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

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

**Agenda item:** 10.9.3

**Source:** Moderator (Nokia, Nokia Shanghai Bell)

**Title:** WF on FR2 HST RRM (part 1)

**Document for:** Approval

# Background

This contribution is to capture the agreements and the directions of further discussions for the email discussion of Rel‑17 NR HST FR2 enhancements RRM core requirements in RAN4#102-e, with the email thread identifier “[102-e][212] NR\_HST\_FR2\_RRM\_1”.

This e-mail thread captures the e-mail discussions for the following sub-agenda items for FR2 HST RRM

* 10.9.4 RRM core requirements
	+ 10.9.3.1 General
	+ 10.9.3.2 RRC Idle/Inactive and connected state mobility requirements
	+ 10.9.3.4 Signalling characteristics requirements
	+ 10.9.3.5 Measurement procedure requirements

The following WFs were approved previously:

* R4-2103679, WF on Rel-17 NR HST FR2 enhancements, RRM requirements, Nokia, Nokia Shanghai Bell, RAN4#98-e
* R4-2105794, WF on FR2 HST RRM requirements, Nokia, Nokia Shanghai Bell, RAN4#98-bis-e
* R4-2115334, WF on FR2 HST RRM requirements (part 1), Nokia, Nokia Shanghai Bell, RAN4#100-e
* R4-2115335, WF on FR2 HST RRM requirements (part 2), Samsung, RAN4#100-e
* R4-2120292, WF on FR2 HST RRM requirements (part 1), Nokia, Nokia Shanghai Bell, RAN4#101-e
* R4-2120416, WF on FR2 HST RRM requirements (part 2), Samsung, RAN4#101-e
* R4-2202594, WF on FR2 HST RRM (part 1), Nokia, Nokia Shanghai Bell, RAN4#101-bis-e
* R4-2202767, WF on uplink timing for FR2 HST, Samsung, RAN4#101-bis-e

The detailed discussions related to the WF can be found in the e-mail discussion summary for [102-e][212] NR\_HST\_FR2\_RRM\_1 [R4-220xxxx].

# WF on Topic#1: General

## Sub-topic 1-1: General

#### Issue 1-1-1: Lightweight network assistance signaling

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| **GtW Agreement:*** Agreements
	+ Inter-RRH indication
		- Do not introduce explicit inter-RRH indication signalling for NR FR2 HST in Rel-17
		- FR2 HST Inter-RRH indication signalling enancements can be considered in Rel-18 subject to RAN plenary decision
	+ FFS whether additional assumptions for the definition one shot UL timing adjustment requirements shall be introduced (e.g. UE is configured with aperiodic L1-RSRP reporting before the TCI state switch, or UE performed fine time tracking within X ms before/after TCI state switching)
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#### Issue 1-1-3: Applicability of enhanced Set-1 RRM requirements

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| **Candidate options:*** Option 1:Set 1 requirements are developed based on the analysis with Dmin = 10m and Ds = 750m, and recommended applicable range of Dmin for Set 1 requirement is Dmin <= [50] m. For the deployment with larger Dmin, Set 2 requirements are recommended to be configured by network.
	+ The value of the Dmin threshold:
		- Option 1.a: 50 m
		- Option 1.b: 30 m
* Option 2: RAN4 will not capture any strict deployment limitations for enhanced RRM requirements applicability.
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| *Background:*The companies are discussing whether there is a need to limit/recommend deployment parameters (Dmin, Hdiff (height difference between train rooftop mounted CPE and RRH)) for scenarios with 2Rx beam seep requirements (set 1).If it found to be necessary, a corresponding text shall be added to the TR.*Recommendations for 2nd round:** Option 1 seems to be a compromise. Companies are encouraged to indicate whether wording of Option 1 is agreeable.
* Companies are encouraged to indicate the preferred value of Dmin applicability threshold for Set-1.
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| **Company** | **Comments** |
| Ericsson | We supported Option 2, but Option 1 can be acceptable. Regarding exact number of Dmin, we slight prefer Option1.a, because we consider the performance can be acceptable for set1 but not based on the degradation from set2, even we agree degradation comparison between set1 and set2 is a good metric. Generally, set1 has worse performance than set 2 in most ranges, but a too stringent Dmin may result into rare set1 implementation in practice, even set1 can have better mobility performance.  |
| QC | We support option 1, and option 1b for the threshold. When companies select between option 1a and 1b, we hope the following comments we made during the first round can be considered or discussed:1. Throughput difference:

When Dmin = 50m, the throughput difference is 20%; Dmin = 40m, the throughput difference is 15%,;and Dmin = 30m, the throughput difference is 9%, between set 1 and set 2 requirements. Given the analysis result, we consider 30m as good threshold as the tput difference is within 10%. 1. We should consider throughput instead of link budget when discussing this threshold. In practice, throughput improvement is definitely preferred, and the LOS path may not be as strong as RMaLOS model we consider in this WI.

To Ericsson: this is just the guidance instead of requirement, and the main consideration is throughput. Could you consider to compromise to 1b if we add wording like from throughput perspective? Because we already have clear mobility requirement captured in the spec and operators can check, but throughput difference is not there. Therefore, using TR to add the throughput perspective information should be beneficial to operators. |
| ZTE | We support Option 1. Between 1.a and 1.b, we are fine for both of them. |
| Samsung | Option 2 means no impact on “requirement”, so no change will be introduced to TS38.133. For Option 1, our understanding is the intention is to provide information and recommendation for NW configuration in different deployment scenarios. For option 1a and 1b, we have not yet conducted simulation and analysis yet. If the conclusion is intended to be made on this meeting, we are okay with both options.  |

## Sub-topic 1-2: UE capabilities and features

#### Issue 1-2-1: Type definition for HST FR2 RRM features

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| **GtW Agreement:*** Agreement:
	+ The following UE feature list description for feature “x-1 Support of FR2 HST operation” is endorsed in the RRM session. Further confirmation in the RAN4 Main and Demod session is required.

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| Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | Consequence if the feature is not ignalin by the UE | Type | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| x-1 | Support of FR2 HST operation | 1) Support of FR2 UE PC62) Support of enhanced RRM requirements for FR2 HST (except the requirement for one shot large UL timing adjustment)3) Support of demodulation processing for FR2 HST  | [R15 RAN4 feature group:Support of FR2 UE power class 6] | Yes | No | UE does not meet FR2 high speed train scenario | Per Band | No | Applicable to FR2 only | N/A | FR2 UE power class PC6 signalling is used to indicate support of feature group | Optional with capability signaling |

**Agreement:*** Remove pre-requisite feature groups “[R15 RAN4 feature group: Support of FR2 UE power class 6]”
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| *Recommendations for 2nd round:*Confirm in the 2nd round that the pre-requisite feature group can be removed. |
| **Company** | **Comments** |
| Ericsson | Ok with recommendation. |
| Apple | Agree |
| ZTE | Fine with the recommendation. |
| Samsung | Agree, and pls. note that the main session already have GTW agreement on this (last Friday).  |

#### Issue 1-2-2: Capability for one shot large UL timing adjustment

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| **Agreement:*** Introduce feature group x-2 “Support of one shot large UL timing adjustment” with prerequisite feature group (x-1, “Support of FR2 HST operation”)

**Candidate options:*** Option 1 (Intel, CATT, Samsung): Define One shot large UL timing adjustment feature as mandatory with capability signaling.
* Option 2 (QC, Apple, Nokia): Define One shot large UL timing adjustment feature as optional with capability signaling.
* Proposal 1 (Apple): For inter-RRH TCI state switching, whether UE can start PDCCH/PDSCH receiving without additional SSB receiving can be an UE capability.
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| *Background:*The companies seems to agree that a new feature group “Support of one shot large UL timing adjustment” is needed.However, there are different opinions whether the feature shall be defined as mandatory or optional.An additional proposal to add an new UE capability in this feature group was received in the 1st round (Proposal 1).*Recommendations for 2nd round:*Companies are encouraged to discuss in between Option 1 and Option 2 and share their view on Proposal 1 (see also Issue 2-3-1). |
| **Company** | **Comments** |
| Ericsson | Support Option1. If it is optional, we doubt UE will realize the capability. And regarding fall-back solution, we understand it depends on network to enable and disable dedicated signaling, but UE shall have capacity to do one shot UL timing adjustment. Otherwise, RA and one-shot UL timing adjustment shall be optional solutions, no relevant to fall-back.  |
| Nokia | Support Option 2 as other solutions are feasible. |
| Apple | Option 2  |
| QC | We support option 2.Our question to option 1 wasn’t addressed in the first round, and paste it here:Since network as RA mechanism as an option, why we should make this feature mandatory? The system still can operate without support of this feature, RA can be a replacement. For network, RA is supported already, but for UE, one shot large UL capability is new.To us, proposal 1 is a separate capability and can be discussed separately. The capability we discussed here is the capability for the UE autonomous one shot UL timing adjustment exceed Tq. |
| Samsung | Option 1, we see the benefits from introducing one shot timing adjustment, which minimize the impact due to legacy UL timing adjustment with RA. From our understanding, this capability is independent from Issue 2-3-1. Here we are discussing only the method to adjust UL with a one shot way.  |

#### Issue 1-2-3: Indication of HST FR2 RRM feature support and Applicability of enhanced RRM requirements (PC 6)

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| **Agreement:*** No enhanced requirement should be applied to other than PC6 UEs even when HST FR2 flags are configured.
* PC6 shall be used to identify the feature support of HST FR2 operation.
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# WF on Topic#2: Mobility, Measurement procedure and Signaling characteristics

## Sub-topic 2-1: RRC CONNECTED and IDLE state mobility requirements

#### Issue 2-1-1: Cell reselection in IDLE/INACTIVE mode

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| **Agreement:**

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| **DRX cycle length [s]** | **Scaling Factor (N1)** | **Tdetect,NR\_Intra [s] (number of DRX cycles)** | **Tmeasure,NR\_Intra [s] (number of DRX cycles)** | **Tevaluate,NR\_Intra****[s] (number of DRX cycles)** |
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| 0.32  | 2 or 6Note1  | 2.56 x N1 x M2 (8 x N1 x M2)  | 0.32 x N1 x M3 (1x N1 x M3)  | 0.96 x N1 x M4 (3 x N1 x M4)  |
| 0.64  | 5  | 17.92 x N1 (28 x N1)  | 1.28 x N1 (2 x N1)  | 5.12 x N1 (8 x N1)  |
| 1.28  | 4  | 32 x N1 (25 x N1)  | 1.28 x N1 (1 x N1)  | 6.4 x N1 (5 x N1)  |
| 2.56  | 3  | 58.88 x N1 (23 x N1)  | 2.56 x N1 (1 x N1)  | 7.68 x N1 (3 x N1)  |
| Note 1: N1 refers to the number of Rx beams and equals 2 for Set 1, and 6 for Set 2 Note 2: when SMTC < = 40 ms, M2 = M3 = M4 = 1; and when SMTC > 40 ms, M2 = 1.5, M3 = M4 = 2 Note-3: The requirement in this table shall only apply to power class 6 UE*,* when the network signaling [*highSpeedMeasFlag-r17]* is configured to [set1] or [set2], |

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| *Recommendations for 2nd round:*Agree on tentative agreement. |
| **Company** | **Comments** |
| Ericsson | Agree on tentative agreement. |
| Apple | Agree  |
| QC | Support the tentative agreement. |
| ZTE | We believe “x N1” was missing for 0.32 case, so we add it. |
| Samsung | We agree with the tentative agreement with the correction from ZTE.  |

## Sub-topic 2-2: Measurement procedure requirements

#### Issue 2-2-1: Time period for PSS/SSS detection and Measurement period for intra-frequency measurements

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| **GtW Agreement:*** Agreements
	+ Scaling factors (Mpss/sss\_synch\_w/o\_gaps and Mmeas\_period\_w/o\_gaps) equal to 6 for Set 1 and [18] for Set 2
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## Sub-topic 2-3: Signaling characteristics

#### Issue 2-3-1: TCI switching delay

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| **Candidate options:*** Option 1: For inter-RRH TCI state switching, TOk is 1. For intra-RRH TCI state switching, TOk can be 0.
* Option 2: The legacy known condition of TCI state can be reused for FR2 HST
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| *Background:*The Option 1 has been clarified by the proposing company:Our proposal is that for inter-RRH TCI state switching, due to large timing difference, UE will need to perform SSB detection after receiving TCI state switching. Therefore, TOk should be 1. Basically gNB should not configure the TCI state in the active TCI state list. For intra-RRH TCI state switching, TOk can be 0. Also from the next Issue:If some UE is capable to maintain time/freq sync for inter-RRH switching, TOk =0, then 1 symbol is enough. We propose to add UE capability to support inter-RRH active TCI state or not if needed. *Recommendations for 2nd round:** Since Option 1 was updated the companies are encouraged to share their view on Option 1.
* It is recommended to take into account the discussion in Issue 3-2-1 and in [213]NR\_HST\_FR2\_RRM\_2
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| **Company** | **Comments** |
| Ericsson | We don’t suggest to add a capability specially for inter-RRH switching, we suggest follows current rule: ‘TOk = 1 if target TCI state is not in the active TCI state list for PDSCH, 0 otherwise.’ If UE can handle/track multiple TCI state and the TCI state is in active TCI state list, only needs to follow the req. when Tok=0.  |
| Nokia | Options 1 and 2 do not conflict with each other. Option 1 is related to sub-topic 1-3 in thread [213] which is under discussion.Support Option 2. |
| Apple | If UE indicate the supported active TCI state is 2, typically it does not consider the case where 4CP timing offset is observed with TCI state switching. So it is possible UE support 2 active TCI state for intra-RRH, but only 1 active TCI state for inter-RRH due to large timing offset. We support both option 1 and option 2. If new UE capability is not introduced, by default, gNB should assume 1 active TCI state for inter-RRH switching.  |
| QC | SSB after TCI state switch is for fine timing tracking (time tracking based on CIR instead of SSB detection). If SSB detection is after TCI state switching, TOk should be 2 instead of 1. However, if our proposal in thread 213 can be agreed, SSB detection is not needed after TCI state switching, and TOk can be 1 in that case.It’s not obvious why intra-RRH TCI state switching has Tok = 0 since the target TCI state may not be in the active TCI state list. Even if it is, 1 additional slot/symbol might need to be added to account for the propagation delay difference. |
| ZTE | Support Option 2.If inter-RRH indication allowed, Option 1 makes sense. But it has been agreed not introducing any NW assistance signaling, we concern Option 1 is not realistic since before acquiring new DL timing, UE do not known whether inter-RRH switching happening or not. Option 1 is somehow causality problem.  |
| Samsung | As we comment in the email thread 213, we think the definition of TOk, i.e., the additional time allowed if the target TCI state is not in the active TCI state list. How to enlarge the time for UE to track the timing of the target TCI state can be FFS, but based on the original logic, if UE can track more than one active TCI state in the list while the target TCI state is contained in the list, TOk should still be equal to 0, since the target TCI state is tracked as active TCI state.  |

#### Issue 2-3-2: Inter-symbol interference during TCI switching

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| **Candidate options:*** Option 1 (Intel, Samsung, CATT, ZTE): *UE shall be able to receive PDCCH with target TCI state of the serving cell on which TCI state switch occurs at* ***symbol #m of*** *the first slot that is after slot n+ THARQ + + TOk\*(Tfirst-SSB + TSSB-proc) / NR slot length****, where m = 1 for power class 6 and m = 0 for other power classes****.*
* Option 2 (Ericsson): No necessity to limit receiving in RRM requirements.
* Option 3 (Apple): Define an additional symbol of interruption during TCI switching only for the UEs capable to maintain time/freq sync for inter-RRH switching.
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| *Background:*One of the companies prefers not to introduce one slot interruption for a nonconstant interference.One more company commented that:* The inter symbol interference issue only happen when TCI state is known and in the active TCI state list.
* Inter-RRH TCI state switching should not be in active TCI list, TOk = 1. There is no inter-symbol interference in this case.
* If some UE is capable to maintain time/freq sync for inter-RRH switching, TOk =0, then 1 symbol is enough.

Other companies seems to agree that one additional symbol delay should be enough to avoid interference.*Recommendations for 2nd round:** Discussion Candidate options in the second round.
* Coordinate the discussion with [102-e][213]NR\_HST\_FR2\_ RRM\_2
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| **Company** | **Comments** |
| Ericsson | If Tok=1, no ISI; if Tok=0, ISI exists and one additional symbol delay can be defined.Update:For more clarification on the additional symbol: if Tok=0, we prefer to shorten the PDCCH symbols with old TCI state, but it’s OK with Option1, adding 1 symbol on delay with new TCI state.  |
| Nokia | For unidirectional deployment scenarios, ISI occurs when UE is moving in the same direction as RRH TX beams but not when UE is moving in the opposite direction to the RRH Tx beams. It is not clear if there is ISI in bidirectional deployment scenarios.  |
| Apple | If Tok=1, no ISI. For Tok=0, as we commented for issue 2-3-1, if UE capability for inter-RRH TCI state switching is not introduced, then network should not configure inter-RRH TCI state in active TCI list. If Tok=0, option 3 is a super set of option 1, which can be either the 1st symbol of new TCI state, or the last symbol of the old TCI state. We prefer the last symbol of the old TCI state, as below: The UE shall be able to receive PDCCH with the old TCI state until ***symbol #m before***slot n+ THARQ + *+ TOk\*(Tfirst-SSB + TSSB-proc) / NR slot length*.We can go with option 1 as well for Tok=0.  |
| QC | We can support option 1 with the modification on TOk as commented in the previous issue. |
| ZTE | Support Option 1. |
| Samsung | Option 1, but option 1 + Tok=1, no ISI is also okay for us.  |

#### Issue 2-3-3: CSI-RS based RLM and BFD requirements

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| **Agreement:**For CSI-RS based RLM and BFD, there is no standard impact for Rel-17 FR2 HST UE (i.e., FR2 PC6 UE). |

#### Issue 2-3-4 (new): Scheduling restriction on SSB

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| Proposal 1 (Apple): To minimize L1-RSRP measurement impact and limit specification change, network should not use adjacent SSBs in FR2 HST. |

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| *Background*One additional point we would like to raise on scheduling restriction is on SSB. In 104bis-e, it was agreed that “RAN4 introduce scheduling restriction for the symbol before and after reference symbols used for L1-RSRP measurement. Such scheduling restriction shall be specified in clauses of L1 measurement (i.e., L1-SINR and L1-RSRP)”It is observed that SSB pattern for 120KHz and 240KHz has SSBs adjacent to each other. In 120KHz SCS, 2 SSBs are adjacent to each other, and for 240KHz SCS, 4 SSBs are adjacent to each other. In this case, the inter-symbol interference between different SSBs and the corresponding restriction should apply as well. To minimize L1-RSRP measurement impact and limit specification change, network should not use adjacent SSBs in FR2 HST. For example, in case of 120KHz SCS, network should not use SSB0 and SSB1 together. SSB0 and SSB2, or SSB1 and SSB2 are valid.  *Recommendations for 2nd round:*Companies are encouraged to share their opinion on the Proposal 1. |
| **Company** | **Comments** |
| Ericsson | We suppose it doesn’t impact scheduling restriction for the symbol before and after reference symbols used for L1-RSRP. 71GHz session has similar situation, required scheduling restriction boundary has been in the consecutive SSB symbol. Update:We can support Proposal1. |
| Nokia | As mentioned in Issue 2-3-2, this is needed when UE is moving in the opposite direction to the RRH Tx beams. |
| Apple | We support the proposal. Network should not use adjacent SSBs in this case.  |
| QC | We can support this proposal, but to capture this in spec, should we say the following?FR2 HST requirement is applicable when SSBs are not adjacent.Or we can soften the condition as:FR2 HST requirement is applicable when SSBs from different RRHs are not adjacent.To Ericsson: based on our understanding, the concern here is not scheduling restriction on data reception as 71GHz discussion. When SSB 0 and SSB 1 are overlapping because of propagation delay difference, there could be impact on PSS/SSS detection or PBCH decoding performance. |
| ZTE | Based on the previous agreement referred by the proponent, we can agree Proposal 1. |
| Samsung | P1 works as NW configuration restriction, but we need to discuss how to capture this in the spec.  |

# WF on L1 and L3 measurement accuracy

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| **Way forward:*** Option 1: Interested companies are invited to bring link-level simulation study of L1 and L3 measurement accuracy in HST FR2
* Option 2: No L1 and L3 measurement accuracy link-level simulations are needed in HST FR2
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| *Background:*One of the companies has provided a draft of link simulation assumptions for L1 and L3 measurement accuracy for FR2 HST scenarios [R4-2205900].Some companies have provided their comments on the proposal.One of the companies mentions that in FR1 HST already concluded that high speed channel has no impact on RSRP measurement requirement. Thus, HST FR2 discussion might not be needed even in the performance part.Therefore, firstly, it is necessary to confirm whether measurement accuracy shall be studied in the performance part.Secondly, the simulation parameters need to be modified according to the comments.*Recommendations for 2nd round:** Companies are invited to share their view on a need of link-level simulations of L1 and L3 measurement accuracy is needed in HST FR2
* Companies can further share simulation parameters for information purposes
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| **Company** | **Comments** |
| Nokia |  We support link simulations of L1 and L3 measurement accuracy for FR2 HST. |
| QC | The FR1 HST shows that frequency drift impact to RSRP measurement accuracy is limited, and that’s regardless of frequency range. Therefore, we support option 2 but open to further discussion in the next meeting. |
| Samsung | We are okay if companies prefer to evaluate the impact on measurement accuracy due to FR2 HST deployment scenario.  |

# CR/TP comments collection

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| **Tdoc number** | **Title** | **Source** |
| [R4-2203714] | **TP to TR 38.854 on the Number of Rx beams** | **Qualcomm** |
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| **Tdoc number** | **Title** | **Source** |
| [R4-2204721] | **draft CR On RRC\_CONNECTED state mobility for HST FR2 RRM** | **Ericsson** |
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| **Tdoc number** | **Title** | **Source** |
| [R4-2204489] | **Draft CR for Cell re-selection for HST FR2** | **ZTE Corporation** |
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| **Tdoc number** | **Title** | **Source** |
| [R4-2204490] | **Draft CR for L1-RSRP measurements for Reporting for HST FR2** | **ZTE Corporation** |
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| **Tdoc number** | **Title** | **Source** |
| [R4-2204629] | **CR to TS 38.133: intra-frequency measurements without gaps for for FR2 NR HST** | **Nokia, Nokia Shanghai Bell** |
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| **Tdoc number** | **Title** | **Source** |
| [R4-2204895] | **Scheduling restriction for L1-SINR for FR2 HST** | **Huawei, Hisilicon** |
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| **Tdoc number** | **Title** | **Source** |
| [R4-2203901] | **Draft CR on RLM/BFD requirement for FR2 HST** | **CATT** |
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| **Tdoc number** | **Title** | **Source** |
| [R4-2205894] | **Draft CR to introduce active TCI state switching delay requirement for FR2 HST UE** | **Samsung** |
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