3GPP TSG-RAN WG2 #121bis R2-xxxx

E-meeting, 17th Apr. – 26th Apr., 2023

**Agenda item: 7.17.3**

**Source: vivo**

**Title:** **[AT121bis-e][230][MUSIM] UE capability restrictions (vivo)**

**Document for: Discussion and Agreement**

# 1 Introduction

This document is to kick off the following email discussion:

* [AT121bis-e][230][MUSIM] UE capability restrictions (vivo)

       Scope: Discuss and attempt to converge on the set of UE capabilities allowed to change for MUSIM.

       Intended outcome: Discussion report in [R2-2304397](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_121bis-e/Docs/R2-2304397.zip).

       Deadline: Deadline 2

# 2 Contact Information

Rapporteur encourages the participating delegates to provide their contact information in this table.

|  |  |
| --- | --- |
| Company | Contact: Name (E-mail) |
| Xiaomi | Yumin Wu (wuyumin@xiaomi.com) |
| Qualcomm | Ozcan Ozturk (oozturk@qti.qualcomm.com) |
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| MediaTek | Felix Tsai (chun-fan.tsai@mediatek.com) |
| Apple | Sethuraman Gurumoorthy (sethu@apple.com) |
| vivo | Wenjuan Pu (wenjuan.pu@vivo.com) |
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# 3 Discussions

## The maximum MIMO layers

|  |  |
| --- | --- |
| **Contributions** | **Related proposals** |
| OPPO[R2-2302551] | Proposal1: MIMO layers capability and bandwidth capability should at least be reported per direction (i.e. DL/UL) per FR for R18 MUSIM. FFS: whether MIMO layers capability and bandwidth capability should be further reported per band/per band combination. |
| Intel[R2-2302782] | Proposal#4: To indicate number of MIMO layers, it can be provided per UE per UL/DL per FR like in overheating and UE power saving.  |
| Samsung[R2-2302966] | Proposal 2: RAN2 to consider reusing existing procedure for providing preference on the maximum number of MIMO layers for power saving also for MUSIM purpose. This can be trigerred when there is a change of UE-A’s maximum number of MIMO layers preference due to MUSIM dual-active operation. |
| vivo[R2-2303268] | 1. The UE is allowed to report the following capabilities to the NW A for dual active MUSIM operation:

- the constrained Band/Band combinations;- the maximum DL/UL MIMO layer (per FSPC);- the SRS switching capability (per band per BC);- the measurement gap requirement (per serving cells and per non-serving frequency band);- the maximum DL/UL bandwidth (per band per BC). |
| Apple[R2-2303410] | Proposal 1: MUSIM UE should have the preference to dynamically request (e.g via UAI) its preferred number of CC and/or MIMO layers.  |
| Huawei[R2-2303470] | Proposal 4: In addition to release/recovery of Scells/SCG, at least the UE’s capability on maximum UL/DL MIMO layers and measurement gap can be reported to the network due to the temporary UE capability restriction.Proposal 6: Separate information are introduced in UAI message for updating different UE capabilities:* Serving index for SCell is reported for indicating release of Scell
* A single bit is introduced for indicating release of SCG
* The maximum UL/DL MIMO layers is reported per serving cell
* The current *needForGapsInfoNR* is reused for updating measurement gap capability
 |
| MediaTek[R2-2303623] | Proposal 1: The UE can indicate the following capability restriction for MUSIM purpose (via RRC signalling)* Maximum number of MCG CC and SCG CC
* Maximum number of MIMO layer
 |
| CT[R2-2303624] | Proposal1：The following capabilities restriction should be considered for for dual-active MUSIM: * Uplink/ downlink MIMO layers per frequency carriers.
* DC/CA band combination.
* Temperory maximum uplink power.
* SRS switching capability.
 |
| Ericsson[R2-2303640] | 1. The UE restricts the maximum UL/DL MIMO layer capability and the maximum number of CC to have enough hardware resources and processing power to handle two simultaneous connections
 |
| ZTE[R2-2303779] | Proposal 1: For the temporary capability restriction, keep the same granularity as in the UE capability message, e.g. the Transmission and reception capabilities (e.g. MIMO layers) and the Supported bandwidth can be reported (per cc) per BC, while the measurement capabilities can be reported per UE. |
| Qualcomm [R2-2302721] | Proposal 3: The UE can request changes to at least the following UE capabilities:* + MIMO layers (DL/UL, FR1/FR2)
	+ Measurement gaps
	+ Supported bandwidth
	+ Supported bands or band-combinations
 |

Based on the above proposals from companies, many companies think the maximum MIMO layer maybe changed due to Rel-18 MUSIM dual active operation, and the change can be indicated to the NW A. So, the companies are requested to answer the below question.

**Q1: For Rel-18 MUSIM dual active operation, do you agree that the maximum MIMO layer maybe changed and the change can be indicated to the NW A?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Xiaomi | Yes |  |
| Qualcomm | Yes |  |
| ZTE | Yes |  |
| OPPO | Yes |  |
| Huawei/HiSilicon | Yes |  |
| Intel | Yes |  |
| Ericsson | Yes |  |
| MediaTek | Yes |  |
| Apple | Yes |  |
| vivo | Yes |  |
| Samsung | Yes |  |
| Sharp | Yes |  |
| Nokia | Yes with comments | Whether the capability changes require some immediate configuration updates in NW for this capability needs to be discussed. |

There are different opinions on the granularity among companies, i.e., per direction (DL/UL), per FR, per UE, per FSPC, per serving cell, etc.

Per direction (DL/UL) and per FR:

The reason for adopting per direction (DL/UL) and per FR provided by the companies is to follow the current UE assistant information reporting for power saving and overheating cases. The rapporteur would like to clarify that in the current UAI, the UE can only indicate the same preferred value of the number of maximum MIMO layers for each serving cell.

|  |
| --- |
| 5.7.4.3 Actions related to transmission of *UEAssistanceInformation* message<Omit>1> if transmission of the *UEAssistanceInformation* message is initiated to provide *maxMIMO-LayerPreference* of a cell group for power saving according to 5.7.4.2 or 5.3.5.3:2> include *maxMIMO-LayerPreference* in the *UEAssistanceInformation* message;2> if the UE has a preference on the maximum number of MIMO layers for the cell group:3> if the UE prefers to reduce the number of maximum MIMO layers of each serving cell operating on FR1:4> include *reducedMaxMIMO-LayersFR1* in the *MaxMIMO-LayerPreference* IE;4> set *reducedMIMO-LayersFR1-DL* to the preferred maximum number of downlink MIMO layers of each BWP of each FR1 serving cell that the UE operates on in the cell group;4> set *reducedMIMO-LayersFR1-UL* to the preferred maximum number of uplink MIMO layers of each FR1 serving cell that the UE operates on in the cell group;3> if the UE prefers to reduce the number of maximum MIMO layers of each serving cell operating on FR2-1:4> include *reducedMaxMIMO-LayersFR2* in the *MaxMIMO-LayerPreference* IE;4> set *reducedMIMO-LayersFR2-DL* to the preferred maximum number of downlink MIMO layers of each BWP of each FR2-1 serving cell that the UE operates on in the cell group;4> set *reducedMIMO-LayersFR2-UL* to the preferred maximum number of uplink MIMO layers of each FR2-1 serving cell that the UE operates on in the cell group;2> else (if the UE has no preference on the maximum number of MIMO layers for the cell group):3> do not include *reducedMaxMIMO-LayersFR1* and *reducedMaxMIMO-LayersFR2* in the *MaxMIMO-LayerPreference* IE;<Omit> |

Per FSPC:

Some of the others suggest to use the same granularity as in the UE capability message, i.e., per FSPC (per cc per band per BC). This can provide full flexibility for the UE.

| ***maxNumberMIMO-LayersPDSCH***Defines the maximum number of spatial multiplexing layer(s) supported by the UE for DL reception. For single CC standalone NR, it is mandatory with capability signaling to support at least 4 MIMO layers in the bands where 4Rx is specified as mandatory for the given UE and at least 2 MIMO layers in FR2. If absent, the UE does not support MIMO on this carrier. | FSPC | CY | N/A | N/A |
| --- | --- | --- | --- | --- |
| ***maxNumberMIMO-LayersCB-PUSCH***Defines supported maximum number of MIMO layers at the UE for PUSCH transmission with codebook precoding. UE indicating support of this feature shall also indicate support of PUSCH codebook coherency subset. | FSPC | No | N/A | N/A |
| ***maxNumberMIMO-LayersNonCB-PUSCH***Defines supported maximum number of MIMO layers at the UE for PUSCH transmission using non-codebook precoding.UE supporting non-codebook based PUSCH transmission shall indicate support of maxNumberMIMO-LayersNonCB-PUSCH, maxNumberSRS-ResourcePerSet and maxNumberSimultaneousSRS-ResourceTx together. | FSPC | No | N/A | N/A |

Per serving cell:

Some companies suggest the UE only indicates the maximum MIMO layers for each/specific serving cells. This has less signalling overhead and can provide some flexibility to the UE as the UE can indicate different MIMO layer capability for different serving cells.

Based on the above information, the companies are asked to provide your answer for the below question.

**Q2: For Rel-18 MUSIM dual active operation, what granularity do you think should be used by the UE to report its maximum MIMO layers to the NW A?**

* **Option 1: per direction (DL/UL) and per FR, with the same maximum MIMO layer for each serving cell**
* **Option 2: per FSPC**
* **Option 3: per serving cell**
* **Option 4: others, please provide.**

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| --- | --- | --- |
| **Company** | **Option(s)** | **Comments** |
| Xiaomi | Option 2 or Option 3 | Since the current UE capability signaling of MIMO layer is already FSPC, the MIMO layer of a CC not shared by another SIM-B can still be unchanged. |
| Qualcomm | Option 2 | The same granularity as the actual UE capability is the best, given that this was chosen as the granularity when the feature was introduced and the UE can have different capabilities across different PDSCH and PUSCH as listed in the above quoted 38.306 text. Also note that using the same granularity is better for forward compatibility when more MIMO enhancements are introduced. |
| ZTE | Option 2 | We share the same view as Qualcomm |
| OPPO | Option1 | We think Option1 it’s efficient from overhead perspective compared with other options. |
| Huawei/HiSilicon | Option 3 | Option 1 (“per FR” reporting) decreases the performance as the UE has to report the same values for “all the serving cells” covered by the FR. Option 3 offers finer granularity compared to Option 1.Option 2 has similar granularity as Option 3, however, Option 2 is just the terminology we use for UE capability signaling structure and it’s not clear to us how it can be used. We understand the restricted MIMO layer is based on existing configuration, so we prefer Option 3. |
| Intel | Option1 | We think Option 1 will allow the reuse of the existing overheating and power saving preference for this purpose. |
| Ericsson | Opt.1 | The same approach as for power saving and overheating cases can be used. No reason to use a different granularity |
| MediaTek | Option 1 or Option 3 | Follow overheating/power saving indicator should be enough. We are also fine to have per serving cell. FSPC seems too complicate. |
| Apple | Option 1 | Because it will allow to reuse the exiting power save UAI framework |
| vivo | Option 2 or 3 | For option 1, the UE can only indicate the same maximum MIMO layers for all serving cells, but in fact the UE may only downgrade the MIMO layers on one serving cell, so this solution will sacrifice UE’s throughput performance. So, we prefer option 2 and 3. For option 2, the optimization can be further discussed to solve signaling overhead issue.  |
| Samsung | Option 1 |  |
| Sharp | Option 1 | Reuse the existing mechanism for overheating and power saving is the simplest and enough. |
| Nokia | Option 1 |  |

## Measurement gap capabilities

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| --- | --- |
| **Contributions** | **Related proposals** |
| OPPO[R2-2302551] | Proposal2: Gap requirements are reported per band/per serving cell for R18 MUSIM. |
| Intel[R2-2302782] | Proposal#3: RAN2 to study extending the existing gap capability request to Rel-18 MUSIM using the UAI.  |
| Samsung[R2-2302966] | Proposal 3: RAN2 to consider measurement capabilities including gaps requirements for the supported NR bands as per configured *requestedTargetBandFilterNR*, when a change in gap requirements is determined due to MUSIM dual-active operation, as candidate MUSIM temporary capability restrictions in UAI.  |
| Vivo[R2-2303268] | 1. The UE is allowed to report the following capabilities to the NW A for dual active MUSIM operation:

- the constrained Band/Band combinations;- the maximum DL/UL MIMO layer (per FSPC);- the SRS switching capability (per band per BC);- the measurement gap requirement (per serving cells and per non-serving frequency band);- the maximum DL/UL bandwidth (per band per BC). |
| Huawei[R2-2303470] | Proposal 4: In addition to release/recovery of Scells/SCG, at least the UE’s capability on maximum UL/DL MIMO layers and measurement gap can be reported to the network due to the temporary UE capability restriction.Proposal 6: Separate information are introduced in UAI message for updating different UE capabilities:* Serving index for Scell is reported for indicating release of Scell
* A single bit is introduced for indicating release of SCG
* The maximum UL/DL MIMO layers is reported per serving cell
* The current *needForGapsInfoNR* is reused for updating measurement gap capability
 |
| Ericsson[R2-2303640] | [Proposal 3 The UE indicates that support of *independentGapConfig* is restricted in UAI message.](#_Toc131700416)[Proposal 4 Rel-18 MUSIM UE uses existing NeedForGap feature to indicate changes in need for gap caused by MUSIM operation.](#_Toc131700417)[Proposal 5 An indication in UAI message (e.g. same as proposed in Proposal 3 above) indicates a change in UE’s needForGaps, and Nw can trigger a reconfiguration procedure to allow the UE to indicate its new needForGaps.](#_Toc131700418) |
| Qualcomm [R2-2302721] | Proposal 3: The UE can request changes to at least the following UE capabilities:* + MIMO layers (DL/UL, FR1/FR2)
	+ Measurement gaps
	+ Supported bandwidth
	+ Supported bands or band-combinations
 |

Based on the above proposals from the contributions, several companies think that the measurement gap requirement maybe changed due to Rel-18 MUSIM dual active operation, and this change hould be indicated to the NW A to enable the NW A updates measurement gap configuration properly. The reason is, after capability switching, the UE may perform some intra/inter frequency measurement from non-gap-assisted to gap-assisted. So, the companies are requested to provide your answer for the below question.

**Q3: For Rel-18 MUSIM dual active operation, do you agree that the measurement gap requirement maybe changed and the change can be indicated to the NW A?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Xiaomi | Yes |  |
| Qualcomm | Yes |  |
| ZTE | Yes |  |
| OPPO | Yes |  |
| Huawei/HiSilicon | Yes | If UE uses full RF chains in NW A, measurement gaps may be not needed for measuring target bands. But if RF chains are shared in both NWs, measurement gaps are needed to measure some target bands. |
| Intel | Yes |  |
| Ericsson | Yes | See our comments on Q4 |
| MediaTek | See comment | NR already support dynamic needForGap reporting in RRC response message. Even if we don’t change anything, the UE is allowed to report the latest gap requirement information in next RRC Reconfiguration cycle. We don’t really see strong need to have this but fine to have this enhancement if majority prefer.A clarification question, do company only want to indicate Rel-16 gap requirement information to NW A? What about NCSG capability in Rel-17? Note that RAN4 now request UE to report whether interruption is needed while no gap is reported in Rel-18 (see R2-2302431 and discussion [AT121bis-e][023][MGE]). Is that also included in the reporting?  |
| Apple | Yes |  |
| vivo | Yes | Regarding to MediaTek’s comments, if we don’t change anything, the network may not request the UE to report its latest gap requirement as the network has already have the gap requirement of the UE and assumes the UE does not change its gap requirement. For additional Rel-18 UE signalling to differentiate UE supporting no gap with interruption that mentioned MediaTek, we can further discuss.  |
| Samsung | Yes |  |
| Sharp | Yes |  |
| Nokia  | Yes |  |

Many companies propose to reuse or consider the current needForGapsInfoNR for updating the measurement gap requirement. The rapporteur would like to clarify that in needForGapsInfoNR feature, the UE reports measurement gap requirement for each serving cells and target NR bands or all its supported NR bands, which means the measurement gap ignalingt reporting is based on UE’s current configuration.

|  |
| --- |
| 5.3.5.3 Reception of an *RRCReconfiguration* by the UEThe UE shall perform the following actions upon reception of the *RRCReconfiguration,* or upon execution of the conditional reconfiguration (CHO, CPA or CPC):<Omit>2> if the *RRCReconfiguration* message was received via SRB1, but not within *mrdc-SecondaryCellGroup* or E-UTRA *RRCConnectionReconfiguration* or E-UTRA *RRCConnectionResume*:3> if the UE is configured to provide the measurement gap requirement information of NR target bands:4> if the *RRCReconfiguration* message includes the *needForGapsConfigNR*; or4> if the *NeedForGapsInfoNR* information is changed compared to last time the UE reported this information:5> include the *NeedForGapsInfoNR* and set the contents as follows:6> include *intraFreq-needForGap* and set the gap requirement information of intra-frequency measurement for each NR serving cell;6> if *requestedTargetBandFilterNR* is configured:7> for each supported NR band that is also included in *requestedTargetBandFilterNR*, include an entry in *interFreq-needForGap* and set the gap requirement information for that band;6> else:7> include an entry in *interFreq-needForGap* and set the corresponding gap requirement information for each supported NR band;<Omit> |

Based on the above information, the companies are requested to provide your view on the below question.

**Q4: If the ANS to Q3 is YES, do you agree the measurement gap requirement is reported for each serving cells, and for target bands or all supported NR bands depending on whether target bands are configured by the NW A?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Xiaomi |  | No strong preference, but fine to reuse the current needForGapsInfoNR. |
| Qualcomm | Yes but | We can re-use the same granularity as *NeedForGapsInfoNR.* However, we should stick to our agreement to use UAI and introduce a similar IE in UAI. |
| ZTE | Yes | We think the current mechanism can be reused |
| OPPO | Yes | The similar view with QC. |
| Huawei/HiSilicon | Yes | We think this principle should be applied for temporary measurement gap capability restriction, no matter if temporary gap capability is reported by RRC Reconfiguration Complete message or UAI message. |
| Intel | Yes | Similar view as Qualcomm that the NeedForGap mechanism is introduced into UAI, together with limiting the target bands via requestedTargetBandFilterNR |
| Ericsson | Yes | We see no need add any new NeedForGap ignaling in UAI, existing NeedForGap ignaling should be used.Additionally, UE should indicate that support of independentGapConfig is restricted in UAI message. |
| MediaTek |  | If something is needed. We prefer Ericsson’s approach, which has smallest impact. |
| Apple | Yes | Agree that reusing UAI to indicate is one way to go. |
| vivo | Yes | We can further discuss whether to reuse the RRC reconfiguration complete message or copy all the parameters to UAI.  |
| Samsung | Yes |  |
| Sharp | Yes | Prefer to reuse the needForGapsInfoNR. |
| Nokia | Yes |  |

## SRS Switching capability

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| --- | --- |
| **Contributions** | **Related proposals** |
| Xiaomi[R2-2303350] | Proposal: The UE should be able to indicate its temporary *srs-TxSwitch* capability. |
| vivo[R2-2303268] | 1. The UE is allowed to report the following capabilities to the NW A for dual active MUSIM operation:

- the constrained Band/Band combinations;- the maximum DL/UL MIMO layer (per FSPC);- the SRS switching capability (per band per BC);- the measurement gap requirement (per serving cells and per non-serving frequency band);- the maximum DL/UL bandwidth (per band per BC). |
| CT[R2-2303624] | Proposal1：The following capabilities restriction should be considered for dual-active MUSIM: * Uplink/ downlink MIMO layers per frequency carriers.
* DC/CA band combination.
* Temperory maximum uplink power.
* SRS switching capability.
 |

There are several companies mentioned that SRS switching capability maybe changed due to Rel-18 MUSIM dual active operation. SRS antenna switching is used to acquire DL CSI. Due to MUSIM dual active transmission, the UE may not be able to send the SRS in network A as configured if the related RFs are switched from the network A to network B, then the DL performance will decrease. To solve this issue, the UE needs to report its SRS switching capability change due to Rel-18 MUSIM operation. So, the companies are invited to provide your answer to the below question.

**Q5: For Rel-18 MUSIM dual active operation, do you agree that SRS switching capability maybe changed and the change can be indicated to the NW A?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Xiaomi | Yes | Proponent |
| Qualcomm | Yes |  |
| ZTE | Yes |  |
| OPPO | Yes |  |
| Huawei/HiSilicon | No | Agree that SRS switching capability may be changed but the NW A can know this based on the temporary capability restriction of maximum MIMO layers indicated by the UE via UAI message and legacy srs-TxSwitch-v1610 indicated by the UE in the UE capability message. No need to introduce a new indication for indicating the temporary SRS switching capability to the NW A for MUSIM purpose. |
| Intel | No | Similar view as Huawei that it can be derived from reduction in MIMO layer and also the downgraded pattern in srs-TxSwitch-v1610  |
| Ericsson | No | RAN2 should consider if the restriction on SRS switching capability is implicitly indicated to Nw when UE indicates restriction on MIMO layers and frequencies that the Nw should avoid to use.We understand the problem with reduced SRS switching capability is similar also for e.g. existing IDC feature. |
| MediaTek | No | Similar view as Huawei |
| Apple | Yes |  |
| vivo | Yes | After checking with our RAN1 colleagues, the SRS switching capability restriction cannot be derived by the network from the MIMO layer restriction. Because SRS antenna switching and MIMO layer are different things, and currently they are reported in different granularity. Moreover, the fallback SRS switching capability was introduced from Rel-16, and the UAI for power saving and overheating was introduced in Rel-15, in which the maximum MIMO layers are already supported to be reported to the network. We are not sure whether the current srs-TxSwitch-v1610 can be reused.  |
| Samsung | See Comments | We agree that SRS switching capability may be changed but we are not sure whether UE needs to indicate to the NW A explicitly as others commented. Thus, we suggest to discuss this aspect first. |
| Sharp | No | Agree with Huawei |
| Nokia | No | In general the UE behaviour on this TX switching or Power sharing for different channels in MUSIM operation to be discussed and common view needs to be obtained. Decision to support this capability restriction can be based on the same. In this case whether restriction is due to non-availability of antenna ports or power for NW-A operation is not clear.  |

Currently, SRS switching capability srs-TxSwitch is reported per band per BC. And for power saving purpose, a downgraded SRS switching capabilities supported srs-TxSwitch-v1610 was introduced in the UE capability message [R2-2002260], and the granularity is also per band per band combination.

| ***Srs-TxSwitch, srs-TxSwitch-v1610***Defines whether UE supports SRS for DL CSI acquisition as defined in clause 6.2.1.2 of TS 38.214 [12]. The capability signalling comprises of the following parameters:- *supportedSRS-TxPortSwitch* indicates SRS Tx port switching pattern supported by the UE, which is mandatory with capability signalling. The indicated UE antenna switching capability of ′xTyR′ corresponds to a UE, capable of SRS transmission on ′x′ antenna ports over total of ′y′ antennas, where ′y′ corresponds to all or subset of UE receive antennas, where 2T4R is two pairs of antennas. *supportedSRS-TxPortSwitch-v1610*, which is optional to report, indicates downgrading configuration of SRS Tx port switching pattern. If the UE indicates the support of downgrading configuration of SRS Tx port switching pattern using *supportedSRS-TxPortSwitch-v1610*, the UE shall report the values for this as below, based on what is reported in *supportedSRS-TxPortSwitch*.

|  |  |
| --- | --- |
| *supportedSRS-TxPortSwitch* | *supportedSRS-TxPortSwitch-v1610* |
| *t1r2* | *t1r1-t1r2* |
| *t1r4* | *t1r1-t1r2-t1r4* |
| *t2r4* | *t1r1-t1r2-t2r2-t2r4* |
| *t2r2* | *t1r1-t2r2* |
| *t4r4* | *t1r1-t2r2-t4r4* |
| *t1r4-t2r4* | *t1r1-t1r2-t2r2-t1r4-t2r4* |

- *txSwitchImpactToRx* indicates the entry number of the first-listed band with UL (see NOTE) in the band combination that affects this DL, which is mandatory with capability signalling;- *txSwitchWithAnotherBand* indicates the entry number of the first-listed band with UL (see NOTE) in the band combination that switches together with this UL, which is mandatory with capability signalling.For *txSwitchImpactToRx* and *txSwitchWithAnotherBand*, value 1 means first entry, value 2 means second entry and so on. All DL and UL that switch together indicate the same entry number.The entry number is the band entry number in a band combination. The UE is restricted not to include fallback band combinations for the purpose of indicating different SRS antenna switching capabilities.NOTE: The first-listed band with UL includes a band associated with *FeatureSetUplinkId* set to 0 corresponding to the support of SRS-SwitchingTimeNR. | BC | FD | N/A | N/A |

*BandCombinationList* information element

-- ASN1START

-- TAG-BANDCOMBINATIONLIST-START

<Omit>

BandCombination-v1540::= SEQUENCE {

 bandList-v1540 SEQUENCE (SIZE (1..maxSimultaneousBands)) OF BandParameters-v1540,

 ca-ParametersNR-v1540 CA-ParametersNR-v1540 OPTIONAL

}

<Omit>

BandCombination-v1610 ::= SEQUENCE {

 bandList-v1610 SEQUENCE (SIZE (1..maxSimultaneousBands)) OF BandParameters-v1610 OPTIONAL,

 ca-ParametersNR-v1610 CA-ParametersNR-v1610 OPTIONAL,

 ca-ParametersNRDC-v1610 CA-ParametersNRDC-v1610 OPTIONAL,

 powerClass-v1610 ENUMERATED {pc1dot5} OPTIONAL,

 powerClassNRPart-r16 ENUMERATED {pc1, pc2, pc3, pc5} OPTIONAL,

 featureSetCombinationDAPS-r16 FeatureSetCombinationId OPTIONAL,

 mrdc-Parameters-v1620 MRDC-Parameters-v1620 OPTIONAL

}

<Omit>

BandParameters-v1540 ::= SEQUENCE {

 srs-CarrierSwitch CHOICE {

 nr SEQUENCE {

 srs-SwitchingTimesListNR SEQUENCE (SIZE (1..maxSimultaneousBands)) OF SRS-SwitchingTimeNR

 },

 eutra SEQUENCE {

 srs-SwitchingTimesListEUTRA SEQUENCE (SIZE (1..maxSimultaneousBands)) OF SRS-SwitchingTimeEUTRA

 }

 } OPTIONAL,

 srs-TxSwitch SEQUENCE {

 supportedSRS-TxPortSwitch ENUMERATED {t1r2, t1r4, t2r4, t1r4-t2r4, t1r1, t2r2, t4r4, notSupported},

 txSwitchImpactToRx INTEGER (1..32) OPTIONAL,

 txSwitchWithAnotherBand INTEGER (1..32) OPTIONAL

 } OPTIONAL

}

BandParameters-v1610 ::= SEQUENCE {

 srs-TxSwitch-v1610 SEQUENCE {

 supportedSRS-TxPortSwitch-v1610 ENUMERATED {t1r1-t1r2, t1r1-t1r2-t1r4, t1r1-t1r2-t2r2-t2r4, t1r1-t1r2-t2r2-t1r4-t2r4,

 t1r1-t2r2, t1r1-t2r2-t4r4}

 } OPTIONAL

}

<Omit>

-- TAG-BANDCOMBINATIONLIST-STOP

-- ASN1STOP

For MUSIM case, we think the same granularity can be applied. So, the companies are invited to answer the below question.

**Q6: For Rel-18 MUSIM dual active operation, do you agree that SRS switching capability can be reported per band per BC?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Xiaomi | Yes | Reusing the current capability signaling structure would be simpler for UE implementation. |
| Qualcomm | Yes | Same granularity is the most flexible and future compatible option. |
| ZTE | Yes | Share the same view as Xiaomi and Qualcomm |
| OPPO | Yes |  |
| Huawei/HiSilicon | No | See our comment for Q5 |
| Intel | No |  |
| Ericsson | No | See comment to Q5 |
| MediaTek | No |  |
| Apple | Yes |  |
| vivo | Yes |  |
| Sharp | No |  |
| Nokia | No |  |

## DC/CA capabilities

According to the companies’ contributions, there are several options:

- **Option 1:** the UE indicates the maximum CC number to the network A, and it’s up to the network A to decide whether to release or deactivate some SCell/SCG. This could be per direction (DL/UL), or per FR, or per CG. This option cannot solve band conflict, so if we support option 1, we also need to have extra options.

- **Option 2:** the UE indicates its constrained/affected bands to let the network A to deduce the UE temporarily supported Band/BCs. To reduce the signalling overhead, the network A may configure a band filter list or constraint info to restrict the content to be reported by the UE. The bands included in the band filter list can be serving bands or non-serving frequency bands.

- **Option 3:** the UE requests the specific CCs to be released for MUSIM purpose.

- **Option 4:** the UE requests the specific CCs to be deactivated for MUSIM purpose. This can reduce the signalling overhead caused by SCell/SCG release.

The rapporteur requests the companies to provide your answer on the below question.

**Q7: For Rel-18 MUSIM dual active operation, which of the above solution(s) do you prefer to implicitly or explicitly indicate DC/CA capabilities?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Options**  | **Comments** |
| Xiaomi | Option 3 | We think Option 3 is more aligned with the RAN2 agreement made in RAN2#121 meeting, as quoted below:* A6: For dual-active MUSIM, UE signaling will support the request for release (and reversal) of SCells and SCG.
 |
| Qualcomm | Option 3 | The conflict with NW B can happen only for certain SCells. Therefore, releasing (or deactivating if agreed) only these SCells is more efficient for both the UE and the NW. |
| ZTE | Option 2 (can accept Option 3) | We prefer Option 2 and whether there is a need to do signaling optimization can be further discussed. We think when the network gets the temporary capability restriction from the UE, the network can either release CC or reduce other capabilities (e.g. reduce MIMO layer or bandwidth), which can be left to the network implementation.Whether there is a explicit indication of CC release, we are open to see other companies’ view and can follow the majorities. |
| OPPO | Option 3 (can accept Option 4) | the same view as Qualcomm |
| Huawei/HiSilicon | Option 3 and Option 4 | Option 1 is not enough to solve the band conflict issue. The motivation for power saving is different from that for MUSIM. For MUSIM, UE will not be able to support some specific SCells due to RF resource conflict.Option 2: we doubt how this works as the constrained/effected bands may be different depending on the CA configuration. For example, say there is PCell of band A in SIM A. Due to SIM B, SIM A can support band combination A+B, or A+C but cannot support A+B+C. So here both bands B and C are constrained/effected bands in A+B+C, but A+B can be supported. So, the question is if band B should be indicated as constrained/effected band. If band B is indicated as constrained/effected band, incompatibility can be avoided but the candidate configurable CA combinations are limited and this will degrade the performance in NW A. |
| Intel | Option 2 | This will allow both proactive (i.e. non-serving CC/bands) and reactive (i.e. serving CC/bands) reporting by the UE to the NW A. Option 3 and 4 do not allow proactive reporting. We can discuss signalling optimization later (e.g. using SCell Id). |
| Ericsson | Both Opt. 1 and 2 | Opt 2: We consider similar/same solution as already existing for IDC feature (option 2) can be used also for UE to indicate HW conflicts, “band conflicts”, and “reduced DC/CA capabilities.A major benefit that we should appreciate in this WI is that it reuses already existing specification and implementation principles in Nw and UE. On Nw side, this would reuse interactions with resource allocation features and UE capability verification.Opt 1: We are fine to allow also max number of CCs, since already exist in UIA framework, e.g. to reduce intra-band CCs. |
| MediaTek | Option 4, Option 3, Option 1 | Option 4 is simple, with low signaling overhead and low processing time. It should be the baseline on DC/CA capability reduction.We are okay to have option 1 and option 3 in additional. (Isn’t option 3 already agreed)Option 2 requests high signaling overhead and larger SPEC impact. We don’t see the need to have it while others simpler could have similar functionality. |
| Apple | Option 2Followed by Option 3 and Option 4 | In our view, Option 2 is very proactive approach, while Option 3 and 4 are reactive. If option 2 is implemented correctly on both UE and NW side, we might not have to employ Option 3 and 4. That said, option 3 also helps in this context, and is slightly preferrable compared to Option 4. |
| vivo | Option 2, 3, 4 (Option 3 maybe covered by option 2) | Option 1 cannot solve band conflict issue. Option 2 basically follows the IDC framework to solve band conflict issue and also DC/CA capability restriction. Since the bands requested by the network can be serving band or non-serving bands, both proactive way and reactive way are supported, as mentioned by Intel. Option 3 can be covered by option 2. If a network filter can be introduced, then the content the UE can report is under network control. So, we don’t see the benefit to only support option 2. Option 4 can maintain the CA/DC configuration for fast CA/DC setup. And RLM/BFD is configurable by the network, so we don’t think it is the bottleneck to use SCG deactivation.  |
| Samsung | Option 2 |  |
| Sharp | Option 3&4 | Option 1 itself does works. Option 2 with high signaling overhead. Option 3 and 4 are efficient, simple and have small impact on specification.  |
| Nokia  | Option 3 with comments | Simple indication of carriers to be released and if required carriers to be swapped or modified (with alternative frequency information) is sufficient.  |

## Bandwidth

|  |  |
| --- | --- |
| **Contributions** | **Related proposals** |
| Intel[R2-2302782] | Proposal#2: To indicate the band combination and bandwidth restriction due to Rel-18 MUSIM, the UE capability restriction information explicitly indicates the frequency band indicator and its corresponding centre frequency and frequency range that are no longer possible/available in NW A due to connectivity in NW B. FFS whether to reuse the Rel-18 IDC request.  |
| OPPO[R2-2302551] | Proposal1: MIMO layers capability and bandwidth capability should at least be reported per direction (i.e. DL/UL) per FR for R18 MUSIM. FFS: whether MIMO layers capability and bandwidth capability should be further reported per band/per band combination.  |
| vivo[R2-2303268] | 1. The UE is allowed to report the following capabilities to the NW A for dual active MUSIM operation:

- the constrained Band/Band combinations;- the maximum DL/UL MIMO layer (per FSPC);- the SRS switching capability (per band per BC);- the measurement gap requirement (per serving cells and per non-serving frequency band);- the maximum DL/UL bandwidth (per band per BC). |
| ZTE[R2-2303779] | Proposal 1: For the temporary capability restriction, keep the same granularity as in the UE capability message, e.g. the Transmission and reception capabilities (e.g. MIMO layers) and the Supported bandwidth can be reported (per cc) per BC, while the measurement capabilities can be reported per UE. |
| Qualcomm [R2-2302721] | Proposal 3: The UE can request changes to at least the following UE capabilities:* + MIMO layers (DL/UL, FR1/FR2)
	+ Measurement gaps
	+ Supported bandwidth
	+ Supported bands or band-combinations
 |

There are several companies mentioned that the bandwidth can be indicated to the NW A. Thus, the rapporteur requests the companies to provide your view on the below question.

**Q8: For Rel-18 MUSIM band conflict issue, do you agree that the maximum bandwidth can be changed and the change can be indicated to the NW A?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Xiaomi | Yes |  |
| Qualcomm | Yes | For band-conflict, the whole band may not be usable. Thus, we should indicate either zero maximum BW or use a different signaling, e.g. change the supported BC. |
| ZTE | Yes |  |
| OPPO | Yes |  |
| Huawei/HiSilicon | No | It is not clear how to understand “maximum bandwidth”. For UE capability, there are several bandwidth concepts, e.g., ca-BandwidthClassDL/UL-NR for BC, channelBWs-DL/UL for band, supportedBandwidthDL/UL for CC. Currently, the reduced bandwidth is about maximum aggregated bandwidth across all DL/UL carrier(s) per FR, and we are not sure about the use case, and the kind of bandwidth that will be impacted. |
| Intel | Yes |  |
| Ericsson | Maybe | We have not identified the real motivation for the restriction of Supported BW. But since it already exists max aggr BW in the UAI framework, we are ok to reuse also for MUSIM purpose, depending on company preferences. |
| MediaTek | No | Reducing DC/CA capability (as in Q7) is also kind of bandwidth reduction and we think that is enough for MUSIM. |
| Apple | Yes |  |
| vivo | Yes | The motivation is to solve band conflict issue. The UE can indicate the constrained bandwidth instead of indicating the whole band is constrained.  |
| Samsung | Yes |  |
| Sharp | Yes |  |
| Nokia | No | The scenario where the BW reduction needed for MUSIM operation is not clear. |

| ***ca-BandwidthClassDL-NR***Defines for DL, the class defined by the aggregated transmission bandwidth configuration and maximum number of component carriers supported by the UE, as specified in TS 38.101-1 [2] and TS 38.101-2 [3]. When all FeatureSetDownlinkId:s in the corresponding FeatureSetsPerBand are zero, this field is absent. For FR1, the value ‘F’ shall not be used as it is invalidated in TS 38.101-1 [2]. | Band | No | N/A | N/A |
| --- | --- | --- | --- | --- |
| ***ca-BandwidthClassUL-NR***Defines for UL, the class defined by the aggregated transmission bandwidth configuration and maximum number of component carriers supported by the UE, as specified in TS 38.101-1 [2] and TS 38.101-2 [3]. When all FeatureSetUplinkId:s in the corresponding FeatureSetsPerBand are zero, this field is absent. For FR1, the value ‘F’ shall not be used as it is invalidated in TS 38.101-1 [2]. | Band | No | N/A | N/A |

For the granularity, currently, bandwidth class is reported per band for DL/UL, as shown above. And bandwidth class can indicate the maximum aggregated CC and the maximum bandwidth for each CC in this band, as specified in TS 38.101. So, from the rapporteur’s understanding, the UE can indicate its bandwidth class per band to the NW A. Thus, the companies are requested to provide your view on the below question.

**Q9: If the ANS to Q9 is YES, which granularity do you think should be used to indicate the maximum bandwidth change to the NW A for Rel-18 MUSIM dual active operation?**

**- Option 1: per band**

**- Option 2: others, please provide**

|  |  |  |
| --- | --- | --- |
| **Company** | **Options** | **Comments** |
| Xiaomi | Option 1 |  |
| Qualcomm | Option 1 |  |
| ZTE | Option 2 (per FSPC) | We prefer to take the same granularity as the UE capability, which can also keep aligned with the above mentioned MIMO layer and SRS capability.In the current UE capability, there is per CC per BC bandwidth reporting (similar to the maximum MIMO layer) e.g supportedBandwidthDL/UL |
| OPPO | Option 2(per direction (i.e. DL/UL) per FR) | We think the proposed Option2 it’s efficient from overhead perspective compared with other options |
| Huawei/HiSilicon |  | See comment for Q8 |
| Intel | Option 1 | This can done via indicating the affected center frequency and frequency range similar to IDC. |
| Ericsson | Option 1 | Reuse same reporting as in existing UAI framework. |
| Apple | Option 1 |  |
| vivo | Option 1 |  |
| Samsung | Option 1 |  |
| Sharp | Option 1 |  |

## UL power

For uplink maximum power, some companies think the UE needs to indicate its dynamic power class or power change to the network A. And some of the others think UE’s maximum power backoff can be done via UE implementation or PHR. Currently, only FR2 P-MPR can be included in PHR. For FR2 case, the dynamic power backoff can be reported via PHR. In FR1 case, the maximum power backoff due to MUSIM dual active transmissions is 3dB, and this can be covered by the current RAN4 requirement. There could large power backoff in FR1 due to interference, from our understanding, the UE should trigger the solution for solving band conflict, instead of performing power backoff. Thus, the rapporteur requests the companies to provide your view on the below question.

**Q10: Do you agree that the maximum UL power may be changed due to Rel-18 MUSIM dual active operation, but there is no need to report UE maximum power to the NW A?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Xiaomi |  | No strong view. We think that the UE maximum Tx power available for NW A can be changed, and the UE is able to use power backoff and report it via PHR. However, it is unclear to us whether the gNB can use the PHR properly, since the values reported in PHR is still calculated based on the Pcmax. |
| Qualcomm | Yes | For uplink scheduling, PHR is sufficient information for the gNB. |
| ZTE |  | On this Issue, on one hand, it seems that there is a need to coordinate the two networks to restrict the maximum output power (e.g. a little similar to the coordination between the MCG and SCG), on the other hand, PHR mechanism seems also works. So we are open to see other companies’ views. |
| OPPO | No | Currently, PHR is calculated for the activated Serving Cell, which is not suitable for R18 MUSIM case when USIM A is in RRC\_CONNECTED mode while USIM B is willing to enter RRC\_CONNECTED mode as USIM B is still in idle or inactive, so USIM A will not consider USIM B situation when reporting PHR, i.e. there is no room to consider the USIM B power requirements in idle or inactive according to the MAC spec, in this sense, legacy PHR procedure still does not solve the power sharing issue between USIMs.*5.4.6 Power Headroom Reporting**The Power Headroom reporting procedure is used to provide the serving gNB with the following information:**- Type 1 power headroom: the difference between the nominal UE maximum transmit power and the estimated power for UL-SCH transmission per activated Serving Cell;**- Type 2 power headroom: the difference between the nominal UE maximum transmit power and the estimated power for UL-SCH and PUCCH transmission on SpCell of the other MAC entity (i.e. E-UTRA MAC entity in EN-DC, NE-DC, and NGEN-DC cases);**- Type 3 power headroom: the difference between the nominal UE maximum transmit power and the estimated power for SRS transmission per activated Serving Cell;**- MPE P-MPR: the power backoff to meet the MPE FR2 requirements for a Serving Cell operating on FR2.* |
| Huawei/HiSilicon | Yes | Agree with QC |
| Intel |  | This is not something that can be reconfigured by the network via RRC configuration. Hence it is not clear to us what NW A can do. |
| Ericsson | Yes | We can leave to UE impl to handle by existing PHR. |
| MediaTek | Yes |  |
| Apple | Yes | We prefer to use the existing PHR mechanism for this purpose. Open to any other suggestions as well. |
| vivo | Yes | Actually, there is no need to the UE’s power backoff to the network, as there is nothing that the network can do. In FR1, the power backoff due to MUSIM dual transmission is under the current RAN4 requirement. For FR2, MPE P-MPR was introduced in the PHR, and the reason is that there maybe higher power backoff in FR2 than FR1. In MUSIM dual active transmission, the MUSIM UE can reuse MPE P-MPR IE to report its power reduction. So, we think no spec effort is needed on this.  |
| Samsung | Yes | Existing PHR is sufficient. |
| Sharp | Yes |  |
| Nokia | See comments | How the PHR based mechanism is sufficient for all other channels such as PUCCH and uplink reference signals. Even for RACH transmissions how the power sharing works to be analysed. |

## Other

There are some proposals that are only proposed by one company is not included in this email discussion. If the companies have strong concerns on these proposals and if there is any other impacted capabilities are not covered by the content of this email discussion, please provide the comments in the below tables.

**Q11: Do you think there are other capabilities that maybe impacted due to Rl-18 MUSIM dual active purpose and not covered by the above questions?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | We slightly prefer to have a more generic solution to allow the UE to change any of it’s reported capability without specifying each potential affected capability bit in the *UEAssistanceInformation* message, as we may introduce more capability bits in Rel-18 and the future release which could also be impacted by MUSIM operation. However, we can also follow the majority view, if companies considers that reusing the framework as the overheating indication is preferable.  |
| Qualcomm | Agree with Xiaomi that a generic solution would have been. For the band-conflict case, we should be able to indicate that a specific band is not usable.  |
| ZTE | Agree with Xiaomi and Qualcomm that a generic solution would be more preferred.Considering that in the current capability structure, a band combination always has a corresponding featuresetCombination (to indicate the base band and RF capabilities), we think we can reuse the Featureset concept to cover almost all of the base band and RF capabilities and to avoid discuss each base band/RF capability one by one. |
| Huawei/HiSilicon | No. We should focus on the real issues that impact performance. We don’t think a heavy solution like UE capability reporting should be introduced for MUSIM. There will be a big impact on spec, and brings much complexity for both the UE and the NW. We understand the UE capability is still semi-static, only some resources may be suspended temporarily during dual-active mode. The temporary limitation may last for a short time, or change frequently based on NW configuration. Even for delta capability reporting mechanism, it is still unclear how to understand the capabilities which are not included, e.g. supported with same value, or not supported? |
| Intel | Agree with Huawei’s view. We should avoid porting the UE capability ignaling to UAI. |
| Ericsson | We agree with Huawei.The UE capability structure and its use is one of the most complex features in NR. We agreed on using the UIA framework as baseline for the solution developed for Dual RX/TX MUSIM WI. Main reason for this is that introducing some more advanced replica of the existing UE capabilities for temporary use would require considerable standardization effort in this very limited WI, as well as implementation impact on Ues and Nws.Therefore we expect the solution should be built on principles that already exist in UAI, and complemented with the capabilities/parameters we find are essential. |
| MediaTek | Agree with Huawei. |
| Apple | We do not want to port the entire UE Capability ignaling to UAI. At a very minimum we prefer the UE should be capable of indicating the conflicting bands and allow the NW to derive the set of band combinations to avoid. |
| vivo | Agree that we should focus on the essential capabilities (i.e., not each capability and each feature set) that their dynamic change can really help the MUSIM device improve performance and cost. We see there are some signaling overhead concerns on the finer granularity on the essential capabilities, but in our understanding, MUSIM case is different with the power saving and overheating cases. So, the finer granularity is beneficial and the signaling overhead can be under NW control, as in the current specification there already have some methods for the network to control the content of the UE’s reporting, e.g., for capabilities or UAI.  |
| Samsung | Agree to focus on essential capabilities.  |
| Nokia | We suggest to make use of UAI extensions where the UE indicate the information to NW-A that will assist NW to reconfigure resources for simultaneous operation will be sufficient. Exchange of complete capability container indicating the restricted capability is not needed. For example in case of band-conflict, UE only report or request for release of change of carriers in current configuration instead of reporting all the possible list of BC now allowed /restricted due to other MUSIM. |

# 4 References

R2-2302551 Allowed MUSIM temporary capability restrictions OPPO discussion Rel-18 NR\_DualTxRx\_MUSIM-Core

R2-2302782 Signalling to indicate temporary capability reduction for Rel-18 MUSIM Intel Corporation discussion Rel-18 NR\_DualTxRx\_MUSIM-Core

R2-2302966 Allowed MUSIM temporary capability restrictions Samsung R&D Institute India discussion Rel-18

R2-2303189 Adidtional aspects related to capability restriction signalling Nokia, Nokia Shanghai Bell discussion

R2-2303350 Capability sharing issue for SRS Tx switching capability Xiaomi discussion Rel-18 NR\_DualTxRx\_MUSIM-Core R2-2301116

R2-2303351 Remaining issues on band combination restrictions due to band conflict Xiaomi discussion Rel-18 NR\_DualTxRx\_MUSIM-Core R2-2301117

R2-2303268 Discussion on temporary capability restriction for Rel-18 Multi-SIM vivo discussion Rel-18

R2-2303455 Further discussion on the UE-initiated SCell/SCG deactivation and activation for MUSIM Huawei, HiSilicon, Vodafone, Vivo discussion Rel-18

R2-2303410 Parameters for MUSIM temporary capability restriction Apple discussion Rel-18 NR\_DualTxRx\_MUSIM-Core

R2-2303470 Further discussion on MUSIM temporary capability restrictions Huawei, HiSilicon discussion Rel-18 NR\_DualTxRx\_MUSIM-Core

R2-2303623 Discussion on temporary UE capability restriction for MUSIM MediaTek Inc. discussion R2-2300816

R2-2303624 Disucssion on UE capability restriction signaling China Telecommunications discussion

R2-2303640 Discussion on restricted UE capabilities Ericsson discussion Rel-18 NR\_DualTxRx\_MUSIM-Core

R2-2303779 Support of UE requesting SCell/SCG Deactivation for eMUSIM Sharp discussion

R2-2303938 Discussion on temporary capability restriction for Dual Tx/Rx Multi-SIM ASUSTeK discussion Rel-18 NR\_DualTxRx\_MUSIM-Core

R2-2304027 Simple Methods for MUSIM Temporary Capa Restriction LG Electronics discussion Rel-18 NR\_DualTxRx\_MUSIM-Core

R2-2303873 Consideration on the Temporary Capability Restriction ZTE Corporation, Sanechips discussion Rel-18 NR\_DualTxRx\_MUSIM-Core

R2-2302721 UE Capability restrictions for Dual-Active MUSIM Qualcomm Incorporated discussion