as improved MSD performance can be identified in the evaluation based on reasonable assumptions, we see no need to further unify the assumptions. |
| AT&T | Option 2. We agreed at the last RAN4 meeting to allow companies to utilize a range of assumptions in the feasibility study. Many companies have already used this approach for the feasibility studies presented at this meeting. |
| Qualcomm | Option2: No. In our opinion it will be very difficult to agree on a set of unified assumptions. Companies may have different designs which may have different MSD reduction mechanisms. We believe that companies should be able to use whatever mechanisms at their disposal to achieve lower MSD and that there is no need to agree on a unified set of assumptions. |
| Verizon | Option 2 |
| Apple | Option 1  Setting an agreed practical performance upper bounds such as for PCB isolation and antenna isolation may help consolidate the amount of feasible MSD improvement. |
| NTT DOCOMO | Option 2. RAN4 agreed in last meeting that minimum requirements are kept unchanged and MSD improvement capability is an optional capability. So, our view is that this is an enhanced optional feature, and we don’t have to limit the range of parameters to cover all UE types while we may need to avoid unrealistic values. |
| CHTTL | Option 2. |

### Sub-topic 2-2: Feasibility of MSD improvement

#### ***Issue 2-2-1: Whether it is feasible for MSD improvement***

* ***Proposal: lower MSD(s) than minimum requirements is possible under the condition that the extent of the amount of MSD improvement and measures are different from MSD types to types as well as UE to UE (R4-2215792 Nokia).***

***Moderator’s recommendation:***

***It is important to make a conclusion on the feasibility of MSD improvement for the signalling part discussion.***

* Recommended WF
  + TBA based on 1st round discussion

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | Feasibility of the MSD improvement shall be confirmed in this meeting.  As commented in issue 2-1-1, according to the MSD trend analysis from companies in these two meetings and the measurement data provided by operators in past meetings, it is justified to confirm the feasibility of MSD improvement already in both theory and practice. |
| OPPO | Agree in principle. If companies use improved component parameters then the results will be “improved”, does this mean the UE today is better than the Rel-15 UE? Probably not, but from papers it is, not sure how to justify it in reality. |
| Xiaomi | We are ok to make a conclusion that MSD improvement is feasible for some UE implementation. |
| Nokia | Yes, it is possible. How it is achieved or values to be achieved are different from MSD types to types as well as UE to UE. That is why Lower MSD is optional capability. This conclusion is needed to move forward and avoid spending time on feasibility study. Feasibility study should focus on something to help signaling aspect discussion. |
| Huawei (JW) | The proposal is agreeable. |
| Meta | If RAN4 only focus on the feasibility of MSD improvements by UE reported signaling, we can acceptable to the moderator recommendation. |
| Skyworks | We don’t understand the proposal. Does it mean a single improvement is signaled (based on the worst of all types?) or improvement per type? In our view it is probably more beneficial to have improvement per type of MSD as thresholds a 1dB difference between two UE should not be critical or result in a different management of the UE. MSD values could be as <1, <3, <7, <15dB and would already give a good understanding of the improvement vs critical MSD cases (>10dB?) |
| Sony | We are fine to conclude the MSD improvement is feasible. |
| AT&T | We are OK to conclude that MSD improvement is feasible. The feasibility studies provided by companies utilized assumptions that are representative of existing UEs. RAN4 should now focus on the necessary signalling options. |
| Charter Communications Inc | MSD improvements are feasible. We agree that we should focus on the necessary signaling options. |
| Qualcomm | Based on the contributions for this and the last meeting most companies agree that MSD improvement is possible for certain band combinations. We think that the analysis objectives of this WI have been met and now companies should focus on designing the signaling for low MSD |
| Verizon | We agree the feasibility of the MSD improvement can be confirmed in this meeting. |
| Apple | We are fine to conclude that MSD improvement is feasible so that companies do not have to spend time on these exercises again in the coming meetings. |
| NTT DOCOMO | We agree the proposal, and we think RAN4 should focus on the signalling design. |
| KDDI | We agree the feasibility of the MSD improvement can be confirmed in this meeting. |
| CHTTL | We support to conclude the MSD improvement is feasible. |

#### ***Issue 2-2-2: Justification of lower MSD***

* ***Proposal: To discuss how much MSD is improved can be considered as valuable in practical? (R4-2215889 ZTE)***
  + Option 1: When the MSD/MSD is improved to below [5] dB, the concern about the self-interference level for such UEs may be alleviated (R4-2216776 HW).
  + Option 2: It is unnecessary to report the MSD values in case the specified MSD itself is small or the improvement is not significant (R4-2215734 Samsung).
  + Option 3: There is no need to report MSD > [15] dB (R4-2216776 HW).
  + Option 4: For sake of sufficient information provided to facilitate network scheduler, 15dB, 10dB, 5dB could be considered as PC3 candidate thresholds in case multiple exact absolute thresholds would be defined with assumption that identical thresholds shared by different interference source (R4-2215734 Samsung).

***Moderator’s recommendation:***

***To check the following range of lower MSD based on companies’ proposals:***

* ***Whether absolute MSD <=15dB after improvement in contrast to minimum requirements could be considered as improved lower MSD***
* ***Whether absolute MSD below 5dB does not need to consider further improvement***
* Recommended WF
  + TBA based on 1st round discussion

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| --- | --- |
| **Company** | **Comments** |
| Samsung | We think moderator’s recommendation could be considered.  Option4 are proposed based on our MSD trend analysis, it is observed that the improved MSD due to different MSD types/orders from different victim bands actually would fall into different ranges when different RF parameters has improvement, it might be very tough to agree on single MSD threshold with which may also not able to provide relative sufficient information for network scheduler, making the whole capability lose its significance. It should be noted that the first important thing is to provide relative sufficient information for NW, rather than over pursuit of signaling overhead saving.  With above consideration, we think the absolute MSD ≤ 15dB after the improvement could be considered as valuable in practice. Furthermore, 15dB, 10dB, 5dB could be considered as threshold set candidate in case multiple thresholds would be defined with the assumption that identical thresholds shared by different kinds of MSD.  In addition, we think it is unnecessary to report the MSD values in case the specified MSD itself is small or the improvement is not significant, regarding how to justify and define the “small specified MSD”, we think 5dB might be rational, or it could be left to UE decision. |
| OPPO | Option 2 and 3 is ok in general. When the MSD is small there is no need for further improvement and reporting. And when the MSD after improvement is still high (e.g. 15dB) there is also no need to inform NW since there is no much difference comparing to larger MSD.  Whether MSD <15 after improvement is considered improved lower MSD is difficult to get consensus and probably can up to NW decide. Different NWs may have different strategy whether to configure the band combination based on the MSD values reported by UE. |
| Xiaomi | Generally we support the view and the intention of the proposal ½/3. The originally intention of MSD improvement is to avoid the performance loss due to high MSD issue. If the MSD for some band combinations is already very low, we think those band combinations don’t need to be involved. If the improved MSD for some band combinations still very high, the gain for the MSD improvement may be small. However, how to justify the reasonable range of MSD range for that may be difficult. |
| Nokia | We don’t think that the actual threshold is determined now, though it is not harmful. In our understanding, if the MSD value is used as offset, any values can be utilized somehow. While how much useful is different depending on if we want to utilize Ues with poor performance as much as possible or Ues with better performance as much as possible. E.g., if there is a UE with MSD with 15 dB while the minimum requirement is 30 dB. If there is a network that it doesn’t configure a UE with CA due to the huge MSD of min requirements as some other companies implied, and if most of the Ues have more than 15 dB MSD, the network wouldn’t have opportunities to use CA for that band combination. On the other hand, setting large threshold itself is not efficient since anyway, the CA is configured with the UE only when the UE is close to gNB. Hence the possibility is very low. From this perspective, smaller threshold is more meaningful in terms of making maximum use of higher ability UE’s performance.  And actual threshold also is affected by how much bits we can use. |
| Huawei (JW) | Regarding the two questions in the moderator’s recommendation, both of our answers are “yes”.  If the MSD after certain optimization is still large (e.g. >15 dB), most likely the NW wouldn’t activate the CA configuration for such Ues, effectively treating them the same as Ues without MSD improvement. By setting an upper bound for MSD reporting, the value range to be reported can be reduced, which would help the signaling design.  MSD is an indication of self-interference level. However, Ues at the cell edge tend to suffer from inter-cell interference, which is likely to well above the thermal noise level. For small MSDs (e.g. <5dB), it’s unlikely to be the dominant factor of SIR for cell edge Ues. Therefore, there’s no need to use fine granularity in signaling design to differentiate small MSDs. |
| Meta | We are also discussion paper for the MSD capabilities. We can acceptable for Proposal 1,2 and 3. For Proposal 4, we think that the difference level between improved MSD and conventional MSD can be reported up to 8dB difference level. 15dB is very large difference. But we can refer the UE vendor proposals in this meeting. For the less than 5dB MSD improvement, it will also beneficial to the IMD4 and 5 problem in own Rx bands. |
| Skyworks | In our view it is probably more beneficial to have improvement per type of MSD as thresholds a 1dB difference between two UE should not be critical or result in a different management of the UE. MSD values could be as <1, <3, <7, <15dB and would already give a good understanding of the improvement vs critical MSD cases (>10dB?) |
| AT&T | We are really not sure that a threshold needs to be defined at this time if we are now focused on possible signalling solutions. We can discuss further if different thresholds need to be defined based on the signalling solution but we don’t think that we know if this is required or not at this time. |
| Charter Communications Inc. | Let’s focus on the signaling solutions and then determine the threshold values |
| Qualcomm | It is difficult to say whether MSD≥[15] dB after improvement is useful to the NW or not. This may depend on how the NW is configured to use the MSD information for scheduling the different carriers. As the feature is intended for lowering large MSDs there may not be much benefit in either trying to improve MSDs that are low even before improvement or have been reduced below a certain lower threshold such as [5] dB. We believe that this should be studied further in order to have a clearer position on these thresholds. |
| Verizon | We believe the correct way is RAN4 should focus more on where are the main interference sources although we really like single-digit number from this work. |
| Apple | Maybe the question is below what absolute MSD value, the combination is considered as usable by the network? |
| NTT DOCOMO | Regarding 2nd question from moderator, question for clarification is that “absolute MSD below 5dB” means “absolute MSD before improvement is 5dB"?  We generally agree that it is not needed to report MSD improvement in case that MSD before improvement is already small or that MSD after improvement is still large. But it may need further discussion to agree the threshold since it depends on how NW use this capability. We may need flexibility of the range of MSD improvement. |
| CHTTL | It seems like this issue is related to issue 3-3-4. Regarding the upper bound, we consider up to 18dB  with the step of 3x6dB, but we are open to discuss. Maybe one thing we would like to clarify first is that this is proposed for PC3 only or applied to all other PC as well? As the MSD for PC2 will be higher. But regarding the lower bound on 5dB, we prefer to consider MSD = 0 case in the report as commented in issue 3-3-4. |

## Companies views’ collection for 1st round

### Open issues

### CRs/TPs comments collection

*Major close to finalize Wis and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going Wis, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
|  | Company A |
| Company B |
|  |
|  | Company A |
| Company B |
|  |

## 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#2-1** | ***Issue 2-1-1: Clarification on purpose of study for MSD improvement***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  ***Issue 2-1-2: Evaluation assumptions for MSD improvement***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |
| **Sub-topic#2-2** | ***Issue 2-2-1: Whether it is feasible for MSD improvement***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  ***Issue 2-2-2: Justification of lower MSD***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

### CRs/TPs

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

|  |  |
| --- | --- |
| **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)

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
|  |  |  |

*Moderator can provide summary of 2nd round here. Note that recommended decisions on tdocs should be provided in the section titled ”Recommendations for Tdocs”.*

# Topic #3: Study of signaling for Lower MSD (Agenda 6.6.4.2)

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** | **T-doc name** | **Company** | **Proposals / Observations** |
| [**R4-2215378**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215378.zip) | Signalling for low MSD | Qualcomm Incorporated | ***Observation 1: It would be difficult for companies to agree on specific low MSD values for each band combination where lower MSD is possible. We see the ability for the UE to declare the achievable lower MSD for each band combination as an easier method for implementing this feature***  ***Proposal 1: For each band combination that can support low MSD allow the UE to declare which impairment improvement it supports (IMD2, IMD4, HD2 etc.) and the associated lower MSD value for each impairment using capability signalling.***  ***Proposal 2: The resolution of the UE declared low MSD value is [1.0] dB***  ***Proposal 3: Further discuss the lower MSD threshold which should be agreed for a given band combination to qualify for MSD reduction.***  ***Observation 2: Knowing a UE can achieve lower MSDs enables a network to schedule carriers more efficiently.*** |
| [**R4-2215382**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215382.zip) | Lower MSD signalling and the effects of the introduction | Nokia, Nokia Shanghai Bell | ***Proposal 1: With consideration of observations 1 – 6, RAN4 should agree that it is essential to introduce lower MSD capability in order to help NW do better admission control and/or set even more appropriate threshold to decide configuration of a carrier at least via static DL centric approach.***  ***Proposal 2: With consideration of observations 7 – 10, in order to make maximum use of the reported value, MSD must be able to be reported per victim band per MSD type/order per BC.***  ***Proposal 3: Handling of different PC should be further discussed together with MSD feasibility study and MSD indication method.***  ***Proposal 4: With consideration of observations 11 – 15, the approach 1(fixed delta approach) shouldn’t be adopted and either the approach 2 (observation 13) or the approach 3 (observation 14) should be selected.***  ***Proposal 5: With consideration of observations 16, not to discuss the unique threshold or at least it may be better to discuss it (if necessary) after seeing the whole picture.***  ***Proposal 6: With consideration of observations 17 – 18, share the information on relation between higher order BCs and fallback BCs in terms of lower MSD capability with RAN2 if lower MSD capability is specified.*** |
| [**R4-2215481**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215481.zip) | Discussion on lower MSD capability | CMCC | ***Observation 1: the room for UL power back-off is limited considering the severe MSD usually occurs when UE needs higher UL power.***  ***Proposal 1: when ignallin the MSD reduction by power back-off, the loss of UL performance should also be considered.***  ***Observation 2: gNB may roughly know UE’s MSD performance when configuring UL RS to simulate harmonic, IMD or cross band interference and measuring corresponding DL RS CQI. But this scheme works only when UE’s MSD is much severe and it’s challenging for gNB to identify MSD when it is relatively less.***  ***Proposal 2: it’s suggested to focus on the MSD capability report which works for all band combinations considering current scheme may only work for very severe MSD cases.***  ***Observation 3: final NW ignallin is related to several factors besides MSD capability, e.g. UE DL received power strength, UE’s UL and DL throughput demand. NW may take all UE’s capability and condition into consideration to make global optimal solution.***  ***Proposal 3: it’s better to let UE report supported MSD value and let gNB use such information to determine final ignallin considering the trade-off between UL performance gain and DL degradation rather than letting gNB determine candidate values and send to UE to let UE report which/whether is supported.***  ***Proposal 4: the MSD capability is suggested to be per victim band per interference type and per interference order.***  ***Proposal 5: it’s suggested to define one common capability report scheme that apply for all band combinations rather than only example BC.*** |
| [**R4-2215667**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215667.zip) | Views on ignalling for improved lower MSD | Apple | ***Observation 1: If network would use MSD capability differentiation to exclude the Ues not supporting the “lower” MSD from using the combination on all occasions, the nominal MSD requirements would then become meaningless as UE passing the requirements still may not have the access to the combinations due to the capability differentiation by the network.***  ***Observation 2: MSD in the range of 20 to 30 dB does not only appear in CA or DC combinations. In some FDD bands, such as n8 and n71, the desensitization level can also be above 20 dB for wider channel BW.***  ***Observation 3: Maintaining one set of requirements with practical MSD improvement would motivate UE vendors to enhance but not costly outstretch their device performance which could potentially provide better overall link performance and shall benefit the entire cellular network ecosystem in the long run.***  ***Proposal 1: Further clarifications are needed on how network would handle UE with nominal or lower MSD differently before the consideration of UE capability introduction.***  ***Proposal 2: Keep one set of MSD requirements and specify MSD with practical device performance improvement for the new combinations going forward.*** |
| [**R4-2215735**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215735.zip) | Views on ignalling for Lower MSD | Samsung | ***Proposal 1: It is proposed to define Lower MSD capability as per-BC basis, and UE could indicate Lower MSD capability for a band combination as long as one kind of MSD from one victim band is improved.***  ***Proposal 2: Do not consider report the exact improved MSD values.***  ***Proposal 3: For 2-bands combination, Lower MSD information (improved MSD) are supposed to be reported separately as per source per band per band combination, that is MSD of different victim bands caused by different interference source are supposed to be reported separately.***  ***Proposal 4: For IMD, only the lowest order is considered when the victim band within the band combination suffers more than one orders of IMD, with the same UL/DL configurations and test points as for the minimum requirements in current spec.***  ***Proposal 5: For harmonic/harmonic mixing, the improved MSD should be derived and verified under the same UL/DL configurations of the minimum victim DL CBW& minimum aggressor UL CBW & the interference directly hit the DL as for the minimum requirements in current spec; For cross band isolation, the improved MSD should be derived and verified under the same UL/DL configurations of the minimum victim DL CBW& maximum aggressor UL CBW as for the minimum requirements in current spec***  ***Proposal 6: For 3-bands combination with specific UL and DL, the Lower MSD information (improved MSD) is only reported for IMD of dual UL falls into the third band DL.***  ***Proposal 7: For combination with more than 3 bands, no need to report the Lower MSD capability any more.***  ***Proposal 8: Explicit Lower MSD capability threshold(s) should be defined.***  ***Proposal 9: Define identical Lower MSD threshold(s) for different interference type could be considered.***  ***Proposal 10: It is suggested to define exact absolute Lower MSD threshold(s).***  ***Proposal 11: Combined with the analysis of improved MSD, it is suggested to define multiple thresholds for sake of sufficient information provided for network scheduler.***  ***Proposal 12: Lower MSD capability is applicable for PC1.5, PC2 and PC3. Particularly, for one band combination with specific UL and DL, Lower MSD capability is subject to the maximum power class the band combination supported.***  ***Proposal 13: Meanwhile, if the maximum PC is capable of Lower MSD capability, network could assume all the supported lower PC(s) has the identical Lower MSD capability (class).*** |
| [**R4-2216118**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216118.zip) | Signaling on Lower MSD | vivo | ***Proposal 1: Define Lower MSD as per BC capability.***   * ***Prefer not to differentiate with different MSD types for signalling simplicity and better adapt deployment need.*** * ***Prefer not to differentiate the cases when different victim bands suffered the same MSD type and order***   ***Proposal 2: Prefer to use lower MSD capability means all MSD types for a band combination have been improved.***   * ***Whether the same threshold value is chosen for different UE types may need further discussion.***   ***Proposal 3: Absolute thresholds values might be more preferred to have a more unified behaviour expectation for UE satisfy Low MSD.***  ***Proposal 4: For any Low MSD UE, only one MSD threshold is expected for a band combination, and no more differentiation to represent “very low/slightly low” etc.***  ***Proposal 5: Do not consider UL power back-off / dynamic reporting / UE SIR measurement and similar schemes for lower MSD.***  ***Proposal 6: Apply the same lower MSD capability for different power classes. However, whether the same lower MSD thresholds values can be the same between different power classes can be further discussed.***  ***Proposal 7: Minimising signalling overhead need to be considered.*** |
| [**R4-2216146**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216146.zip) | Discussion on lower MSD ignalling for inter-band CA/EN-DC/DC | Xiaomi | ***Proposal 1: the lower MSD ignalling should be defined per band combination, and only one highest value (or MSD threshold) among all MSD types is reported for the sake of reducing ignalling complexity.***  ***Proposal 2: if MSD value needs to be reported, the directly improved MSD values is reported.***  ***Proposal 3: only a single improved MSD value reported for a band combination is preferred, and the single improved value comes from the highest value among all MSD types, where the highest value (MSD threshold) should be derived based on the available parameters from commercial smartphone implementation point of view.*** |
| [**R4-2216435**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216435.zip) | R18 Discussion on MSD improvement signalling | OPPO | ***MSD signalling***  ***When separate improved MSD requirements are defined in RAN4***  ***Proposal 1: When separate improved MSD requirements are defined in RAN4, UE indicate supporting improved MSD requirement with per interference type per band combination granularity.***  ***When MSD improvement study is only for feasibility justification purpose***  ***Proposal 2: When no improved MSD requirement to be defined in RAN4 spec, MSD ignalling is used to indicate the real absolute MSD that UE can achieve.***  ***Proposal 3: If MSD threshold is NW configuration based, then several candidate thresholds can be defined, for example {5dB, 10dB, 15dB, 20dB}.***  ***Proposal 4: Per band combination granularity can be applied for threshold configuration and also UE reporting to indicate the real sensitivity.***  ***NW behaviour of MSD signalling***  ***Proposal 5: How NW handle the band combination configuration based on the MSD capability reporting is up to NW implementation.***  ***Proposal 6: Further consider dynamic MSD reporting to indicate the real time interference status.*** |
| [**R4-2216719**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216719.zip) | Discussion on the capability signalling design for Low MSD indication | CHTTL | ***Proposal 1: RAN4 to confirm the feasibility of the great MSD improvement compared to the minimum requirement, and the benefit of introducing the low MSD capability.***  ***Proposal 2: Consider a joint solution of one bit low MSD indication per BC with additional optional MSD report for different interference types under the per BC indication.***  ***- The improvement of the MSD for different interference sources can be provided by the additional optional MSD report, and if only the one bit low MSD indication is reported for a BC, then it means that all MSD types for this BC have been improved above a threshold.***  ***Proposal 3: The threshold for the one bit low MSD indication in proposal 2 can be defined as follow:***  ***- All PC3 MSD of this given band combination is < X dB if the MSD in the spec is higher than Y dB or 0 dB if the MSD in the spec is below Y dB, and additional X2, Y2 can be set for PC2 IMD when UL PC2 is supported.***  ***Proposal 4: The MSD report for different interference types in proposal 2 can be defined as follow:***  ***- The MSD for a given interference type is not larger than the reported value. The applicable report values can be MSD = 0 and multiple of X dB. (i.e. multiple thresholds)***  ***Proposal 5: The IMD impact on different victim bands is considered as different interference types in the low MSD report.*** |
| [**R4-2216777**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216777.zip) | Further discussion on the feasibility of signalling for low MSD | Huawei, HiSilicon | ***Proposal 1: Low MSD may be defined as an optional UE capability which is used to indicate that the effective level of self-interference at the UE is lower than that specified by 3GPP minimum requirements.***  ***Proposal 2: Large MSD values (>[15] dB) are not reported. The exact upper bound for reporting can be FFS.***  ***Proposal 3: Define MSD <= [5] dB as low MSD. The exact low MSD threshold can be FFS.***  ***Proposal 4: How to report the MSD values between the low MSD threshold and the MSD upper bound for ignalling is FFS. One or more intervals may be used depending on the need of the network.***  ***Proposal 5: Define and evaluate the low MSD capability based on the 1st test point (TP#1) for a band combination in the 3GPP spec. How to extrapolate the MSD for the actual DL/UL BW in use is FFS.***  ***Proposal 6: When reporting low MSD capability for a given band combination, include the information about the victim band and MSD type (Uln/DLm n=2,3,4,5, m=1,2,3,5, cross-band ISO, or IMDn, n=1,…,7).***  ***Proposal 7: For a band combination consisting of more than 3 bands DL, the low MSD capability is derived based on that of the 2/3 bands DL fallbacks.***  ***Proposal 8: The low MSD capability may be reported by the UE upon network query. The query can be filtered by the set of band combinations, the victim band, or the MSD type.***  ***Proposal 9: Consider the use of a single-bit low MSD indicator, which is reported together with the supported band combinations.*** |

## Open issues summary

### Sub-topic 3-1: Network behaviour for the lower MSD

#### ***Issue 3-1-1: What’s the supposed NW behaviour for the possible lower MSD capability***

***Option 1: Further clarifications are needed on how network would handle UE with nominal or lower MSD differently before the consideration of UE capability introduction. (R4-2215667 Apple)***

***Option 2: How NW handle the band combination configuration based on the MSD capability reporting is up to NW implementation. (R4-2216435 OPPO)***

***Moderator’s recommendation:***

***More companies favour to introduce a lower MSD UE capability, but some clarification is still needed especially when companies have different view on whether to introduce the capability.***

* Recommended WF
  + TBA based on 1st round discussion

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| --- | --- |
| **Company** | **Comments** |
| Samsung | We agree with Option2. We are not able to standardize the expected NW behavior not only for this feature, but also for many other features/capabilities. The inability of standardizing the NW behavior should not be a reason to preclude this capability.  Regarding Option 1, In last meeting, Samsung provided contribution to discuss the expected NW behavior with the intent to present the potential benefit with this capability as far as we know as NW vendor, so did CMCC. It is observed that many companies also think there is indeed some benefit with the capability introduction. For example, without this capability, in case the operators have strong concern on BC deployment under the worst case UL/DL configuration+ maximum output power, NW may not configure any UE under the worst case which is a waste of the valuable and expensive spectrum resources; With this capability introduction, NW would configure part of Ues compared to previously no UE would be configured under the worst case, that is the motivation of this capability. Also, the capability may also provide some valuable information to facilitate inter-cell measurement and Scell configuration/deactivation process. In addition, we do not believe the NW would reject the access of “normal UE’ on all occasions, as CMCC point out this capability is not the only factor leading to the final decision on Scell configuration, other factors also contribute to final decision including DL receiver power, UL and DL throughput demand, NW may take all UE’s capability and condition into consideration to make global optimal solution.Meanwhile we see no benefit from NW perspective to reject the nominal UE access on all occasions. |
| OPPO | Option 2. There is no guarantee NW behavior here, since it is not standardized in 3GPP. We see no benefit to further clarify NW behavior. |
| Nokia | Option 2 and we don’t need to discuss this anymore. We have already shared our views on how lower MSD capabilities are utilized by network while in the end, how to handle the capabilities is up to network/operator policy. And we don’t think we need to discuss the details anymore. There are many UE capabilities. For example, there is a *uplinkTxSwitchingPeriod-r16* that indicates the length of UL Tx switching period of 1Tx-2Tx switching per pair of UL bands per band combination when dynamic UL Tx switching is configured. We hadn’t discussed how this capability is utilized. |
| Huawei (JW) | We support option 2 as the fundamental assumption. On the other hand, we see no harm to discuss how the NW can potentially utilize the new UE capability to be introduced. Instead, thinking from the NW perspective might help the signaling design.  First of all, the large MSDs defined in the specs only happen at the specific configurations of carrier frequencies as well as max Tx power levels. And MSDs of different types won’t happen at the same time. The operator/NW can pre-determine whether the large MSD for a band combination would happen based on its spectrum holdings. If the MSD will not occur, the NW doesn’t need the UEs to report low MSD information.  If the MSD may happen, Ues without low MSD capability can still be scheduled by careful UL/DL RB allocation, or avoid simultaneous Rx/Tx, or when the RSRP is high enough as suggested in Nokia’s paper. |
| Meta | Before make decision, UE vendor need to know how NW will operate the capability signaling between normal UE and lower MSD UE. This is quite important issue between NW and UE behavior. So we prefer Option 1 at this stage. |
| Skyworks | In our view it is important that the NW uses the signaling only to optimize how to share resource between Ues and not prioritize UE with lower MSDs. To that respect we do not think that it is useful to have a very fine granularity in signaling lower MSD but it is important to understand improvement per type since it may imply different handling by the network. MSD per type with <1, <3, <7, <15dB might be good enough |
| Sony | Option 2. Although we are happy to hear further discussion on the network behavior, we don’t think the spec. would specify the network behavior anyway. Therefore, option 2 is reasonable. |
| AT&T | Option 2. |
| Qualcomm | Option 2. We believe that the NW should be allowed to use the low MSD information as it desires. Any additional knowledge that we learn regarding NW use of this information will be for our own knowledge only as RAN4 does not mandate NW behavior |
| Apple | We understand that there is probably no easy answer to clarify the network behaviors. However, the signaling likely cannot be properly designed without the guidance from network side. For example, would the network differentiate 15dB MSD from 20dB MSD? What should be the granularity of the MSD capability? The anticipated signaling overhead and the test complexity should be justified by the technical benefits. |
| NTT DOCOMO | Option 2. It is up to NW implementation. One possible way is configurable band combination selection, as we mentioned in our paper in last meeting, but other ways are not precluded. |
| KDDI | Option 2. Handling UE capability depends on NW implementation. |
| CHTTL | Support option 2, as the same view as Nokia. |

### Sub-topic 3-2: MSD capability

#### ***Issue 3-2-1: Whether to introduce the optional lower MSD UE capability based on the easibility study of MSD improvememt?***

***Option 1: Yes***

***Option 2: No***

***Option 3: Other/FFS***

***Moderator’s recommendation:***

***Seems most companies prefer to introduce the optional UE capability. It is the basis for the following detailed discussion.***

* Recommended WF
  + Check whether option 1 is agreeable during 1st round discussion

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| **Company** | **Comments** |
| Samsung | Option 1, Yes, it is suggested to confirm the feasibility of capability signaling in this meeting. |
| OPPO | Option 1, yes. |
| Xiaomi | Option 1 |
| Nokia | Option 3: Clarification is needed for Option 1. The question seems still the introduction requires feasibility study. Or if the question wanted to say that optional lower MSD UE capability is introduced and how the capability design is structured depends on feasibility study of MSD improvement? If the intention is the latter, we agree with it. |
| Huawei (JW) | Option 1. We think it’s feasible to improve the MSD under the conditions as in Issue 2-2-1. Hence, we support to introduce the new capability. |
| Meta | Option 1 |
| Skyworks | We need to first agree if capability is per MSD type or based on worst case MSD. |
| Sony | Option 1. |
| AT&T | Option 1. We assume that optional lower MSD UE capability is introduced but how the capability design is structured depends on further discussion on the signalling options. |
| Qualcomm | Option 1. Based on company contributions to the feasibility study it is clearly seen that MSD improvement is possible. Therefore, we agree with the introduction of the optional lower MSD UE signaling capability. |
| Apple | Option 3  We think the anticipated signaling overhead and the test complexity should be justified by the technical benefits. |
| NTT DOCOMO | Option 1. We agree to introduce the optional UE capability. |
| KDDI | Yes |
| CHTTL | Option 3, we are not sure this question implies further feasibility study is needed or not. But if Issue 2-2-1 is confirmed, we support option 1 to introduce the new capability. |

#### ***Issue 3-2-2: Granularity of the optional lower MSD UE capability***

***Option 1: per victim band per MSD type per band combination (Samsung, Nokia, CMCC, HW)***

***Option 2: not to differentiate with different MSD types (vivo)***

***Option 3: Others***

* Recommended WF
  + To check whether option 1 is agreeable during the 1st round discussion

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| **Company** | **Comments** |
| Samsung | We support Option 1 as main direction, **but** **one question for clarification: we should say per victim band per MSD type per BC or per ~~victim~~ band per MSD type per BC? Our understanding is that they may represent two signaling approach (hopefully is not my over-interpreted):**  1)Per victim band per MSD type per BC, sounds like to report the victim band&MSD type a BC suffered along with the MSD values;  2) Per band per MSD type per BC, appears to be an approach that the relationship between the bit and the MSD type&victim band is predefined and fixed, for example (Band1 harmonic, Band1 harmonic mixing, Band1 IMD, Band1 cross band isolation, Band2 harmonic, Band2 harmonic mixing, Band2 IMD, Band2 cross band isolation), the benefit is that NW could check the interested MSD directly by entering the corresponding bit.  **Would like to know companies’ interpretation/expectation is 1) or 2) or others? Our expectation is 2).**  We do not support Option 2, as elaborated in our paper, for a band combination, operators may only care about certain kind of MSD their holding spectrum suffered, so we propose to report different kinds of MSD from different bands separately, with which operators could directly check the MSD information they concerned. If the improved MSD is reported as the maximum value among all kinds of MSD, firstly which kind of MSD is improved might be unclear, in addition, the operators may lose the chance to know the actual MSD behavior they are interested in, which leads to meaningless of this capability although the signaling overhead is saved. |
| OPPO | Option 1 is ok, but signaling overhead would be high, how to simplify signaling can be further discussed. |
| Xiaomi | Our preference is option 2 for the sake of signaling overhead reduction. |
| Nokia | Option 1. It is so unfortunate to go with Option 2. If a UE has one MSD type whose MSD is huge while the other MSD types whose MSD is lower for a band combination, the UE cannot report the MSD capability at all or report it with larger value just slightly smaller than min requirements, and network cannot utilize MSD types with lower MSD at all. |
| Huawei (JW) | Option 1. MSDs from different sources (harmonic, cross-band isolation, IMD, etc) will happen at different configurations of carrier frequencies. For a given deployment, whether there’s MSD or which one might happen are pre-determined. It’s necessary to differentiate MSD types/sources.  To be accurate, the UE may report <MSD value index>, <victim band index>, <MSD source index> as an n-tuple for a BC. And how many tuples are reported is up to the UE. |
| Meta | We propose as follow in our paper (R4-2215758)  Option4: Single difference MSD value as the threshold according to the different MSD sources. But do not define the individual MSD levels for all CA/DC band combinations.  ***Proposal #5: RAN4 only introduces a threshold to indicate the lower MSD capability according to the different MSD sources and do not define the individual MSD levels for all CA/DC band combinations if RAN4 has clear evaluation results to define lower MSD capability.***  ***Proposal #6: Single difference value of the MSD as the threshold is considered for the lower MSD capability according to the different MSD sources when UE report the capability of lower MSD for the inter-band CA/DC band combinations if RAN4 has clear evaluation results to define the lower MSD capability.***  ***Proposal #7: RAN4 can recommend that the single difference MSD value for the lower MSD level according to the different MSD sources will be reported with 1dB granularity MSD step and the largest difference is up to 8dB with 3bits.*** |
| Skyworks | ***Option 1: per victim band per MSD type per band combination, with granularity of <1, <3, <7, <15dB*** |
| Sony | Option 1. |
| AT&T | Option 1. |
| Qualcomm | Option 1 adequate for now. Other criteria may have to be added later based on signaling discussions and future findings in this WI. |
| NTT DOCOMO | Basically, option 1 unless clear relationship of improvement among different MSD sources is identified. Per MSD source signalling would be useful since not all MSD sources become issues in an operator as whether the relevant interference will occur or not depends on the operator’s spectrum holding. |
| KDDI | Option 1. |
| CHTTL | In our view, the per victim band per MSD type per band combination seems reasonable and probably it is aligned with what we proposed in option 3 of Issue 3-2-4? It seems that option 2 is proposed to reduce the signaling capability? We are wonder whether a joint solution can be considered. |

#### ***Issue 3-2-3: Conditions to trigger the lower MSD reporting***

***Option 1: UE could indicate Lower MSD capability for a band combination as long as one kind of MSD from one victim band is improved (Samsung)***

***Option 2: lower MSD capability means all MSD types for a band combination have been improved (vivo, CHTTL).***

***Moderator’s recommendation:***

* Recommended WF
  + TBA based on 1st round discussion

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| **Company** | **Comments** |
| Samsung | Option 1.  Similar comment as Issue 3-2-2. Operators may only care about certain kind of MSD their holding spectrum suffered, while different kinds of MSD with different contributors would behave differently. For example a band combination suffers harmonic, IMD and cross band isolation interference in terms of full spectrum range (the victim bands might be different), only the MSD due to IMD does not meet the Lower MSD requirement, if following the stringent approach as Option2 accordingly UE is not allowed to indicate improved MSD for all interference type, which is a pity that the operators only suffer the harmonic or cross band isolation loss the chance to know the actual MSD behaviour. |
| OPPO | Both Option 1 and 2 are workable. Option 1 is preferred. |
| Xiaomi | We prefer to support to define one worst case threshold for one band combination which means all MSD types for a band combination is lower than the threshold due to improvement. |
| Nokia | We need clarification on the Option 1. What is something new compared to per victim band per MSD type including order of non-linearity terms per band combination? In any case, we think that per victim band per MSD type including order of non-linearity terms order per band combination can co-exist with Option 2. In case somehow a UE can make all the MSDs for a band combination lower than a certain value on the same or similar level, it is one of the ways to signal it. |
| Huawei (JW) | Similar to the reasons in Issue 3-2-2, we tend to agree with option 1.  Regarding Nokia’s comment, it seems to suggest that some “super UEs” can have some alternative ways of reporting, if we understand it correctly. |
| Meta | As we proposed in our paper,  We prefer as follow  ***Option3: UE could indicate lower MSD capability for MSD types regardless of the band combination to improve MSD.*** |
| Skyworks | Modified option 1: UE could indicate Lower MSD capability for a band combination as long as one kind of MSD from one victim band is improved SIGNIFICANTLY |
| Sony | Option 1 is preferred. |
| AT&T | Option 1. For a particular band combination, there may not be a need to improve all MSD types in order to justify signalling lower MSD capability as long as the MSD type with the improvement is justified. |
| Qualcomm | Option 1. With this type of signaling our understanding is that only the signaled MSD (specified by victim, type and order) will be improved and the other MSDs for that band combination will remain at the values specified in the current standard. |
| CHTTL | We also need clarification on option 1, if the UE can report per victim band per MSD type,  Option 2 we proposed is to reduce signaling overhead that if the UE improve all of the MSD type to a certain level, then one bit indication can be considered to reduce signaling overhead, see our comment in Issue 3-5-1. |

#### ***Issue 3-2-4: How to report the lower MSD capability for a BC with same MSD type but different orders***

***Option 1: For IMD, only the lowest order is considered when the victim band within the band combination suffers more than one orders of IMD, with the same UL/DL configurations and test points as for the minimum requirements in current spec (Samsung).***

***Option 2: When reporting low MSD capability for a given band combination, include the information about the victim band and MSD type (Uln/DLm n=2,3,4,5, m=1,2,3,5, cross-band ISO, or IMDn, n=1,…,7). (HW)***

***Option 3: The IMD impact on different victim bands is considered as different interference types in the low MSD report. (CHTTL)***

***Option4: Others***

***Moderator’s recommendation:***

* Recommended WF
  + TBA based on 1st round discussion

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| --- | --- |
| **Company** | **Comments** |
| Samsung | As proponent of Option1, we would like to provide more explanation and we are open to hear companies’ view.  Option 1 is specifically proposed for IMD. It is suggested only consider **lowest order IMD for 2CC UL CA and lowest order IMD for 3CC ULCA (triple beat).**  In 36.101, only the lowest IMD is specified following the WF R4-1702446 as below. For 38.101-1/3, the current procedure of BC introduction is that the lowest IMD is mandatorily specified but higher order IMDs could be omitted by note “*This band is subject to IMD X also which MSD is not specified*”. It could be found that higher order IMDs have not been introduced for many combos, chances are higher order IMDs for NR-CA and EN-DC would be removed in Rel-18 following the same approach as LTE for sake of spec simplification and test burden reduction.    Regarding Option 2, as we commented in Issue 3-2-2, we prefer to fix and predefine the relationship between the bit and the MSD type&victim band, for example (Band1 harmonic, Band1 harmonic mixing, Band1 IMD, Band1 cross band isolation, Band2 harmonic, Band2 harmonic mixing, Band2 IMD, Band2 cross band isolation), thus the NW could check the interested MSD directly by entering the corresponding bit, and we are open to further discuss the detailed signaling.  Regarding Option 3, it is aligned with “per (victim) band per MSD type per BC” reporting approach in Issue 3-2-2 if my understanding is correct. |
| OPPO | Option 2. |
| Xiaomi | Regarding option 1, for the same victim band, generally we are ok with proposal but how about when the victim band is different? Regarding option 2, the signaling complexity should be considered. |
| Nokia | Option 4.  Regarding Option 1, we cannot agree with this option. If MSD for the lowest order is 15 dB while that for higher order is, e.g., 0 dB, this 0 dB MSD is worth reporting.  With respect to Option 2 and 3, it requires clarification. What’s the difference? As we have proposed per victim band per MSD type including order of non-linearity terms order per band combination is OK while the highest order of non-linearity terms can be further discussed. |
| Huawei (JW) | Option 2. And option 3 is included in option 2 if we understand it correctly.  As commented in issue 3-2-2. MSDs from different sources (harmonic, cross-band isolation, IMD, etc) will happen at different configurations of carrier frequencies. For a given deployment, whether there’s MSD or which one might happen are pre-determined. The NW may care only one type of MSD. It’s necessary to differentiate MSD types/sources for the UE capability.  To be accurate, the UE may report <MSD value index>, <victim band index>, <MSD source index> as an n-tuple for a BC. And how many tuples are reported is up to the UE.  Note that the lower MSD capability under discussion needs a reference point in the specifications. When we say the MSD can be improved from 30 dB to 20/10 dB for a BC, we refer to a specific UL/DL configuration as depicted in the specification.  The number of mandatory test points may be reduced, but it’s better to keep all the relatively large MSD values (e.g. >5dB) even for high order IMDs, which will serve as the reference points for the new capability under discussion. |
| Meta | Option 3 and option 4 are preferred. Please see our proposals  ***Proposal #5: RAN4 only introduces a threshold to indicate the lower MSD capability according to the different MSD sources and do not define the individual MSD levels for all CA/DC band combinations if RAN4 has clear evaluation results to define lower MSD capability.***  ***Proposal #6: Single difference value of the MSD as the threshold is considered for the lower MSD capability according to the different MSD sources when UE report the capability of lower MSD for the inter-band CA/DC band combinations if RAN4 has clear evaluation results to define the lower MSD capability.***  ***Proposal #7: RAN4 can recommend that the single difference MSD value for the lower MSD level according to the different MSD sources will be reported with 1dB granularity MSD step and the largest difference is up to 8dB with 3bits.*** |
| Skyworks | MSD improvement for single type could be declared based on the worst case order (most likely the lower IMD but not necessarily with even and odd orders) |
| AT&T | We think that further discussion on Options 2 and 3 are necessary as we refine the possible signalling solutions. For Option 1, we cannot agree with it as is since we already allow additional test points for higher-order IMDs on a case-by-case basis. |
| Qualcomm | Option 2. We think that a full description of the MSD (i.e. victim band, MSD type, order etc) is required for the more complex band combinations where multiple impairments may exist. |
| CHTTL | Probably option 2 and option 3 and the per victim band per MSD type including order of non-linearity terms order per band combination are aligned…. so in general we are ok with both.  For option 1, we have different view that in some cases the MSD for higher order is also defined with lower order on the same victim band, also the impacted frequency region of the higher order is higher than the lower order. And from the signaling point of view, we think it is better to have the clear information of the order instead of referring to the “lowest”, thus we are not preferable of option 1. |

#### ***Issue 3-2-5: How to report the lower MSD capability for Harmonic/cross band isolation with different test points***

***Option 1: For harmonic/harmonic mixing, the improved MSD should be derived and verified under the same UL/DL configurations of the minimum victim DL CBW& minimum aggressor UL CBW & the interference directly hit the DL as for the minimum requirements in current spec; For cross band isolation, the improved MSD should be derived and verified under the same UL/DL configurations of the minimum victim DL CBW& maximum aggressor UL CBW as for the minimum requirements in current spec (Samsung).***

***Option 2: Define and evaluate the low MSD capability based on the 1st test point (TP#1) for a band combination in the 3GPP spec. How to extrapolate the MSD for the actual DL/UL BW in use is FFS. (HW)***

***Option 3: Others***

***Moderator’s recommendation:***

* Recommended WF
  + TBA based on 1st round discussion

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| **Company** | **Comments** |
| Samsung | Option 1  Option 1 and Option 2 is aligned if my understanding is correct, the definition of “TP#1” generally is the worst case test point/configuration which is introduced in BCS 4/5 WI and agreed to be mandatorily defined, our proposal includes the interpretation of “TP#1”. Considering there is either 1 or 2 or 3 test point/configuration defined in spec in terms of harmonic/harmonic mixing/ cross band isolation, we think that Lower MSD should be derived and verified under the worst case configuration, rather than all configurations.  More elaboration could be found in our paper. Please note that the worst case for cross band isolation for some combos has not been defined yet but thanks for great efforts from Skyworks the work is in the process in BCS4/5 WI (Rel-17 maintainance). For 38.101-3, the MSD table would be updated in Rel-18 adopting the identical approach as 38.101-1 in FS\_BC\_Sim WI.  After further checking the agreement in Rel-17 BCS4/5 WI and the spec, we would like to refine our proposal as below, further checking and wording refinement from companies are welcome.  ***Option 1: For harmonic/harmonic mixing, the improved MSD should be derived and verified under the same UL/DL configurations of the minimum victim DL CBW& ~~minimum aggressor UL CBW &~~ the interference directly hit the DL as for the minimum requirements in current spec; For cross band isolation, the improved MSD should be derived and verified under the same UL/DL configurations of the minimum victim DL CBW& maximum aggressor UL CBW as for the minimum requirements in current spec.*** |
| OPPO | This may depend on the conclusion in Issue 2-1-1, if the improved MSD is not specified in the spec there is no need to further discuss how to test it. But if this issue is about how to derive the improved MSD value then same UL/DL configuration as minimum requirement is preferred. |
| Xiaomi | Option 1 |
| Nokia | We think that option 1 and 2 can co-exist. They can be used as at least as baseline. |
| Huawei (JW) | We also think that option 1 and 2 are aligned in principle. Our intention is to clarify the MSD reference points in the spec, since some MSDs may have multiple test points corresponding to different CBWs. Better not to report MSD improvement for all different test points of the same MSD type.  On the other hand, the actual CBW in use may be different from the reference points. How to extrapolate the MSD for the actual DL/UL BW needs further study. |
| Meta | We prefer option 1 and also need to consider the option2. Need to combine option 1and option 2 to forward. |
| Skyworks | In most case there is no more than 2 test points now and these are usually scaling so we think the improvement can be declared based on the worst case (lowest UL and DL BW for Harmonics for example) |
| Qualcomm | We think that option 1 and 2 can both be used. |

#### ***Issue 3-2-6: Dynamic MSD reporting***

***Option 1: Further consider dynamic MSD reporting to indicate the real time interference status (OPPO)***

***Option 2: Do not consider UL power back-off / dynamic reporting / UE SIR measurement and similar schemes for lower MSD. (vivo)***

***Option 3: when nalysing the MSD reduction by power back-off, the loss of UL performance should also be considered. (CMCC)***

***Moderator’s recommendation:***

* Recommended WF
  + TBA based on 1st round discussion

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| **Company** | **Comments** |
| Samsung | We support Option2.  UL power back off approach is MSD issue avoiding with lower power, essentially NW is still unware of the actual MSD behavior of UE, when the UE is at cell edge, UL power back-off approach to alleviate self-interference may not be implementable; It is anticipated that Dynamic reporting/ UE SIR would lead to considerable complexity for UE implementation nevertheless the expected response from NW is unclear. We do not think they are suitable to be discussed in this WI. |
| OPPO | Option 1 is ok. This is for the issue of UE receive degradation in the field depends on the Tx power and Rx signal level. UE with high MSD can still have good receive performance when the Rx signal level is high and Tx power is low. Then the only way to indicate real MSD in the field is to dynamic reporting MSD. |
| Xiaomi | Open to discuss the dynamic MSD reporting approach |
| Nokia | We support Option 2 as our paper already provided observation 5 and 6 in R4-2215382. |
| Huawei (JW) | We don’t think it’s a good solution to reduce MSD by lowering the Tx power. However, UEs do not always need to use max power, especially for those in the cell centre or close to the gNB.  As suggested in Nokia’s paper, the RSRP (i.e. the signal level) for such Ues could be high. In the meantime, the required Tx power is also reduced owing to decreased path loss. As a result, the MSD (i.e. self-interference) is reduced. The combining effect is that the SIR at the UE is increased. How to allow such Ues to be scheduled worth being further studied.  Based on the above reasons, we think both option 1 and 2 can be further considered. The effect of actual Tx power on MSD can be FFS. |
| Meta | Option 2 do not need to report dynamic MSD reporting this is also related to the NW scheduling issue. |
| Skyworks | Thee is some benefit to understand how MSD works with output power because below some UL power there is no difference between a “normal” UE and an “improved MSD” UE. |
| Sony | Option 1. It is our understanding that UE is not always configured at maximum output power in real life, which can lead to an improved MSD performance than from the conformance test and it can dynamically report such an MSD value.  It should be clarified that this is not a power backoff but rather depend on the real time UE output power as commented by Huawei. This should not affect the coverage since it is typically used when the UE is not on the edge of the cell. It can be up to UE choice whether implement such a reporting and therefore the UE complexity should not be an issue. |
| AT&T | Option 2. |
| Qualcomm | Option 2: Do not consider UL power back-off / dynamic reporting / UE SIR measurement and similar schemes for lower MSD. |
| Apple | Option 1  It is not meant to request network to lower the UE UL power to reduce MSD. It is a natural outcome when UE is close to base stations. In that case, the MSD under the specified condition would no longer be an issue and the network can treat the nominal MSD and lower MSD UE equally. |
| CHTTL | We share the same view as Samsung and Nokia, we support option 2. |

### Sub-topic 3-3: Lower MSD threshold(s)

#### ***Issue 3-3-1: Absolute MSD value/threshold(s) or relative threshold(s)***

***Option 1: It is suggested to define exact absolute Lower MSD threshold(s). (Samsung, vivo, Xiaomi, Nokia, CHTTL, CMCC, HW)***

***Option 2: Relative lower MSD value for each impairment***

***Option 3: Others***

***Moderator’s recommendation:***

***Majority companies prefer absolute MSD threshold(s).***

* Recommended WF
  + Check whether option 1 is agreeable based on 1st round discussion

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| **Company** | **Comments** |
| Samsung | Option1.  Exact absolute threshold(s) and improved MSD values could provide more direct information for NW. If they are relative, NW has to check the corresponding specified MSD, since for example 10dB improvement in contrast to 30dB and in contrast to10dB definitely carry different information. |
| OPPO | Option 1 is ok, but in our view the absolute MSD threshold can be predefined in the spec or NW configured. |
| Xiaomi | Option 1, In current spec the network side has no any knowledge of the MSD minimum requirements, therefore if only delta MSD is reported, the network still could not get the exact MSD value for the band combination, consequently the delta MSD reporting is not meaningful. |
| Nokia | It’s better to further discuss both based on pros and cons. The outcome also depends on the thresholds and the number of available bits. At least there is no reason to make a decision on it in this meeting. Actually, absolute values per band combination have disadvantage in terms of performance meaning that the reported values can have more different than the actual value than relative values. Supposed that 0, 6, 12, 18 dB are possible to be reported regardless of MSDs. If the specified MSD is 30 dB for a MSD type and if an actual MSD is 15 dB, then the UE reports 18 dB and the difference is 3 dB. It may be ok. While another specified MSD is 11 dB and UE’s real performance is 7dB, the UE cannot report lower MSD all. If relative values per impairment (MSD types/order) is used in a way that the value to be reported is one of 0, 3, 6, 9 dB for certain MSD types, then, the UE can report MSD of 9 dB. We guess that thresholds are used in different ways in different questions so that clear definition is needed. |
| Huawei (JW) | Option 1 is preferred. |
| Meta | We are same view with Nokia. But we think that the MSD should be defined based on the existing MSD levels according to different MSD sources in a band combination. |
| Skyworks | Rather than the exact MSD level or its improvement we think it is more valuable to use a set of threshold values: <1, <3, <7, <15dB for example, more/higher levels are acceptable. And this per MSD type |
| AT&T | We agree with Nokia that this needs further discussion. We also think that it would be good to get the views from RAN2 on signalling design for some of the options presented so far so that we can understand the signalling capacity impact. |
| Qualcomm | We think that both option 1 and 2 can be used. If the UE is able to indicate the lower MSD value to the NW for a given band combination, then the reporting of an absolute value would be the most direct method. However, even the reporting of a relative threshold will achieve the same result though it would take more computation as the original MSD would have to be known by the NW. |
| CHTTL | Though there exist pros and cons on option 1 and option 2, we slightly prefer option 1 as it provide clear information, the relative report could be confused if the MSD values are changed among different releases or version of the spec, second, the threshold based on the exact value seem much easier to be defined, but we are also fine not to decide in this meeting and allow more discussion. |

#### ***Issue 3-3-2: Single value/threshold or multiple thresholds***

***Option 1: Single threshold (QC, CHTTL, vivo, Xiaomi, Meta)***

***Option 2: Multiple threshold (Nokia, Samsung, OPPO, HW, CHTTL)***

***Moderator’s recommendation:***

* Recommended WF
  + Check whether option 1 is agreeable based on 1st round discussion

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| **Company** | **Comments** |
| Samsung | Option 2.  Please see our comment for Issue 2-2-2. |
| OPPO | Option 2 is more flexible and can cover different band combinations which have high or low MSD, especially considering how much MSD can be improved is very much rely on UE implementation. |
| Xiaomi | There seems different understanding on Single value/threshold or multiple thresholds here. The first understanding is that whether we define Single/same or multiple thresholds for different MSD types. The second is that for the same types whether we need to define Single or multiple thresholds?  If the former, Our preference is that the same threshold(s) comes from the highest value among all MSD types for the sake of signaling overhead reduction. If the latter, we are also open to define Multiple threshold. |
| Nokia | We are open to discuss both. We tend to agree with option 2. At least it is not necessarily to define single threshold. |
| Huawei (JW) | Option 2 is preferred. |
| Meta | We support option 1 |
| Skyworks | Rather than the exact MSD level or its improvement we think it is more valuable to use a set of threshold values: <1, <3, <7, <15dB for example, more/higher levels are acceptable. |
| Sony | Option 2. |
| AT&T | Option 2. We cannot see agreeing to a single threshold. |
| Qualcomm | Option 1. Single threshold per impairment which is defined by the UE as indicated in our paper R4-2215378. The need for multiple thresholds exist if the thresholds are predefined. However, if the UE defines the lower MSD it is able to achieve, then we think that only one MSD threshold value needs to be defined. We think for a given band combination that this single threshold will vary from UE to UE depending on each UEs capability. |
| CHTTL | We would like to explain a little more, the multiple threshold is preferred to allow more flexibility, when considering the per victim band per MSD type including order of non-linearity terms order per band combination.  The single threshold we considered is for a joint solution to reduce the signaling, as in issue 3-5-1. |

#### ***Issue 3-3-3: In case of single threshold, the proposed value***

***Option 1: Single value with [1.0] dB resolution (QC)***

***Option 2: All PC3 MSD of this given band combination is < X dB if the MSD in the spec is higher than Y dB or 0 dB if the MSD in the spec is below Y dB, and additional X2, Y2 can be set for PC2 IMD when UL PC2 is supported. The*** ***value of X can be [6] dB and Y can be 10 dB (CHTTL)***

***Option 3: the single improved value comes from the highest value among all MSD types, where the highest value (MSD threshold) should be derived based on the available parameters from commercial smartphone implementation point of view (Xiaomi).***

***Option 4: Others***

***Moderator’s recommendation:***

* Recommended WF
  + TBA based on 1st round discussion

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | We do not support any of them. |
| OPPO | Can be predefined one absolute value like 5dB, or NW configured value. |
| Xiaomi | Same comments as 3-3-2 |
| Nokia | At least option 3 is not acceptable.  If we go with single threshold(granularity), we need to discuss Option 1 and 2 further. If available bits are sufficiently high, option 1 has finer resolution than Option 2. And where the highest MSD value that UE can report determines the required number of bits. If 15 dB is the maximum MSD that UE can report, then, 4 bits are needed per victim per band per MSD type/order per BC. If a UE capability is considered, the overhead may not be significant given that network can directly ask UE to report victim band per MSD type/order per BC that the network is interested in since the network must know relevant BC/MSD from their spectrum holdings.  Regarding Option 2, the granularity looks too rough. If the specified MSD is 30 dB, then, UE can report lower MSD only when the actual MSD is below 6 dB. Wouldn’t it be too unfair that the UE whose actual MSD is 7 dB cannot report it? |
| Huawei (JW) | As commented in issue 3-3-2, we prefer multiple thresholds, which should be the same for all power classes. |
| Meta | Prefer the principle in option 2. But need more detail operation for PC3/PC2 UE. |
| Skyworks | We do not support single threshold and do not believe that small granularity is important: if the starting point is 15dB MSD and EU1 signals 4dB and the other 5dB it is not clear that the network can actually distinguish what to do as in reality the 1dB better one may see more interference than the other. For difference between Power classes one can assume some offset from PC3 declared bin. |
| AT&T | We do not support a single threshold. Therefore, we do not support any of the options. |
| Qualcomm | Option 1: If the UE is able to define the lower MSD value for a given band combination then we think that 1.0 dB is a reasonable resolution for this value. |
| CHTTL | To explain option 2, it is proposed under a joint solution of a single bit report and more bits report.  So if we can agree a condition that all the MSD is improved to a certain level, then the UE can report with a single bit indication, but the UE can also choose to provide the detail information based on the per victim band per MSD type including order of non-linearity terms order per band combination directly. |

#### ***Issue 3-3-4: In case of multiple thresholds, the proposed values***

***Option 1: 5dB, 10dB, 15dB (Samsung, [HW])***

***Option 2: MSD=0, [6] dB, [12] dB, [18] dB (CHTTL)***

***Option 3: Others***

***Moderator’s recommendation:***

* Recommended WF
  + TBA based on 1st round discussion

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | Option 1. Please see our comment for Issue 2-2-2.  Actually the values proposed by CHTTL and Samsung, [Huawei] are close, could be further aligned. |
| OPPO | Option 3, the steps could be further discussed after seeing how much can be improved, but probably different band combinations can have different improved values then NW configured threshold can be more flexible? |
| Xiaomi | Same comments as 3-3-2 |
| Nokia | Option 3. We think that if MSD type is reported together with MSD value, the highest value can be defined per impairment, though we don’t think we need to too many of them.  For instance, IMD2, 3 …: 0, 6, 12, 18 dB, IMD4/5…0, 3, 6, 9 dB. Note that the values are just examples. And we believe that MSD = 0 dB should be included as reported value. |
| Huawei (JW) | We’re ok to consider some compromised values between option 1 and 2. |
| Skyworks | We have discussed <1, <3, <7, <15dB but are open to more/different thresholds. |
| AT&T | Option 3: The actual MSD values would need further discussion. We also are not sure about using absolute values versus relative values at this point. We think that both options could be explored further to allow RAN2 to also discuss. |
| Qualcomm | Option 3: We think that if the UE is allowed to indicate the lower MSD value then there is no need for multiple thresholds. The only reason that multiple thresholds are considered is because different UEs will indicate different lower MSD values based on their capability. However, if every UE is allowed to signal the lower MSD value it can achieve then there will be no need for multiple thresholds. |
| CHTTL | Though the interval are close to each other, we share the same view as Nokia on the aspect that we prefer to include MSD = 0. |

#### ***Issue 3-3-5: Whether same lower MSD threshold(s) for different MSD types***

***Option 1: identical Lower MSD threshold(s) for different interference type could be considered. (Samsung)***

***Option 2: Others***

***Moderator’s recommendation:***

* Recommended WF
  + TBA based on 1st round discussion

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | Option 1, from NW perspective, we see no necessity to define different threshold(s) for different kinds of MSD. |
| OPPO | Option 2, can be discussed further after seeing the improved MSD. Generally in our view the threshold can be different for different MSD types since it is up to UE optimization of the different interference types and can have different values. |
| Xiaomi | Our preference is that the same threshold(s) comes from the highest value among all MSD types for the sake of signaling overhead reduction. |
| Nokia | Option 2. It’s too early to draw conclusion on this. |
| Huawei (JW) | Option 1. The MSD is an indication of the level of self-interference, which potentially affects the SIR at the UE. We don’t see the need to use different thresholds based on interference type. |
| Meta | Option2. This is not reasonable to use identical lower MSD according to different MSD source. |
| Skyworks | If there are enough thresholds they could apply to all types. |
| AT&T | Option 2. As different interference types have different impact, we don’t think that it is reasonable to use the same threshold. |
| Qualcomm | Option 2. Different impairments should have different lower MSD values. There could be cases where a band combination has many impairments with different MSD values. The MSD signaling should be able to consider the different MSDs for the different impairments. |
| CHTTL | Maybe it’s a little bit early to conclude this, different threshold could be consider for different order or different PC, prefer to further discuss. |

#### ***Issue 3-3-6: Predefined or NW configurable thresholds***

***Option 1: The MSD thresholds can be predefined.***

***Option 2: The MSD can be configured by NW***

***Option 3: Both option 1 and option 2 can be considered***

***Moderator’s recommendation:***

* Recommended WF
  + TBA based on 1st round discussion

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | We support Option 1.  In our view, explicit Lower MSD capability threshold(s) are necessary. With unified and explicit threshold(s), generally speaking if the actual MSD is larger than the threshold(s) for a band combination, UE is considered as incapable of this capability, consequently does not have to storage the values into UE memory and indicate the capability and values to network; Without explicit threshold(s), engineers have to storage a mass of MSD values into the UE memory, without even knowing what this capability mean（what the logic behind this）, they are helpless of judging which MSD values are supposed to be stored and which are not necessary, but have to store all the values which actually is a waste of efforts and UE resources. For example if the specified MSD is 30 dB while the actual MSD is 25, UE would restore and report 25dB corresponding capability class which is meaningless since it is anticipated that network still have concern on deploying this combo. We understand the intention of Option 2 might be giving network maximum flexibility on scheduling, however it indeed do harm to UE side, it should be noted that the benefit of this capability between UE side and NW side should be balanced.  Regarding Option 2, if it means no explicit predefined threshold(s) but only the NW configurable threshold(s), is unacceptable to us.  In addition, perhaps explicit predefined thresholds+ NW configurable thresholds could also work, but it depends on how the signalling is designed. Could be FFS. |
| OPPO | Option 2 and 3. Predefined and NW configured both are ok. But considering different NW may have different strategy in handling MSD and band combination configuration, probably NW configured threshold is more flexible.  To balance the complexity and flexibility, the threshold that NW configure can be predefined, e.g. 5dB, 10dB, 15dB. And NW choose one of them to configure. For example, one NW may only care about whether UE’s MSD is lower than 5dB to determine the band combination configuration, then the 5dB threshold is configured, and UE can indicate whether its MSD is below 5dB or above 5dB. In this case, UE report 10dB and 15dB doesn’t have much meaning to NW. |
| Xiaomi | We are open to these options. A clarification question, if option 1 is considered, does it mean the requirement would be defined in RAN4 spec? |
| Nokia | Option 4: Need clarification. We should leave this to RAN2. Not sure how only Option 2 alone works. Of course, if the number of available bits is sufficient, the UE can report any value with finer granularity that meets the threshold the network sets. There may be elements to filter out some non-necessary reporting, e.g., the network may ask UE to report specific MSD values to impact on victim bands and MSD types/orders since the network knows which MSD types impact on which bands in advance from their own spectrum holdings information. |
| Huawei (JW) | Option 1 is preferred. The NW may use some custom threshold internally, which doesn’t have to be signaled to the UEs. |
| Meta | Option 1 is our understanding to use the lower MSD capability signaling. |
| Skyworks | Option1, NW defined could be complex to handle by the UE if they are different for different types or evolving with time. |
| AT&T | Option 4. We think that RAN4 can present a set of alternatives and have RAN2 provide their recommendation. |
| Qualcomm | Option 4. Lower MSD capability will vary from UE to UE. For a given band combination a UE should be able to signal its lower MSD capability to the NW. So, in this case the MSD threshold is predefined by the UE based on its capability |

### Sub-topic 3-4: Applicability of lower MSD capability

#### ***Issue 3-4-1: Applicability of the lower MSD capability for power classes***

***Option 1: Apply the same lower MSD capability for different power classes. However, whether the same lower MSD thresholds values can be the same between different power classes can be further discussed. (vivo)***

***Option 2: Lower MSD capability is applicable for PC1.5, PC2 and PC3. Particularly, for one band combination with specific UL and DL, Lower MSD capability is subject to the power class the band combination supported. (Samsung)***

***Option 3: Handling of different PC should be further discussed together with MSD feasibility study and MSD indication method. (Nokia)***

***Option 4: Others***

***Moderator’s recommendation:***

* Recommended WF
  + TBA based on 1st round discussion

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | As proponent of Option 2, refine our proposal as “…..***Lower MSD capability is subject to the power class the band combination ~~supported~~ indicated***”  The justification is that UE would only report one PC the UE supported for a BC, rather than the enumeration of all PCs, therefore we think the Lower MSD capability is along with the PC the UE indicated for the BC.    Regarding Option 1, we think identical threshold(s) shared by different PCs could be considered if multiple thresholds would be defined. Multiple thresholds is proposed based on our MSD trend analysis and with the intent to provide relative sufficient information for NW scheduler. Regarding “Apply the same lower MSD capability for different power classes”, we feel we need more time to further think whether there is applicable scenario for this proposal. |
| OPPO | Option 3, can be further discussed after the basic feasibility study outcome. |
| Xiaomi | Option 3 |
| Nokia | Option 3. |
| Huawei (JW) | It seems that the three options are not exclusive to each other. We share similar view with Samsung that the UE will only report one power class for a given band combination, i.e. the highest class that it can support.  The question is that should the UE report MSDs for different power classes, or should the NW derive the MSDs for other power classes based on the report for one particular power class? For example, the NW may impose certain max power limit of p-max, or the NW does not support HPUEs (e.g. the networks in Japan). |
| Meta | Option 3. It is up to MSD results from interested companies for PC2 UE. |
| Skyworks | It may be feasible to develop rules for offsets vs power class. |
| AT&T | We are generally OK with Option 3 as long as we are focused on the MSD indication method. We believe that the feasibility of MSD improvement is already confirmed in Sub-topic 2-2.  In some cases, we may need to declare lower MSD for PC2 and PC1.5 even though the MSD level for PC3 may have been acceptable. We agree with Skyworks that it may be feasible to develop rules for offsets vs. power class and think that this should be explored further. For the case that I mentioned earlier, the MSD improvement for PC3 would be implicitly defined. |
| Qualcomm | Option 3. We believe that the applicability of lower MSD capability for different power class would have to be handled on a case-by-case basis. For example, in some instances only the higher PCs may benefit from lower MSD while in other cases all PCs may benefit. |
| CHTTL | At this stage, probably go with option 3 at this stage. |

#### ***Issue 3-4-2: Applicability of Lower MSD capability for higher order combination***

***Option 1: (Samsung)***

* ***For 2-bands combination, Lower MSD information (improved MSD) are supposed to be reported separately as per source per band per band combination***
* ***For 3-bands combination with specific UL and DL, the Lower MSD information (improved MSD) is only reported for IMD of dual UL falls into the third band DL.***
* ***For combination with more than 3 bands, no need to report the Lower MSD capability any more.***

***Option 2: share the information on relation between higher order BCs and fallback BCs in terms of lower MSD capability with RAN2 if lower MSD capability is specified. (Nokia)***

***Option 3: For a band combination consisting of more than 3 bands DL, the low MSD capability is derived based on that of the 2/3 bands DL fallbacks. (HW)***

***Option 4: Others***

***Moderator’s recommendation:***

* Recommended WF
  + TBA based on 1st round discussion

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | It appears Option ½/3 are aligned. At least our justification of Option 1 is based on our recognition of Option 2/3.  If consensus could be reached on different kinds of MSD from different bands are supposed to be reported separately for 2-bands combination, we think Option ½/3 could be adopted. |
| OPPO | Option 2. And detailed relation between higher order and low order can be discussed further. |
| Xiaomi | Generally we are ok with these options. |
| Nokia | Option 2. Not sure why three options are listed. They say the same thing in our understanding. The importance is RAN2 needs to know this structure. |
| Huawei (JW) | The three options seem to be aligned in principle. How to capture them in the spec is FFS. |
| Meta | Based on NR DC combination, the option 1 is reasonable approach. And we agree with Samsung comments for option 2 and 3. |
| Skyworks | We agree with approach in option 1 but need to encompass the MSD related to intra ULCA UL configuration: IMDs of 2CC intra or triple beat of 1CC FDD + 2CC intra |
| AT&T | We are OK with all of the options presented as we don’t see that they conflict with each other. Options 1 and 3 generally follow the approach that we use in developing the MSD requirements. |
| Qualcomm | Options 2 and 3 seem to be very similar. It seems that they are saying in the case of band combinations with several bands the low MSD will be based on the lower band combination sets. |
| CHTTL | Seems that the options are aligned, in general ok with them. |

#### ***Issue 3-4-3: Commonality of the lower MSD capability***

***Proposal: one common capability report scheme that apply for all band combinations rather than only example BC. (CMCC)***

***Moderator’s recommendation:***

* Recommended WF
  + To check whether the above proposal is agreeable based on 1st round discussion

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | Agree, generally we think this capability is optional means it is applicable to any BC as long as the lower MSD capability requirement is satisfied for this BC. |
| OPPO | Ok with proposal. |
| Xiaomi | Ok with proposal. |
| Nokia | In our understanding, the outcome applies to all the other band combinations on top of example BCs. |
| Huawei (JW) | Ok with the proposal. |
| Meta | Support the CMCC proposal |
| Skyworks | Agree in principle. |
| AT&T | Agree in principle based on Nokia’s understanding. |
| Qualcomm | A common reporting capability can be used for band combinations that are capable of supporting the lower MSD feature. |
| NTT DOCOMO | Support. |
| CHTTL | Agree in principle. |

### Sub-topic 3-5: Format of lower MSD capability

#### ***Issue 3-5-1: How to report the lower MSD capability***

***Option 1: Consider a joint solution of one bit low MSD indication per BC with additional optional MSD report for different interference types under the per BC indication. (CHTTL, HW)***

***Option 2: Bit map and lower MSD classes per source (Samsung)***

|  |  |  |  |
| --- | --- | --- | --- |
| ***Bit map*** | ***Maximum allowed actual MSD (i.e. Thresholds)*** | ***Lower MSD Capability classes*** | ***Note*** |
| 00 | - | Not supported or not reported | Not supported here generally means the actual MSD is larger than the maximum threshold, while not reported generally means either the actual MSD has almost no improvement, or the specified MSD itself is already very small, or absent. |
| 01 | 5 dB | Ⅰ | 0 ≤ Actual MSD ≤ 5 |
| 10 | 10 dB | Ⅱ | 5 ＜ Actual MSD ≤ 10 |
| 11 | 15 dB | Ⅲ | 10 ＜ Actual MSD ≤ 15 |

***Option 3: Others***

***Moderator’s recommendation:***

* Recommended WF
  + TBA based on 1st round discussion.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | Option1 and Option2 actually address two different aspects.  1. Option1 may make a good point from signaling saving perspective, however it depends on the definition of the capability, could be FFS in future meetings.  1) In case the capability is defined as one kind of MSD from one victim band is improved while multiple thresholds is defined, the additional one-bit seems not necessary, since the capability is already reported as a per-BC package, and without checking the specific bit, it is still unclear the specific MSD capability class per source;  2) In case the specified capability is defined as either “one kind of MSD from one victim band is improved” or “all kinds of MSD should be improved” can be regarded as “Lower MSD”, meanwhile single threshold is defined, the joint solution indeed saves signaling.  3) In case the capability is defined as all kinds of MSD should be improved and single threshold is defined, joint solution is not needed.  4) In case …….  2. Our intention of Option 2 is that we feel quite weird to directly report the values 5/10/15 or 6/12/18 when the actual MSD is below these values (thresholds), in addition, threshold may not be a spec wording. Instead, I was enlightened by the approach adopted for another optional capability: Frequency separation. The table in Option2 adopted the similar approach as below Fs classes table. However we understand it also depends on the signaling design, we are fine to further discuss it. |
| OPPO | This depends on the outcome of threshold discussion whether it is one threshold or several, whether it is predefined or NW configured, etc. |
| Xiaomi | It is a bit premature to discuss this as the signaling is not clear currently |
| Nokia | We don’t think it makes sense to include “not supported or not reported” as 00. This just wastes a bit. Since network considers UE without lower MSD capability as Lower MSD is not supported, we don’t dare to set 00 to “not supported or not reported”. 00 can be considered MSD = 0 dB instead. |
| Huawei (JW) | Regarding option 1, our detailed proposal may be different from that from CHTTL, but we’re ok to further discuss. Our intention is to assist the NW to enquire the UE capability based on the single bit indication and reduce the signaling overhead.  For option 2, we think the design of the bit mapping can be left to RAN2. |
| Meta | Option 3. When we consider IMD4, IMD5, H4 and H5, the 1dB MSD granularity is also useful. So we prefer 3bits with 1dB step or 4bits with 1dB step. |
| Skyworks | Agree with bitmap approach but would like to discuss the values and go with thresholds that are not linear steps |
| AT&T | We are OK with a bitmap approach but as mentioned earlier the thresholds need further discussion. We also agree with Nokia that we should not waste signalling bits. The exact bitmap also needs further discussion since we need to confirm if we also need to identify the MSD type. |
| Qualcomm | Option 3: Let UE report lower MSD values for each band combination it supports based on its capability. We think that a reporting granularity of ~1.0 dB as indicated in our proposal R4-2215378 would be adequate. |
| CHTTL | For option 1, we propose that a joint solution can be considered to reduce signaling overhead, but I think we have different proposal as Huawei regarding the use of the one bit indication. We are ok to discuss other topic firstly. For option 2, we have similar question on the use of 00 as Nokia, and probably this can be discuss later, as we have different view on the threshold interval. |

### Sub-topic 3-6: Reducing signaling overhead

#### ***Issue 3-6-1: Methods to reduce the signaling overhead***

***Option 1: The low MSD capability may be reported by the UE upon network query. The query can be filtered by the set of band combinations, the victim band, or the MSD type (HW).***

***Option 2: Others***

***Moderator’s recommendation:***

* Recommended WF
  + TBA based on 1st round discussion

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | We are open to further discuss it, seems more relevant to RAN2 or NW implementation. |
| OPPO | Ok with option 1. And if NW only configure one threshold then UE can choose to report whether it is lower than the threshold, or choose to not report (higher than the threshold as default). This can also help in the signaling reduction. |
| Xiaomi | Similar view as Samsung. |
| Nokia | As commented in Issue 4-3-6, we should leave this to RAN2. They will take necessary measures if needed. |
| Huawei (JW) | We understand that this issue is largely in RAN2 domain. Our intention is to show that the signaling overhead can be managed, even though we have proposed to report several pieces of key information, including: victim band, MSD source, MSD value for a given band combination. |
| Meta | We can further discuss after study phase. |
| Skyworks | This makes sense, if the network does not make use of the info (either of all or some types) it should only query those that are of use. Note that thee are plenty of existing UEs that already do much better than 3GPP. |
| AT&T | This discussion should be left up to RAN2. |
| Qualcomm | This can be discussed further in the study phase of this WI as more details on MSD signaling is defined |
| Apple | Is such network query to be developed in compliance tests, otherwise, how would the network know if UE falsely reported lower MSD value? |
| CHTTL | It seems that it relates to RAN2. Also if it is designed upon network query, not sure it will also introduce a signaling overhead as the BS needs to send the request. |

### Sub-topic 3-7: Spec impact due to lower MSD capability

#### ***Issue 3-7-1: How to reflect the lower MSD in RAN4 spec***

***Option 1: Explicit Lower MSD capability threshold(s) should be defined. (Samsung)***

***Option 2: Others***

***Moderator’s recommendation:***

* Recommended WF
  + Collect companies’ views in 1st round discussion.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | Option 1, please see our comment on Issue 3-3-6. It is unacceptable to us if there is no explicit threshold(s). |
| OPPO | Option 2. It depends on whether RAN4 is going to specify the lower MSD in the spec or not. If not then this MSD capability threshold can be defined in RAN2 or NW configuration based. |
| Xiaomi | If explicit threshold is defined in RAN4, does it mean the requirement should be verified? |
| Nokia | It depends on the outcome of some of the previous enquires. This must be discussed later. |
| Huawei (JW) | We’re fine to further discuss it. |
| Meta | We prefer to define single threshold as lower MSD capability according to different interference sources. RAN4 do not define explicit lowe MSD capability threshold for each CA/DC band combinations. |
| Skyworks | Not sure the threshold details are needed in RAN4 spec if it is clear from the signalling. |
| AT&T | This can be discussed later after we conclude on the previous discussions. Right now, it would not be clear as to which items belong in the RAN4 spec versus the RAN2 spec. |
| Qualcomm | Option 2. No need to capture specific lower MSD values for each band combination that is capable of this feature in the RAN4 spec. Simply indicate in the spec that certain band combinations are capable of lower MSD and allow the UE to signal the lower MSD value based on its capability. |
| Apple | If no requirements specified, then no verifications needed. All UEs can report lowest MSD capability, true or false. Then it is as if no capability at all. |
| CHTTL | spec impact can be further discuss later. |
|  |  |

## Companies views’ collection for 1st round

### Open issues

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
|  | Company A |
| Company B |
|  |
|  | Company A |
| Company B |
|  |

## 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#3-1** | ***Issue 3-1-1: What’s the supposed NW behaviour for the possible lower MSD capability***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |
| **Sub-topic#3-2** | ***Issue 3-2-1: Whether to introduce the optional lower MSD UE capability?***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  ***Issue 3-2-2: Granularity of the optional lower MSD UE capability***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  ***Issue 3-2-3: Conditions to trigger the lower MSD reporting***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  ***Issue 3-2-4: How to report the lower MSD capability for a BC with same MSD type but different orders***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  ***Issue 3-2-5: How to report the lower MSD capability for Harmonic/cross band isolation with different test points***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  ***Issue 3-2-6: Dynamic MSD reporting***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |
| **Sub-topic#3-3** | ***Issue 3-3-1: Absolute MSD value/threshold(s) or relative threshold(s)***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  ***Issue 3-3-2: Single threshold or multiple thresholds***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  ***Issue 3-3-3: In case of single threshold, the proposed value***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  ***Issue 3-3-4: In case of multiple thresholds, the proposed values***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  ***Issue 3-3-5: Whether same lower MSD threshold(s) for different MSD types***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  ***Issue 3-3-6: Predefined or NW configurable thresholds***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |
| **Sub-topic#3-4** | ***Issue 3-4-1: Applicability of the lower MSD capability for power classes***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  ***Issue 3-4-2: Applicability of Lower MSD capability for higher order combination***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  ***Issue 3-4-3: Commonality of the lower MSD capability***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |
| **Sub-topic#3-5** | ***Issue 3-5-1: How to report the lower MSD capability***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |
| **Sub-topic#3-6** | ***Issue 3-6-1: Methods to reduce the signaling overhead***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |
| **Sub-topic#3-7** | ***Issue 3-7-1: How to reflect the lower MSD in RAN4 spec***  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

### CRs/TPs

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

|  |  |
| --- | --- |
| **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)

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
|  |  |  |

*Moderator can provide summary of 2nd round here. Note that recommended decisions on tdocs should be provided in the section titled ”Recommendations for Tdocs”.*

1. Recommendations for Tdocs
   1. 1st round

**New tdocs**

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

**Existing tdocs**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tdoc number** | **Revised to** | **Title** | **Source** | **Recommendation** | **Comments** |
| *R4-22xxxxx* |  | *CR on …* | *XXX* | *Agreeable, Revised, Merged, Postponed, Not Pursued* |  |
| R4-2216675 |  | TR 38.881 lower MSD v0.1.0 | Huawei, HiSilicon |  |  |
| [**R4-2216676**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216676.zip) |  | TP for TR 38.881 Example band combinations for lower MSD | Huawei, HiSilicon |  |  |
| [**R4-2215379**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215379.zip) |  | Investigation of band combinations for MSD reduction | Qualcomm Incorporated |  |  |
| [**R4-2215666**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215666.zip) |  | Further analyses and views on MSD improvement for inter-band CA/DC | Apple |  |  |
| [**R4-2215734**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215734.zip) |  | Views on feasibility of improved MSD | Samsung |  |  |
| [**R4-2215758**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215758.zip) |  | Consideration on the lower MSD study and capability signaling | Meta Ireland |  |  |
| [**R4-2215792**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215792.zip) |  | Feasibility study on amount of MSD improvement | Nokia, Nokia Shanghai Bell |  |  |
| [**R4-2215889**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215889.zip) |  | Discussion on lower MSD for inter-band CA/ENDC | ZTE Corporation |  |  |
| [**R4-2216117**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216117.zip) |  | Analysis on improve MSD | vivo |  |  |
| [**R4-2216145**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216145.zip) |  | Discussion on lower MSD for inter-band CA/EN-DC/DC | Xiaomi |  |  |
| [**R4-2216187**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216187.zip) |  | MSD evalueation considering the high PCB isolation for CA n1-n3 | LG Electronics France |  |  |
| [**R4-2216434**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216434.zip) |  | R18 Discussion on MSD improvement | OPPO |  |  |
| [**R4-2216776**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216776.zip) |  | Further discussion on the feasibility of improving MSD | Huawei, HiSilicon |  |  |
| [**R4-2215378**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215378.zip) |  | Signalling for low MSD | Qualcomm Incorporated |  |  |
| [**R4-2215382**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215382.zip) |  | Lower MSD signalling and the effects of the introduction | Nokia, Nokia Shanghai Bell |  |  |
| [**R4-2215481**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215481.zip) |  | Discussion on lower MSD capability | CMCC |  |  |
| [**R4-2215667**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215667.zip) |  | Views on signaling for improved lower MSD | Apple |  |  |
| [**R4-2215735**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215735.zip) |  | Views on signaling for Lower MSD | Samsung |  |  |
| [**R4-2216118**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216118.zip) |  | Signaling on Lower MSD | vivo |  |  |
| [**R4-2216146**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216146.zip) |  | Discussion on lower MSD signaling for inter-band CA/EN-DC/DC | Xiaomi |  |  |
| [**R4-2216435**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216435.zip) |  | R18 Discussion on MSD improvement signalling | OPPO |  |  |
| [**R4-2216719**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216719.zip) |  | Discussion on the capability signalling design for Low MSD indication | CHTTL |  |  |
| [**R4-2216777**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216777.zip) |  | Further discussion on the feasibility of signalling for low MSD | Huawei, HiSilicon |  |  |

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
   1. 2nd round

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tdoc number** | **Revised to** | **Title** | **Source** | **Recommendation** | **Comments** |
| *R4-22xxxxx* |  | *CR on …* | *XXX* | *Agreeable, Revised, Merged, Postponed, Not Pursued* |  |
| *R4-22xxxxx* |  | *WF on …* | *YYY* | *Agreeable, Revised, Noted* |  |
| *R4-22xxxxx* |  | *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